Giampiero Campanelli *Editor*

The Art of Hernia Surgery

A Step-by-Step Guide

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Foreword

This new hernia book, *The Art of Hernia Surgery: A Step-by-Step Guide*, edited by Professor Giampiero Campanelli, and which I have the honor and the privilege to present, summarizes the maximum knowledge of abdominal wall surgery at this time. It answers all the questions that surgeons, not just hernia surgeons, will find useful in their daily practice both for the benefit of their patients and for extending their own erudition.

As an esteemed hernia surgeon and as Secretary General of the European Hernia Society (EHS) for more than 15 years, Professor Campanelli, with whom I have collaborated for many years on the EHS Board, has seen many changes and many advances and has rubbed shoulders with the world's top specialists in herniology. He appreciated the value of their publications and for this reason chose these top specialists to write the 67 chapters of this book, which provide exhaustive information in the field of hernia surgery.

Although related to general and visceral surgery, surgery of the abdominal wall is now a specialty in its own right. The names of the early pioneers in modern hernia surgery and their books are well known, such as the publications of H. Fruchaud, L. Nyhus, B. Devlin, J.P. Chevrel or R. Bendavid, V.K. Nigam, and C. Avci.

A number of important events have led to abdominal wall surgery becoming a recognized specialty. These events include the creation of the GREPA Research Group on Wall Surgery in France by J.P. Chevrel in 1979, this Group becoming the EHS in 1996. The following year, in 1997, an international journal, *Hernia*, was founded. Also notable are the creation of the American Hernia Society in 1998 in Miami and the creation of the Asia Pacific Hernia Society in 2004.

As well as these important societies, numerous other national hernia societies have been created, leading to a new surgical dynamic. Publication requirements have gradually improved, with detailed statistical evaluations, randomized trials, comparative studies, and so on. All of this activity has led industry to develop, at our request, multiple kinds of prostheses (more than 250), both synthetic and biological, in various materials, textures, shapes, and dimensions. We could also add the invention of many and varied means of fixation—sutures, staples, and glues. Other advances have led to such changes as laparoscopic surgery, robotic surgery, and ambulatory surgery.

The content of the book is the result of all the scientific research, evaluation, and data generated by these societies through their publications.

The originality of this book lies in its short and easy-to-read chapters, with their complete descriptions of current methods and applicable references. The book offers a broad range of subjects that are rarely tackled by other hernia books. Among these topics, we can mention the problems of prevention and emergencies, the new total extraperitoneal repair technique, open abdomen and component separation operations**,** and the Mini- or Less-open Sublay Operation (MILOS) technique; also provided are hernia classifications and guidelines.

In addition, you will find an original presentation of the anatomy of the abdominal wall, as well as detailed descriptions of traditional techniques in the treatment of various types of hernias, including incisional hernias. Improvements in these techniques and their recent results are also described. In short, you will have everything to guide you in the decision-making process.

In summary, it is a huge pleasure for me to introduce this new and complete practical hernia book, which is based on recent publications, clearly presented, and enhanced with significant illustrations.

I am sure that this book will be a reference for any surgeon, beginner or senior, who is looking for information on recent methods and techniques in hernia surgery.

I extend my congratulations to Professor Giampiero Campanelli and his co-authors for this new hernia book, which is sure to become very successful.

Paris, France Jean Henri Alexandre

Preface

Over 100 years ago Edoardo Bassini, the great pride of Italian surgery, wrote about whether it was still necessary to argue about hernia surgery.

Actually, from Hippocrates' time until today, and certainly for decades to come, we will continue to talk about hernia surgery and to discuss this topic.

In the last 30 years, during my succession of personal, academic, and, especially, professional activities, I have had—for more than 15 years—the honor of holding the leadership of the European Hernia Society. This organization has become a great Society, that, with the American Hernia Society, the Asia Pacific Hernia Society, the Afro Middle East Hernia Society, and the Australasian Hernia Society, involves the best international professionals in the field. The members of these Societies, I like to remember, are responsible for the largest numbers of hernia surgeries carried out worldwide.

With the scientific expansion spearheaded by these Societies, technological and material evolution has been such as to arouse the interest of companies, patients, media, and, especially, surgeons.

The fundamental objective in surgery of the abdominal wall is that of a *restitutio ad integrum*; that is, a reconstruction that is as natural as possible and which can achieve a perfect repair in the different wall regions, with, at the same time, a level of recurrences and complications that is as low as possible.

But today this objective is not our only aim.

More important has become the concept of quality of life, which appears in even the most serious and important series as an essential item whose measurement is requested by the individual patient after such surgery.

Essentially, postoperative comfort for the recovery of normal life and work habits, and in some cases the improvement of sports performances, and finally a natural appearance, have become collateral objectives that are increasingly requested and form an essential part of our daily activity.

To this end, we have gradually developed a concept of tailor-made surgery, which, together with the employment of our international guidelines, must permeate the training and daily activity of surgeons who want to dedicate their professional life to this exciting journey, which nowadays is recognized as a super specialization, mostly realized at specific worldwide hernia centers, but also realized in general surgery departments, by general surgeons.

The precise concept behind this book is to give a real guide to expert herniologists and to general surgeons the world over, suggesting different approaches, outlining technological aspects, and providing tips and tricks.

These contributions come from the wide experience of the authors—friends, who, with me, share their passion and daily practices in the journey along this complex, beautiful, and always developing path.

Milan, Italy Giampiero Campanelli

Contents

Part I

General Aspects

1 History and Evolution of Hernia Surgery

Giampiero Campanelli, Piero Giovanni Bruni, Andrea Morlacchi, Francesca Lombardo, and Marta Cavalli

Abdominal wall hernia is very common; the prevalence in the general population is about 5% [1]. Inguinal hernia is the most widespread presenting as a bulge in the groin.

Although the natural course of the disease is relatively slow, it eventually reaches the size that severely impairs with the patient's ability to perform daily activity. Already in antique times, the surgeons and physicians were trying to find the solution for this condition. Even though progress in surgical techniques and new principals allow the patient to resume a normal life in a very short time, up to 150 years ago, this was not possible.

The currently used term "hernia" comes directly from ancient Greece (*hernios*: offshoot or bud) reflecting in part the pathophysiological mechanism of the disease.

The **Egyptian Papyrus of Ebers** (1552 BC) contains an observation on hernias. Pharaoh Merneptah's mummy (1224–1214 BC) showed a scar in the groin as for hernia operation while that of Ramses V of Egypt showed hernia not operated [2].

Hippocrates (400 BC) differentiated between hernia and hydrocele: the former was reducible and the latter transilluminable [3]. He wrote about inguinal hernia in De Morbis and in De Affectionibus, suggesting enema therapy [1].

Aulus Cornelius Celsus (14 BC–AD 50) was one of the first that described surgical approach to the inguinal hernia: "for a medium size swelling one incision is enough, for bigger size two linear incisions are necessary and the cord is removed, vessels are identified, tied and cut." Lack of anatomical knowledge was clear in that age [4].

Galeno (129–199 AD) in De Semine described the correct anatomy of the inguinal canal. He thought that herniation was produced by rupture of the peritoneum with stretching of overlying fascia and muscle [2].

Jumping to the sixth century AD, the Italian **Paolo d'Egina** in his work *De Medicina* described his intervention of inguinal hernia. He suggested the cauterization: ligation and section of sac with the amputation of the testicle.

Guy De Chauliac (1300) wrote *Chirurgia Magna*. He was the first that distinguished inguinal to the femoral herniation. He also developed a method for reducing hernia on patients in the Trendelenburg position [5]. He prescribed a 50-day bed rest after the surgery: nowadays, after seven centuries, hospitalization is reduced to 1 h.

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Lack of knowledge about the anatomy and relying on Galeno's theory of rupture of the peritoneum as pathogenesis, all of these surgeons were limited to the closure of the peritoneal sac resulting inevitable recurrence of the disease.

Guido Lanfranchi (1300) suggested to avoid cord section, but it is necessary to wait until the sixteenth century when surgeons, supported by improved anatomy knowledge, pursued cord preservation during inguinal hernia repair [4].

Girolamo Fabrici d'Acquapendente (1533–1619) described the cord dissection and the division of spermatic vessel from the sac: this one was sutured with golden stitches.

Practica copiosa was the first book about etiology, morphology, and treatment of hernia written by **Caspar Stromayr** in 1559 [6]. Stromayr for the first time made a distinction between indirect and direct hernias and recommended a testis-sparing procedure for the direct type.

In the anatomic era (seventeenth to nineteenth centuries), autopsy and anatomic dissection spread throughout Europe that increased knowledge about groin herniation. Knowledge culminated during the early nineteenth century in a complete anatomic understanding of the inguinal canal.

The great contribution of the surgical anatomist was between the years 1750 and 1865 and was called the age of dissection. The main contributors were Antonio **Scarpa**, a great anatomist, and Sir **Astley Cooper**, who defined the transversalis fascia position, distinguished this layer from the peritoneum, and emphasized this layer as being the first layer to be breached in groin hernia. He also implicated venous obstruction as the first cascade in the circulatory failure of strangulation. One more important contributor was Percival Pott, who described the pathophysiology of strangulation in 1757 and recommended surgical management. He also emphasized that hernia sac was a part of general peritoneal cavity and had not to be ruptured or broken. Franz Hesselbach described the homonymous triangle which is now very important in laparoscopic surgery.

In the same time, Oliver Wendell Holmes and Semmelweis emphasized the importance of hand washing before operating. The application of Lister's principles of providing clean linen and special coats, cleansing sponges soaked in carbolic acid and thymol, and the segregation of postmortem examinations and operating theaters influenced British and European surgeons and decimated postoperative infection rate [7].

A revolution happened on Christmas night of 1889 when Edoardo **Bassini** first operated a patient for hernia with his novel technique, repairing, for the first time, the posterior wall of the inguinal channel. Bassini's merit was to focus the attention of the surgeons on the posterior wall as the real repair location, lowering hernia recurrence rate from about 100% to about 10%.

Bassini created a physiologic reconstruction of the inguinal canal, suturing the conjoint tendon and the transversalis fascia with inguinal ligament. This operation was considered the gold standard for nearly a century [8].

Some modified versions were suggested (Mugnai, Ferrari, Postemski). McVay popularized the Cooper's ligament repair, in which the aponeurosis of the transversus abdominis and internal oblique were sutured to Cooper's ligament, rather than to the inguinal ligament [9].

In the late 1940s, **Shouldice** refined the Bassini inguinal hernia repair by reconstructing the posterior inguinal wall using continuous sutures equalizing tension throughout the suture line; this technique reported a recurrence rate of less than 1% following primary inguinal hernia repair [10].

Although it was a very popular technique, there were several disadvantages such as suture line tension, patient discomfort, prolonged postoperative recovery, and rehabilitation, and recurrence rates are considered too high. The most critical factor in the development of recurrences following all tissue-based hernia repairs was excessive tension on the suture line, hence the introduction of the concept of ***tension-free hernia surgery*** [11].

The first mesh repair was performed by **Usher** in 1958, and in 1960 he described a tension-free technique of inguinal hernia repair using polypropylene mesh.

Many surgical procedures and devices have been marketed in the last 20 years, some of them evolved, and now they are accepted worldwide and used (Lichtenstein technique).

Lichtenstein tension-free hernioplasty, introduced in 1984, is now the most commonly used technique because it does not need a long learning curve to obtain highly acceptable result; recurrence and complication rate are less than 1% [12]. The original technique requires a polypropylene mesh fixed with unabsorbable suture on the inguinal ligament and with absorbable stitch on the conjoint tendon.

Trabucco in 1989 proposed a tension-free sutureless technique: a flat preshaped memory mesh with proper rigidity was placed on the posterior wall of the inguinal canal without suture fixation on the surrounding tissue. The main advantage of a tension-free and sutureless repair was given by the relevant reduction in postoperative chronic neuralgia, which was not an uncommon complication and, depending on its intensity, can also potentially jeopardize a patient's work and social activities [13].

Lichtenstein and Trabucco's techniques are often the first choice by residents and nonexperts because anterior anatomy is more familiar, whereas preperitoneal approach has no widespread success because of their hard performance and feasibleness under local anaesthesia [4].

In the last year, the advent of the laparoscopic technique and success of laparoscopic cholecystectomy let the surgeons focus their attention on other applications of laparoendoscopy. Teorically, advantages of laparoscopic techniques compared to open ones are, early rehabilitation, reduction of acute postoperative pain and better intraoperative vision [14]. Moreover laparoscopic repair allows also to inspect both inguinal regions to repair concurrent contralateral hernias.

Finally, it's indicated for the repair of bilateral and recurrent inguinal hernia, permitting the approach of the groin region by a non-scarred plane. On the other hand laparoscopy requires a general anaesthesia, higher costs and a long learning curve for surgeons and at the end regarding primary inguinal hernia repair, that could be done easily in local anaesthesia and through a mini-invasive open approach can be considered as overtreatment. Currently, the most widely used laparoscopic techniques for inguinal hernia repair are the transabdominal preperitoneal (TAPP) repair, the intraperitoneal onlay mesh (IPOM) repair, and the totally extraperitoneal (TEP) repair [11].

Since laparoscopic technique is introduced, more attention has been focused on the preperitoneal space for mesh placement also during open anterior approach.

Implantation of mesh behind the transversalis fascia via open approach can be achieved through a transinguinal method such as the Rives operation introduced in 1965, a lower midline abdominal incision (Stoppa repair 1967), and a slit made in the broad abdominal muscle (Wantz repair1988). These approaches are limited to repair recurrent inguinal hernia in the hands of a limited number of hernia experts.

Gilbert tried to take advantages from the placement in the preperitoneal space and combined them with a simple anterior approach.

Gilbert created the "Prolene Hernia System," he used bilayer connected device that incorporates two flat polypropylene mesh patches. The two patches were attached by a polypropylene connector which itself sits in the direct hernia defect of the posterior wall or the deep internal ring of an indirect hernia. With the preperitoneal space sufficiently actualized by sponge and/or finger dissection, the entire PHS device was inserted into the preperitoneal space [15].

Modern advantages in hernia repair are credited with reduced recurrence rate and chronic pain after hernia surgery. A systematic

review reports that 11% of patients suffer chronic pain, but estimates in literature range from 0 to 53% [15].

Chronic pain is defined as pain arising 3 months after hernioplasty; it is a significant complication that can compromise the patient's quality of life. The risk of chronic pain after laparoscopic hernia repair is lower than after open hernia repair and is lower after mesh repair than suture repair [15].

Today there is no consensus opinion about the cause and treatment of chronic postoperative pain. What is clearly important is the prevention: performing local anesthesia, identifying three nerves of the region, leaving nerves in the position if possible, limiting sutures and fixation devices, and, in case of nerve injury, doing selective neurectomy [16].

Choosing the proper biomaterial can determine the success of an operation. The most frequently used prosthetic materials for hernia surgery can be grouped into absorbable and nonabsorbable materials. Absorbable materials can be divided into synthetic and biological materials. All absorbable biomaterials are totally replaced by the host tissue. Nonabsorbable materials can be grouped in base on pore size.

Today the gold standard for primary inguinal hernia repair is an open tension-free technique performed in local anesthesia in day surgery unit or laparoscopic TAPP approach.

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2 Teaching Hernia Surgery: The Experience of the Italian School

Paolo Negro, Linda D'Amore, Elena Annesi, Francesca Ceci, and Francesco Gossetti

2.1 Introduction

Inguinal and ventral/incisional hernia repair is one of the most common operation in surgical practice [1]. Each year 20 million groin hernia repairs are performed worldwide, 800,000 cases of which are only in the USA. Mention must also be made of the frequency of ventral/incisional hernia surgery, 400,000 repairs yearly in the USA, with a projected annual growth rate [2]. The numbers are mostly similar in all countries, in relation to the population size.

Basically herniorrhaphies and the majority of abdominal wall repairs are performed as a part of a broad-based general practice, often delegated to general surgery residents, since they are considered as easy to learn and to perform at the technical level. However, in last decades hernia surgery has become more complex, due to the spread of new surgical approaches, as laparoscopic repair, innovative open techniques, as component separations, and continuous increasing number of available prosthetics or medical devices. Moreover today success rate does not only depend on recurrence indicator but also on other equally important concerns, such as patient satisfaction, quality of life, and costs. Furthermore patient population also has become more complex, due to the increasing age, comorbidity, and challenging mesh-related complications, including recurrence following prosthetic repair. The guidelines of the European Hernia Society recommend that a hernia specialist perform complex inguinal hernia [3]. At the same way, complex incisional hernia repair requires specialization, due to high failure rate, which increases exponentially with subsequent repairs [4]. Cases like these should be treated with a tailored approach by surgeons keeping up to date with the latest developments in hernia surgery. Only specialized surgeons or those who have developed a special interest in hernia surgery can properly be faced with this new hernia surgery era. That's why there is a need for comprehensive hernia centers, in which surgeons with high volume experience work together with a multidisciplinary team [5, 6]. It is paramount to create specialized or expert hernia surgeons. Current methods to train general surgeons could be not sufficient [1], and further evaluation of hernia education should be considered [7]. Based on these considerations, in 2008 the Italian School of Hernia and Abdominal Wall Surgery was created, first in Europe, as an educational branch of the Italian Society of Hernia and Abdominal Wall Surgery (ISHAWS), and in 2009 it was officially presented to the international community [8]. The purpose of the school was to create a new generation of expert surgeons through a comprehensive hernia education program focused on the funda-

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mentals of hernia disease and its clinical and surgical tailored management.

Actually hernia surgery teaching was already proposed in Italy some years before. In 1992, inspired by the question discussed in those years "*…must we specialize herniorrhaphy for better results?"* [9], some of us (PN, FG) established an annual academic postgraduate course on groin and ventral hernias of abdominal wall under the patronage of the Ministry of Public Education [10]. Five editions were delivered, up to the end of 1997 when the course was suspended. During the same period, a similar postgraduate course was held in Milan, promoted by P. Pietri and G. P. Campanelli. A training program was also proposed by Palumbo in 2001 [11]. Since then, the interest in this topic has grown in Europe. The fourth Joint Hernia Meeting of the American Hernia Society (AHS) and European Hernia Society (EHS) dedicated a special session to specialization and hernia teaching surgery focusing on the usefulness and the principles of hernia surgery training [12]. The German Hernia Society (DHG) in collaboration with the Federal Association of German Surgeons (BDC) developed the project of a German Hernia School, starting its first basic training course in 2011. Recently, the experience gained to date by DHG has been evaluated and discussed [5].

2.2 Italian School of Hernia and Abdominal Wall Surgery

The Italian School of Hernia and Abdominal Wall Surgery was developed to meet the need of education and training in modern surgical approaches and to improve results in hernia surgery. The Italian Society of Hernia and Abdominal Wall Surgery strongly supported this innovative idea also through the creation of the Alliance for Hernia, a corporate alliance of industries involved in hernia surgery, which contributes to the costs of the training courses. This cooperation offers product specialists the opportunity to participate in the basic sessions of the school. The school is governed by the Educational Board and the Director. Both these administrative bodies are designated by the ISHAWS Board, every 3 years.

The first course of the Italian School of Hernia and Abdominal Wall Surgery was held in 2010 in Rome, which later became the stable seat of the school. From the beginning it was addressed to residents in surgery and surgeons interested to develop a special knowledge in hernia surgery. The comprehensive program, which was first worked out in 2009, is structured in interrelated segments: (a) a basic training course, of 30 h, in 3 days, ending with a final exam consisting in a standardized multiple-choice test to set up participants' improved knowledge; (b) clinical stages for a minimum of 15 h of hands-on training in accredited regional centers under the supervision of expert surgeons and high volume of activity in hernia repair; and (c) documented active research in hernia surgery and participation to national and international scientific meetings. At the end of this track, participants are awarded an ISHAWS certificate of Expert in Hernia Surgery.

The 3-day basic course was initially limited to 35 participants. In the following years, this number was progressively increased to meet the increasing demand involving not only surgery residents but also surgeons interested in renewing and updating their curriculum in hernia surgery. The eighth course involved 80 participants (32 surgeons, 48 surgery residents) and 18 product specialists. Every year, at the end of the classes, all participants are asked to give a detailed feedback to evaluate all aspects of their experience, as organization, appraisal of lectures, faculty, and relevance of discussed topics (Table 2.1). The program is then yearly updated on the basis of the answers to this feedback form, adding or reducing some learning elements, inviting different experts, and inserting a live-surgery session. The faculty is composed of at least 30 surgeons and scientists with remarkable curricula.

The basic course begins the evening before its opening with "guest lectures" on biomaterials and the tissue reparation/regeneration after prosthetic repair, the state of the art, and the history of hernia surgery. On the first day, the anatomy of the inguinal canal and the abdominal wall is explained both theoretically and through film clips registered and commented with special emphasis on anatomic classification. The course program goes

Table 2.1 Feedback form

1. How do you evaluate this basic training course?
(a) *Very well*
(b) *Well*
(c) *Sufficient*
(d) *Insufficient*
2. Do you consider appropriate the duration of this course?
(a) *Yes*
(b) *No*
3. Do you consider the topics to be considerable for your updating in the hernia surgery?
(a) *Very cosiderable*
(b) *Considerable*
(c) *Not considerable*
4. Are you satisfied with the whole organization?
(a) *Very satisfied*
(b) *Satisfied*
(c) *Sufficiently satisfied*
(d) *Not satisfied*

Table 2.2 Key points of the basic course

– Historical aspects of hernia surgery and its state of the art
– Prosthetic materials in hernia surgery and the biology of repair process
– Anatomy of the groin abdominal wall
– EHS classification of groin and abdominal wall hernias
– Open and laparoscopic surgery in groin hernias
– Postoperative complications and chronic pain
– Biological implants
– Open and laparoscopic surgery and component separations in ventral hernia repair
– Pre- and postoperative management in complex abdominal wall hernias
– Umbilical hernias
– Parastomal hernia repair
– Abdominal compartment syndrome (ACS) and open abdomen
– Plastic surgeon's keynotes

on with the description and analysis of the different meshes, both synthetic and biologic, available on the market, carefully evaluating pros and cons of each material. Then standardized surgical procedures for groin, umbilical, and ventral hernia repairs are described step-by-step. The most performed open and endoscopic techniques are shown with the help of a large number of film clips, particularly focusing on the need of standardization and reproducibility of procedures, in order to minimize complications and recurrences. These subjects will be discussed in the following topics together with medicolegal issues.

The second day is entirely dedicated to a live-surgery session with expert surgeons demonstrating some of the previously described open and laparoscopic techniques, directly from the operative room, using a Visera 4 K UHD system that allows a ultrahigh definition and visualization of the procedures. During each operation, different technical options and devices are shown with a special emphasis on the reasons leading to the final selection. A continuous interactive communication between audience and operating surgeons is strongly stimulated.

The third day is dedicated to particular aspects of hernia surgery, as pre- and postoperative management, hernia in sportsmen, parastomal hernias, open abdomen and complex abdominal wall repairs, panniculectomy, and plastic and reconstructive techniques (Table 2.2).

During the course, industries involved in the Alliance for Hernia are invited to give short presentations regarding new techniques or incoming materials and devices. Industries' sponsorship does not influence any teaching or planned subjects neither the choice of devices to be implanted in the live-surgery session. Teachers and participants are encouraged to have meals together to promote their relationships and offer a further chance of discussion.

Since the beginning of this experience (2010–2017), a total of 396 surgeons and surgery residents have attended the basic course (Table 2.3). Results were monitored through participants' response to the feedback form, and some contents were accordingly updated. Each edition of the course recorded a high level of customers' and teachers' satisfaction increased over the years (Tables 2.4, 2.5, 2.6 and 2.7).

A critical analysis of this experience reveals that the Italian School should definitively be improved with the implementation of practical activities. A weak point seems to be the lack of hands-on exercise with anatomy specimens, to improve knowledge in anatomy of the groin. This is the reason why a cadaver lab has been recently organized to integrate the basic course, in spite of

Table 2.3 (**a**) Courses participants 2010–2017. (**b**) Courses participants 2010–2017

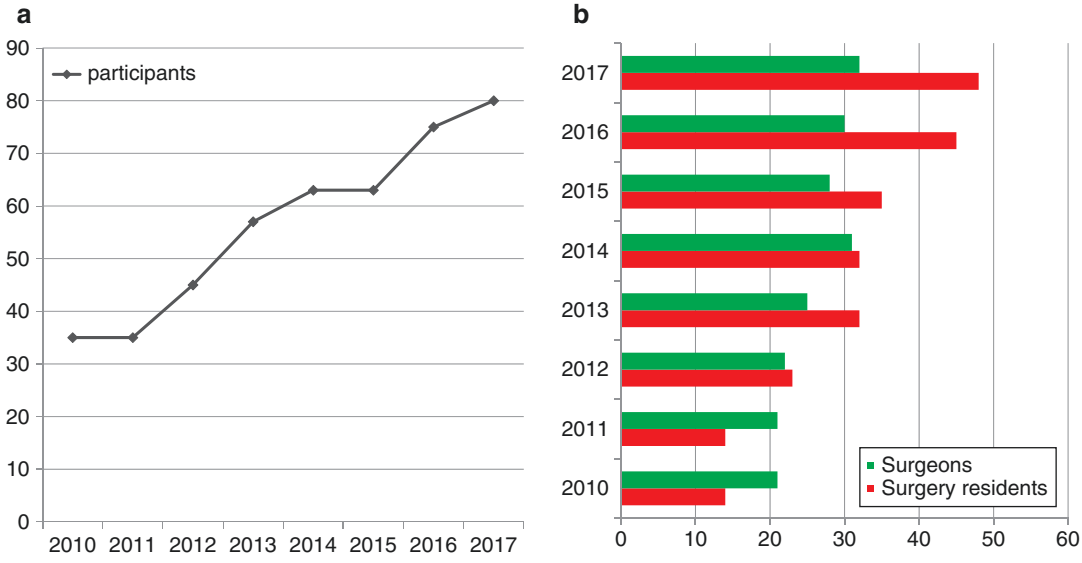


Table 2.4 How do you evaluate this basic training course?

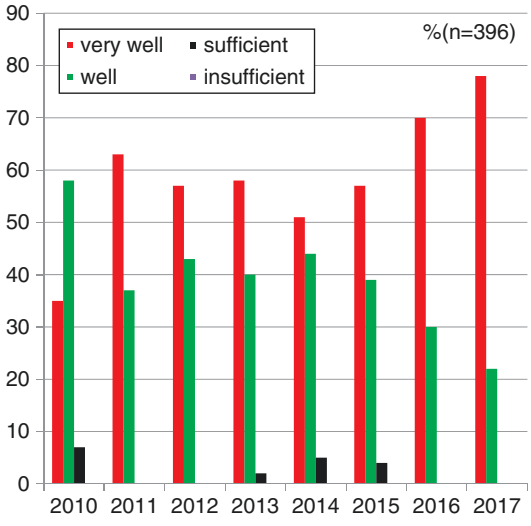
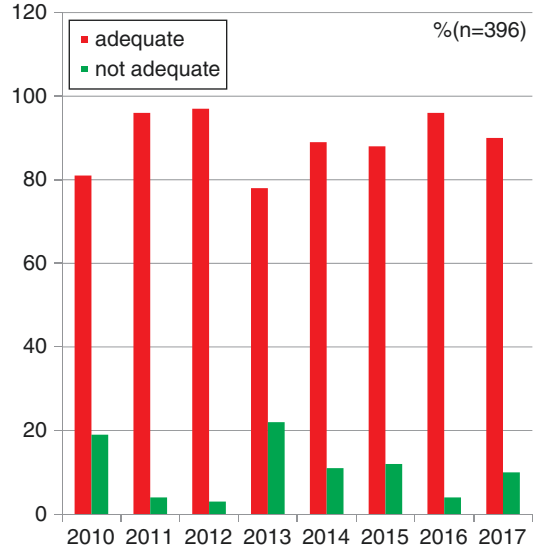


Table 2.5 Do you consider appropriate the duration of this course?



the high costs of cadavers and, therefore, the respective fees.

Only few participants have undergone clinical stages in accredited hernia centers, probably due to economic problems and working distance. A more active participation of trainee surgeons in the operating table should improve their skills with appropriate learning curve under the supervision of experienced surgeons. This is particularly true when performing laparoscopic repair, whose learning curve is undoubtedly longer than open procedures. Besides costs, difficulties lay in the selection of the training centers. In a recent paper [5], the need was stressed to identify hospital units and referral centers accredited in abdominal wall reconstruction in Italy, with suitable

Table 2.6 Do you consider the topics to be considerable for your updating in the hernia surgery?

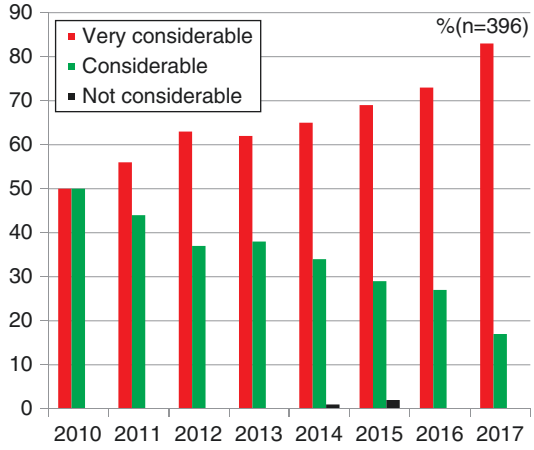
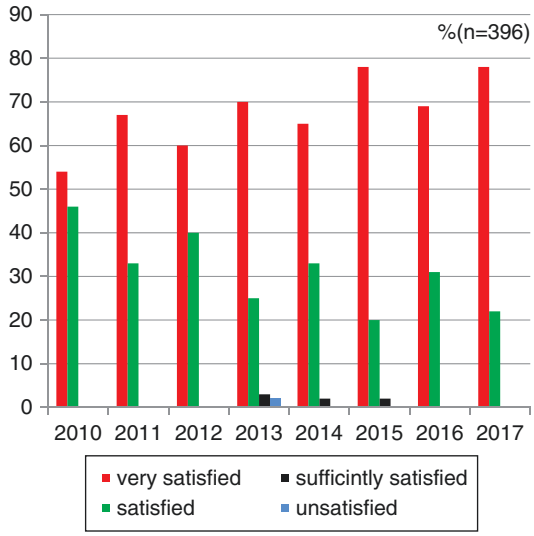


Table 2.7 Are you satisfied with the whole organization?



structural and organizational features and quantitative and qualitative standards, useful also in the educational training of hernia surgeons. In order to be more competitive, these centers should have more than one seat in different areas of the country and provide adequate human, structural, and technological resources, with a sufficient yearly number of procedures, the skill of training surgeons to perform all laparoscopic and open techniques for hernia repair with a low rate of complications and adequate follow-up, and a theoretical and updated knowledge in hernia field.

At the moment, the Italian School seems to have contributed to the continuous learning and education of Italian surgeons, with the regular review of basic hernia care, and the knowledge of new techniques, updating also materials and devices, to ensure that hernia patients receive "tailored" care, leading to excellent outcomes. It has been highlighted the need that expert surgeons with particular skill in hernia surgery actively train and educate a new generation of surgeons.

A systematic, standardized, and widespread educational program of continuing training is strongly advisable with the creation and the development of local training courses in each European country. The excellent experience of the German-Austrian Hernia School [13] together with the know-how of the Italian School should perform as a model to promote the awareness of standardized groundwork, updating surgeons' knowledge and skills in hernia surgery, according to the suggestion of the EHS.

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3 Alterations of the Extracellular Matrix of the Connective Tissue in Inguinal Herniogenesis

Gemma Pascual and Juan M. Bellón

3.1 Introduction

Inguinal hernia is still one of the most frequently performed procedures by general surgeons. Their socio-health and labor costs are important. In the USA, this pathology has a cost of approximately three billion dollars a year [1]. Its etiology and pathogenesis are complex, with multiple factors contributing to its development, including individual predisposition and some congenital alterations such as peritoneal-vaginal duct persistence. Positive familial susceptibility to inguinal hernia development has been demonstrated, suggesting the role of genetic contribution in the etiology of the disease, but site-specific familial factors might exist [2]. Studies of families with inguinal hernia propose a genetic trait for both primary and recurrent inguinal hernias [3]. Mutations in different collagen genes have been recently suggested to be associated with the development of inguinal hernia [4], and four novel inguinal hernia susceptibility loci have been identified, showing an important role for two of these genes (EFEMP1 and WT1) in connective tissue maintenance and homoeostasis [5].

From a general point of view, the integrity of the abdominal wall at the level of the inguinal region depends on the oblique orientation of the inguinal canal, a sphincter-like structure that forms part of the deep inguinal ring and the transverse fascia (TF) [6]. The latter structure, which constitutes the posterior wall of the inguinal canal, is the one that finally prevents hernia formation and, in a special way, direct hernias. Some authors [7], after performing mechanical studies, attribute to the integrity of TF, a containment mechanism that would prevent the formation of both direct and indirect type hernias.

The development of hernias at the abdominal wall level and its recurrence has been shown to occur more frequently in patients with connective tissue disorders, not to mention some other important factors such as smoking [8]. It has been suggested that defective connective tissue metabolism is involved in the pathogenesis of both the indirect and the direct types of inguinal hernia. In diseases with connective tissue alterations, the incidence of inguinal hernia is higher, such as patients with aortic aneurysm, Marfan and Ehlers-Danlos syndromes, cutis laxa, osteogenesis imperfecta, and congenital dislocation of the hip [9, 10].

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An important database study [11] including a large number of patients operated on inguinal hernia has been published some years ago showing that patients with direct or recurrent inguinal hernias are at a higher risk of developing ventral hernia repair compared to patients with indirect inguinal hernia. This fact was supported by previous studies demonstrating that the more important connective tissue alterations are found in these patients suffering direct or recurrent inguinal hernia, suggesting future research that reveals the specific alterations of the connective tissue.

This review paper aims to collect the experience and previous results of our group in the study of the constituents of the abdominal wall extracellular matrix of connective tissue, in the development of inguinal herniogenesis.

3.2 Role of the Extracellular Matrix in Hernia Pathology

The extracellular matrix is a complex integrated system developing a structural network that supports and surrounds cell populations within the connective tissue. It includes a set of tissue fibers such as collagen and elastic fibers that are present in variable amounts depending on the structural needs or function of the connective tissue. In addition this matrix contains a variety of proteoglycans, multiadhesive glycoproteins, and glycosaminoglycans that constitute the ground substance.

The mechanisms of the development of the inguinal hernia involve changes in the expression of different components of the extracellular matrix detectable at the TF level, such as collagen turnover (collagen I/III ratio) and metalloproteinases (MMPs). In the same way, the elastic component that forms part of the extracellular fibrillar matrix may contribute to the development of this pathology.

The biological factors, proposed by the Read group, involved in the development of hernia have gained acceptance in recent years, conferring a particularly relevant role to metabolic factors in the development of inguinal hernia [12–14]. Other groups such as Jansen et al. [15] have located inguinal hernias in the context of a condition generated by an abnormal composition of the extracellular matrix.

Patients with inguinal hernia show some alterations in collagen metabolism and significantly altered collagen types I/III ratios [16, 17], but few data are known about the elastic component of the extracellular matrix and factors involved in tissue remodeling that may affect the metabolism of elastin.

The extracellular matrix is a very complex integrated system, responsible for the mechanical properties of the connective tissue. The different constituents of the matrix interact with each other, and any alteration of one of them may lead to a disorganization of the extracellular matrix and the development of different pathologies such as inguinal hernia (Fig. 3.1).

Among the most studied different constituents of the extracellular matrix in relation to hernia pathology, collagen and MMPs are found. However, it has been demonstrated by our group that other soluble mediators, such as certain growth factors or enzymes related to the cross-linking of the matrix fibrillar proteins, may be altered in patients suffering from hernias [18, 19].

Following, we will review the most studied extracellular matrix constituents in relation to the pathology of inguinal hernia, with special emphasis on the findings obtained by our research group.

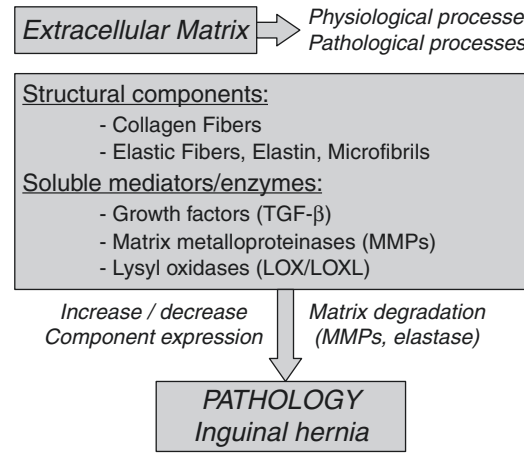

Fig. 3.1 Scheme of the different constituents of the extracellular matrix as a complex integrated system and its disorganization in the development of different pathologies such as inguinal hernia

3.2.1 Collagen Fibers

Collagen is the main and most abundant fibrillar protein in the extracellular matrix. This protein is mainly synthesized by connective tissue fibroblasts. In the process of collagen formation, important hydroxylation reactions occur at the intracellular level to form hydroxylysine and hydroxyproline, which are essential in the synthesis process and confer stability to the collagen molecule. This molecule is formed by three polypeptide α chains assembled at the intracellular level in the form of a triple helix. It is secreted into the extracellular matrix in the form of procollagen, which after a process of cleavage of its terminal uncoiled ends by procollagen peptidases, will become tropocollagen, assembling in the form of collagen fibril in the extracellular space [20]. This cross-linking is mediated by enzymes of the family of lysyl oxidases that promote the formation of highly resistant covalent bonds between lysine and hydroxylysine residues and provides strength and stability to collagen fibril, which are highly organized polymers that further associated with each other to form larger collagen fibers. Some groups [21] have shown a decrease in proline hydroxylation in TF accompanied by a significant decrease in the content of proline and hydroxyproline in the rectus sheath [22] of patients with direct inguinal hernia, indicating a compromised collagen stability at the level of the fascia.

The α chains that constitute the helix are not all the same; to date at least 42 types of α chains encoded by different genes have been identified. There are more than 28 genetically different types of collagens that have been categorized on the basis of the combination of α chains [23]. Type I collagen is the most resistant, widely distributed in the human body, including the fascia, the integumentary system, the ligaments, and the fibrous tissue. Type III collagen is found in small amounts in the same tissues and in greater proportion in the initial stages of tissue repair and wound healing [8, 23]. Type I confers mainly tensile strength, while type III is related to a temporal matrix during the tissue remodeling process. Therefore, a change in the ratio of collagen in favor of the type III would results in a loss of resistance of the structures involved.

Several studies reported an imbalance between type I collagen and type III collagen [16, 17]. When the collagen content in tissue samples is analyzed, the result is frequently quantified by the ratio of collagen type I:III. This collagen ratio has been found that was significantly decreased in the TF of patients with indirect inguinal hernia compared to controls [24]. In contrast, other studies have shown an increase in type III collagen but do not report statistically significant differences in the collagen I: III ratio in TF between patients with inguinal hernia and controls [21, 25]. Other authors [7] have shown that TF of patients with direct hernia shows higher levels of immature type III collagen and that the total amount of collagen is lower in direct hernia than in indirect hernia [26]. Ultrastructural studies using transmission electron microscopy have focused on the study of the collagen and interfibrillar matrix of the connective tissue of patients with this pathology, showing the absence of alterations in the diameter of the collagen fibers in the TF of patients with inguinal hernia [27].

Our group [21], examining the TF ultrastructure of patients with direct and indirect hernia, observed that there were no differences in the uniformity of collagen fibrils nor in their characteristic banding pattern; however, the interfibrillar matrix was more abundant in direct hernias, showing a large amount of small particles with high electrodensity (Fig. 3.2). In this same work, and by using biochemical studies, the degree of hydroxylation of the lysine and proline, essential in the process of synthesis and stability to the molecule of collagen, was analyzed. No differences were observed in proline hydroxylation in different types of hernia, and only a small decrease in lysine hydroxylation was detected in patients with direct hernia of more than 40 years (Fig. 3.3). The ratio of collagen type I:III studied by immunoenzymatic analysis did not show statistically significant differences between controls and patients with hernia pathology (Fig. 3.4).

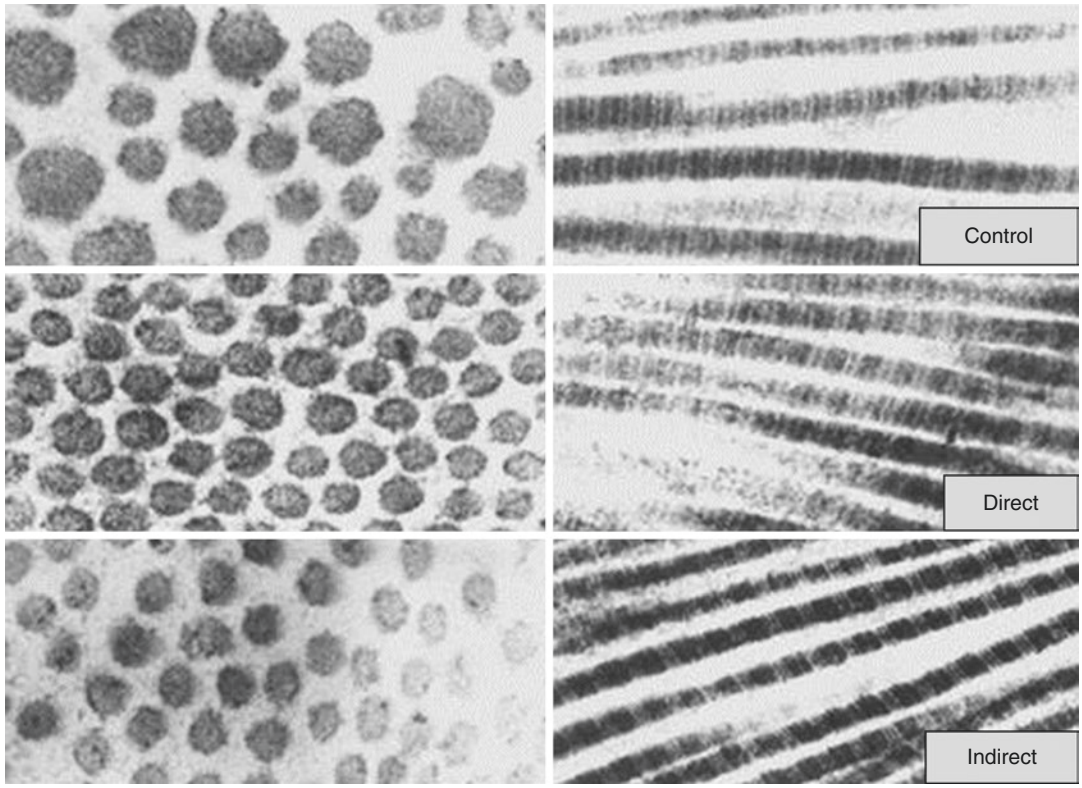

Fig. 3.2 Transmission electron microscopy images of the connective tissue of the transversalis fascia showing absence of ultrastructural alterations of the collagen fibers in the different study groups. Lead citrate and uranyl acetate staining (Magnification 85,000×)

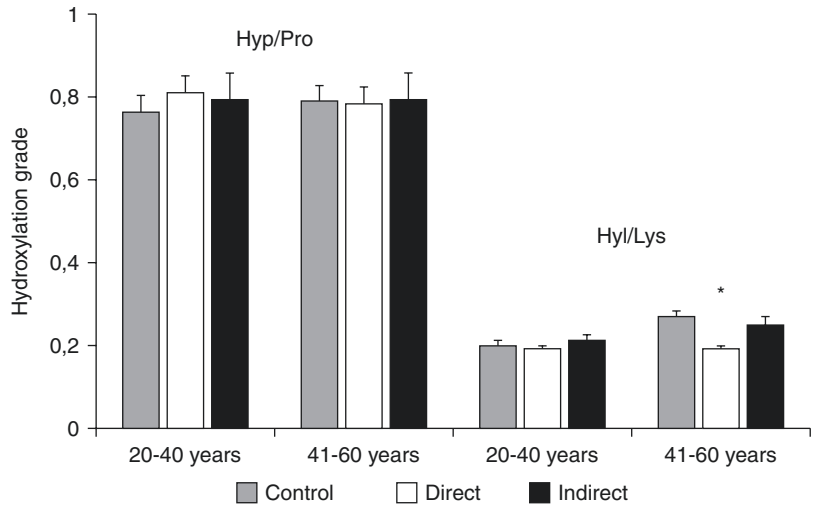

Fig. 3.3 Hydroxylation of proline and lysine in the transversalis fascia of the control groups and direct and indirect inguinal hernias, depending on the age factor of the population. A significant decrease in lysine hydroxylation was observed in the direct hernias of the older group compared to the rest of the study groups ($^{*}p < 0.05$) (Hyp/Pro, Hydroxyproline/Proline ratio; Hyl/Lys, hydroxylysine/lysine ratio)

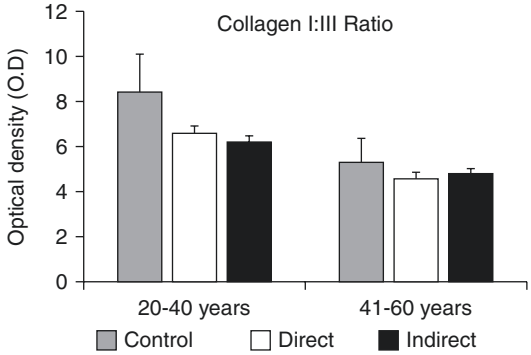

Fig. 3.4 Collagen I:III ratio observed in the different study groups, taking into account the age factor of the population. No significant differences were observed between the different groups of patients (*OD* optical density)

3.2.2 Matrix Metalloproteinases (MMPs)

Matrix metalloproteinases (MMPs) are a family of zinc dependent important proteins involved in extracellular matrix remodeling, which is subjected to a constant dynamic balance between its synthesis and degradation by the action of these enzymes. The MMPs are known to regulate the synthesis and degradation of collagen, but also of many other components of the extracellular matrix, such as proteoglycans, elastin, fibronectin, etc. There are about 23 different types of human MMPs that are grouped into collagenases, gelatinases, stromelysins, matrilysins, membrane MMPs, and other MMPs [28]. The classical MMPs include collagenases like MMP-1, MMP-8, and MMP-13, involved in the degradation of type I, II, and III collagens, and the MMP-2 and MMP-9 gelatinases involved in the degradation of denatured type IV collagens and proteoglycans. However, MMP-2 is also capable of degrading native type I, II, and III collagens [29, 30]. Collagenases and gelatinases are probably the most important MMPs in relation to hernia formation.

In general MMPs are expressed at very low level; however, their expression may be induced as a consequence of different pathological mechanisms. Pro-inflammatory cytokines, growth factors, and hormones are important regulators of MMPs expression. The proteolytic activity of these enzymes, latently secreted, is mainly controlled by the activation of tissue inhibitors of MMPs known as TIMPs [29, 31]. It has been shown that doxycycline administration, as MMPs inhibitor, results in significantly improved strength of repair fascial interface tissue along with a remarkable increase in collagen I, II, and III ratios [32, 33].

Experimental studies performed by different groups have shown that there are no significant differences in the levels of the MMP-1, MMP-9, and MMP-13 enzymes in the TF of patients with direct or indirect hernia compared to controls [34, 35]. Unlike other studies that found significantly higher values of MMP-1, MMP-2, and MMP-9, in inguinal hernia cases [36]. Other authors have found significantly elevated levels of MMP-2 in patients with direct inguinal hernia compared to indirect hernia or control, accompanied by a significant decrease in their inhibitor TIMP-2 [37, 38].

The degradation of the extracellular matrix by the effect of MMPs on the TF has also been the objective of our investigations. Four different types of MMPs (MMP-1, MMP-2, MMP-3, and MMP-9) were analyzed by our group in tissue sections, using immunohistochemical techniques with specific monoclonal antibodies. However, we found only significant differences in the protein expression of MMP-2 [21], where a significant overexpression of the enzyme was observed in the direct hernias of the young patients group with respect to the rest of the groups (Fig. 3.5).

After this study we carried out a second in vitro phase [39], using fibroblasts, in order to check whether the overexpression of MMP-2 observed in tissue was maintained in the cultured cells obtained from TF. The results obtained with immunocytochemical, immunoblotting, and zymography techniques corroborated that MMP-2 would be involved in the degradation process of the TF matrix in patients with direct hernia. The persistence of alterations in MMP-2

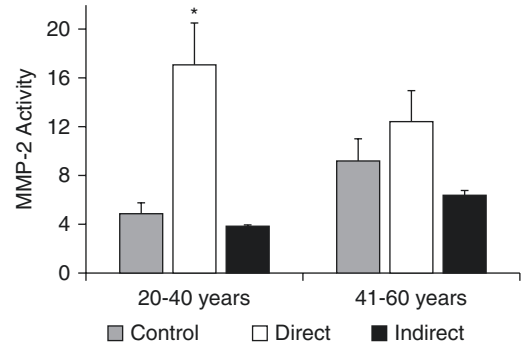

Fig. 3.5 Immunohistochemical staining images for the detection of MMP-2 in tissue sections of transversalis fascia. An increase in expression may be observed in the group of direct inguinal hernia (Magnification 200×). Quantification of MMP-2 activity in the different study groups, depending on the age of the population. A significant ($^{*}p < 0.05$) increase in expression was observed in direct hernias in the group of patients younger than 40 years

levels in cell cultures seems to suggest a genetic defect or irreversible change as the origin of this pathology rather than environmental factors that may later be involved in the development of the disease (Fig. 3.6). These works were the first in the literature to implicate MMP-2 in the pathogenesis of a type of hernia, namely, direct hernia in patients under 40 years of age, where this hernia is often bilateral.

Our research group has even more previous experience [40] related to MMP-2 and its modulators, using human skin biopsies obtained from patients suffering inguinal hernia repair. In this study immunocytochemical and immunoblotting techniques were used in intact tissue and fibroblast cell cultures, as well as zymography techniques to analyze the degradative activity of MMP-2. These results indicate an overexpression of the active form of MMP-2 in the group of direct hernias that could point to an abnormal systemic metabolism as a risk factor for the development of this type of hernia.

3.2.3 Growth Factors

Cytokines or growth factors like TGF-β (transforming growth factor beta) are involved in remodeling processes of different types of tissues. TGF-β is a multifunctional secretion protein that regulates many aspects of cellular function, including cell proliferation, differentiation, and metabolism of the extracellular matrix, [41] through its binding to specific cellular receptors. Five different isoforms have been described, and three of them are found in all species of mammals. TGF-β1 is most widespread and is a 25,000 Kd molecular weight homodimeric protein composed of two identical 12.5 Kd proteins linked by a disulfide bridge [42, 43]. A wide vari-

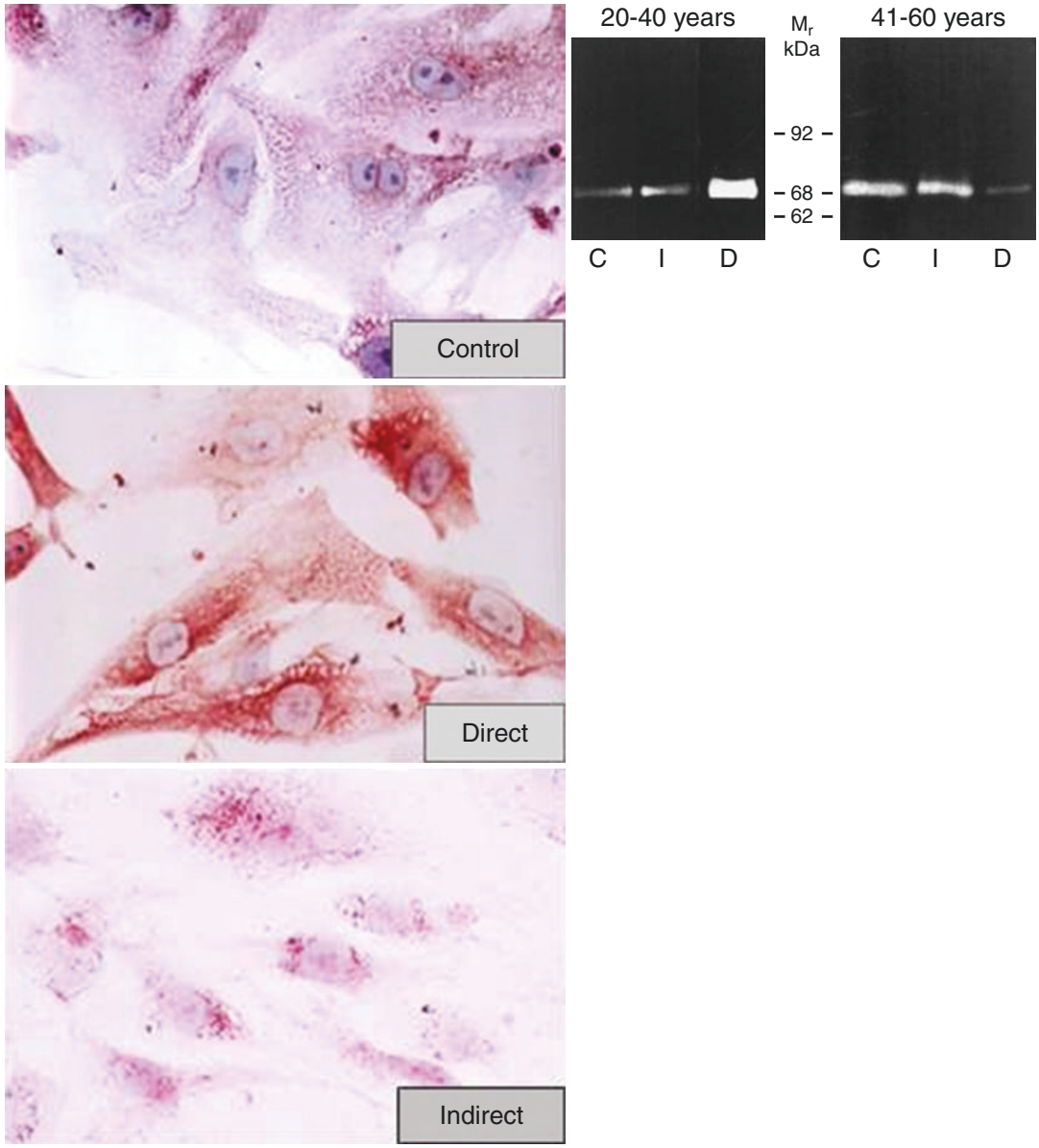

Fig. 3.6 Images of fibroblasts obtained from the transversalis fascia of the different groups of patients, submitted to immunocytochemical techniques for the detection of MMP-2. Higher levels of the enzyme were observed in the group of direct hernias (Magnification 1000×). Gelatinolytic activity determined by zymography techniques in the different study groups, showing an increased degradative band in the group of direct hernias of the younger age group (*C* control, *I* indirect hernias, *D* direct hernias, *Mr* molecular weight)

ety of potential clinical applications have been suggested for this growth factor, including increased scar tissue, control of chronic inflammation associated with fibrosis, and suppression of autoimmune diseases. TGF-β is a pleiotropic factor that can stimulate, inhibit, or modulate cellular events in a time- and concentration-dependent manner. It is a crucial peptide in the control of healing, attracting cells to the wound, but especially promoting the subsequent deposition of collagen and matrix [42]. It has also been identified as a potent modulator of MMPs

expression. Some authors have stated that this growth factor regulates the expression of MMP-2 in several cell types such as fibroblasts and endothelial cells [44, 45].

Our group has carried out different studies in order to evaluate the expression of different growth factors in tissue affected by inguinal hernia [18] and on the integration tissue after the implantation of different types of prosthetic materials in hernia repair [46]. Accordingly, a protein analysis of the distribution and levels of the active and latent form of TGF-β1 was performed, using immunohistochemical and western blot techniques. No significant differences were found in the expression of the latent form of TGF-β1 (LAP-TGF-β1); however, the results of our study indicated an overexpression of the TGF-β1 active form in TF of young patients with direct inguinal hernia (Fig. 3.7). This overexpression of TGF-β1 correlated with the previously described overexpression of MMP-2, in the same group of patients, which could be interpreted as an attempt to counteract the process of degradation of the extracellular matrix observed in this type of hernia.

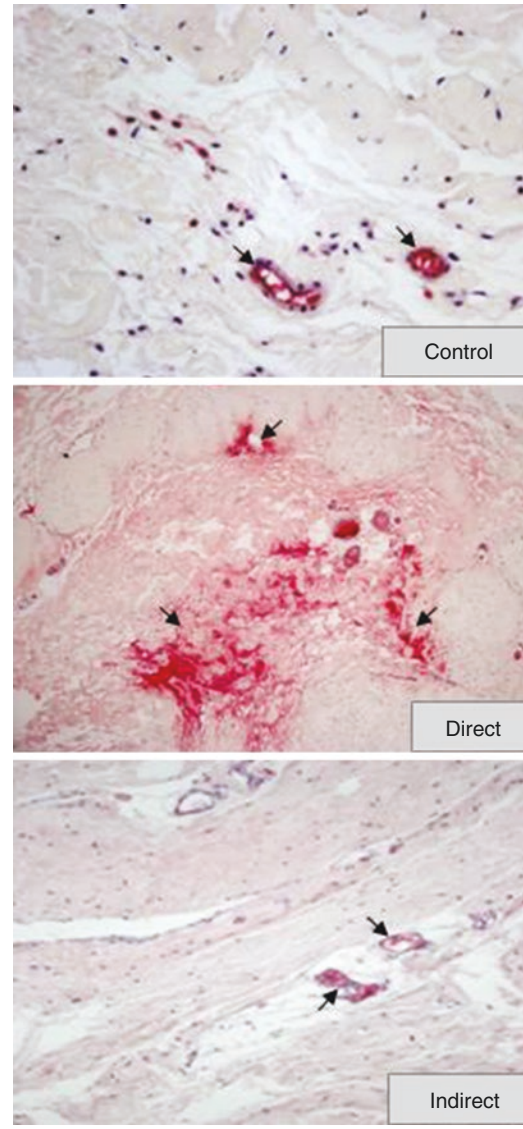

Fig. 3.7 Histological images of the immunohistochemical technique performed on tissue sections of transversalis fascia of healthy patients and patients with direct and indirect inguinal hernias to detect active MMP-2. Overexpression of active enzyme levels on the tissue corresponding to patients with direct hernia can be observed (Magnification 200×)

3.2.4 Elastic Fibers

Elastic Fibers are large fibrillar extracellular matrix structures that provide recovery to tissues undergoing repeated stretching. Elastic fibers are formed by two main components, elastin and microfibrils, that are assembled in a spatial and temporal certain way [47]. Elastin is encoded by a single gene and is the main constituent of the mature fiber. This polymer with a molecular weight of 72 kDa with great capacity of expansion is formed through the cross-linking of tropoelastin (TE) monomers on a support of microfibrils which consist mainly of fibrillin [48] but also associated with proteins such as fibulins, microfibril-associated glycoproteins (MAGPs), and EMILIN-1 [47]. In this crosslinking process, the enzyme lysyl oxidase (LOX) plays a key role. LOX is a family of copper-dependent enzymes that play a critical role in the cross-linking of different extracellular matrix proteins. Some authors [49] have proposed a selective role for LOXL-1 (lysyl oxidase like-1) in the metabolism of elastin, by which elastin deposition is stabilized in a spatially defined manner, as a prerequisite for the formation of functional elastic fibers [50]. One of the most important degradative enzymes of the

elastic system is elastase, which is capable of degrading elastin and elastic fibers, which together with collagen determines the mechanical properties of the connective tissue.

Structural alterations in elastic fibers, related to age, including a considerable reduction in the number of microfibrils leading to a loss of tensile strength and elasticity of transverse fascia tissue have been previously described [51]. This fact could explain the high incidence of inguinal hernia observed from the 50 to 60 years of age.

As we have already mentioned, patients with inguinal hernia show some abnormalities in collagen metabolism and alterations of the MMPs system [16, 17], but there is not much knowledge about the elastic component of the extracellular matrix and the factors involved in tissue remodeling that could affect the elastin metabolism.

Therefore, some studies that aimed to examine in the TF affected by inguinal hernia, the expression of the elastin precursors, tropoelastin (TE), LOXL-1, the enzyme responsible for the cross-linking of elastin polymer and elastase, the main enzyme that causes the degradation of elastin, were performed. Protein analysis techniques such as immunohistochemistry and western blot were used, as well as molecular biology techniques for gene expression analysis. A deficiency in the metabolism of elastin was demonstrated in patients with inguinal hernia that could contribute to the failure of TF [19]. This deficiency was reflected by the insufficient production of LOXL-1 (Fig. 3.8), which plays a selective role in elastin cross-linking, as well as by the overproduction of elastase, one of the most important enzymes involved in the degradation of the elastic component. The findings indicated similar

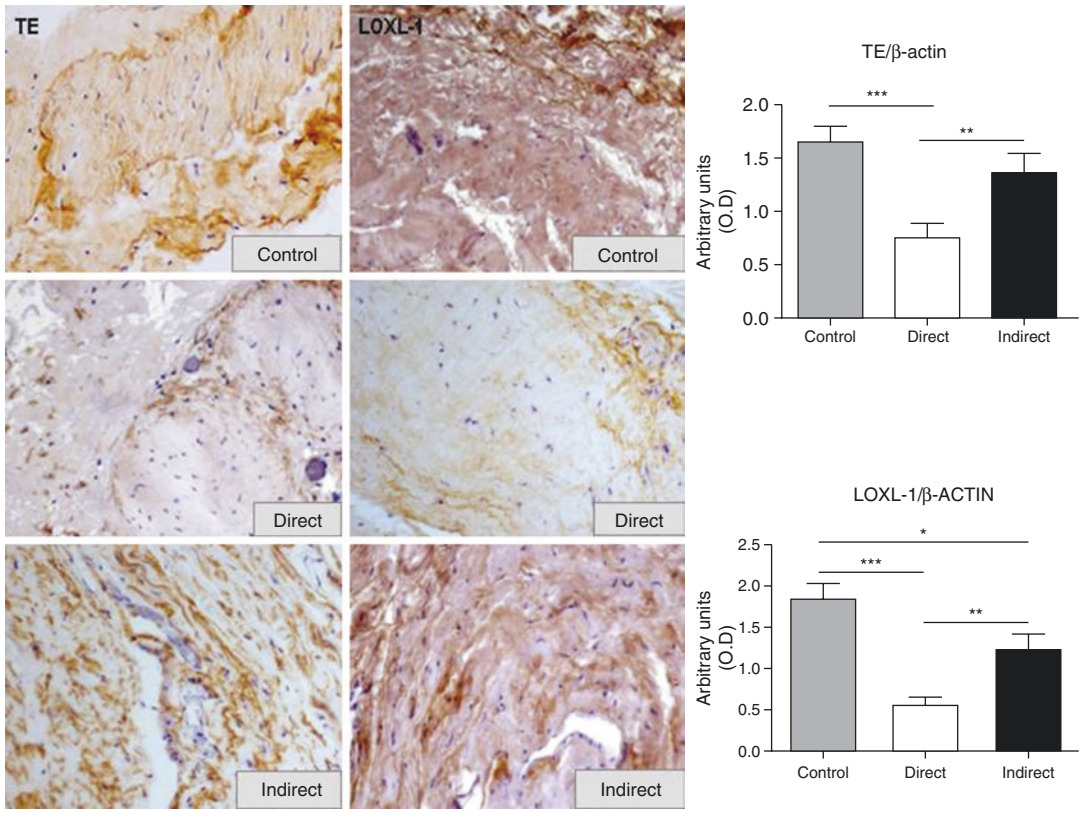

Fig. 3.8 Immunohistochemical detection and levels recorded in the different study groups revealed by western blot analysis of TE and LOXL-1 on transversalis fascia tissue (Magnification 200×). Significantly lower levels were detected in both constituents for the direct hernia group compared to the rest of the groups ($^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$)

amounts of mRNA encoding for TE in fibroblasts isolated from TF from patients with direct and indirect inguinal hernia. But messenger levels for LOXL-1 showed significantly decreased expression in cell cultures obtained from patients with direct inguinal hernia.

Both elastic fiber fragmentation and reduction of its number in spite of an increase in the extracellular matrix have been observed by other groups [52], in patients with hernia. Other studies have reported a decrease in the total amount of elastic fibers in connective tissue in remote locations to the site of the hernia, such as the rectus sheath, supporting the theory of a global connective tissue disorder [53].

3.3 Discussion

Throughout all this review, we have been able to verify in inguinal herniogenesis that the TF is formed by a connective tissue with an altered extracellular matrix, mainly in those patients with direct inguinal hernia. The ultrastructural analyses did not show alterations in the density and diameter of the collagen fibers that justify the formation of hernias [21]. Other groups, according to these findings have reported similar results [54], but some of them have observed some alterations that have been attributed to the age factor and not to the hernia condition [51]. Hydroxylation of the amino acids proline and lysine of the collagen molecule is an essential process in the formation and stabilization of the collagen triple helix. Our results showed no proline hydroxylation differences, as did other authors [22] in patients with hernia. However, a significant decrease in lysine hydroxylation was observed in direct inguinal hernia of patients of the older age group. This could indicate alterations in the cross-linking of collagen that could affect the interaction with other components of the extracellular matrix [18].

Alterations in the collagen I:III ratio have been described by some authors [16, 55], in contradiction with our group that has not demonstrated significant differences in this ratio in TF between different types of hernias. A literature review [8] performed by the group of Henriksen, on collagen alterations in abdominal wall hernia, states that there is evidence of a significant increase in type III immature collagen with respect to mature type I collagen, resulting in the corresponding loss of biomechanical resistance of the repair area. It suggests that these alterations may be due to variations in the process of synthesis, maturation, or degradation of the collagen matrix by MMPs, in combination with other processes or independently. The authors of this review conclude that both the development of primary hernia and its recurrence are associated with a decrease in the collagen I:III ratio.

After the study involving the collagen component, our interest was centered in the analysis of different MMPs. We found only significant differences in the expression of MMP2, whose main substrates are different types of collagens and other extracellular matrix components such as fibronectin, elastin, and proteoglycans [56]. Our results with MMP-2 demonstrated that this enzyme is overexpressed in direct hernias at the tissue level and in cell cultures obtained from the TF of these patients [21, 39]. These results were corroborated by investigations of other groups showing an increase in MMP-1, MMP-2, and MMP-9 in inguinal hernia, stating that these enzymes play a very important role in the development of this pathology [36].

Other groups [57] have subsequently shown dysregulation of the extracellular matrix degradation process in patients with inguinal hernia, showing a significant increase of MMP-2 and 9, accompanied by a decrease in their endogenous inhibitors (TIMPs). The results of this study suggest problems in collagen metabolism that could be the underlying pathophysiological mechanism of inguinal hernia formation.

There is scarcely any bibliography to analyze the importance of growth factors in the development of inguinal hernia. TGF-β1 has been described as an important modulator of MMPs [41]. In our study overexpression of TGF-β1 was correlated with the overexpression of MMP2 in patients with direct hernia. Other authors have shown selective regulation of MMP-2 by TGF-β1 in transcriptional and posttranscriptional lev-

els in fibroblast cultures [58]. Other research work [59], according to this regulation, maintain the possibility that under the pathophysiological conditions, the digestion of the extracellular matrix by the MMPs could induce the TGF-β-mediated tissue reaction released by the connective tissue. All these results are in agreement with our findings in the TF of patients with hernia pathology.

In a model of experimental hernia in rat, some authors [60] have shown that the local application of this growth factor does not increase the biomechanical resistance of the abdominal wall. However, another research group [61], also using an experimental rat model, states that treatment with TGF-β2 prevents the development of hernias, stimulating the mobilization of macrophages and fibroblasts, as well as an increase of collagen deposition in the wound area.

Regarding the elastic component, a genetic mutation has been described by the group of Junqueira et al. [62] involving the elastic tissue and its dysfunction at the TF level. Our studies have shown a disorganization and reduction in the number of elastic fibers in the TF of patients with direct inguinal hernia, which corresponded with the minimal expression of LOXL-1, which would prevent normal cross-linking of TE and with the greater expression of elastase, which degrades the elastic components. These results emphasize the importance of LOXL-1 to avoid the loss of elasticity of tissues in which elastic fibers are essential for the correct functionality.

According to our results, other groups [52] have also observed in inguinal hernia both elastic fiber fragmentation and reduction of its number with an increase in the extracellular matrix. A decrease in the total amount of elastic fibers in connective tissue of remote locations to the site of the hernia have been also reported, supporting a global connective tissue disorder [53]. Conversely, some studies [19] have shown a significant increase of elastic fibers in the fascia of patients with direct inguinal hernia. Other papers using immunohistochemical evaluation showed no statistically significant differences in the amount of elastic fibers and collagen I and III among patients with inguinal hernia when compared with subjects without hernia [63].

There are very few published reports in the literature relating inguinal hernia to the analysis of the enzymes involved in elastin and collagen cross-linking. These include a study by Kayaoglu et al. [64] in which significant lower plasma and hernia sac copper levels were detected in patients with direct hernias than those with indirect hernias. Given that copper is an essential cofactor for lysyl oxidase, the authors proposed that patients with direct hernia could show impaired collagen and elastin synthesis because of the deficient activity of LOX. Other studies [65] evaluating copper and zinc levels in hernia formation have showed significantly lower tissue levels compared to control, which might reflect excessive consumption or dysfunction of lysyl oxidase as playing a role in the etiology of hernias.

The amounts of collagen and elastic fibers in the TF determine its tensile strength and elasticity. Significant biomechanical changes in the TF of patients with hernia have been reported by Pans et al. [7] Some other authors [66], according to our results and in a search for possible relationship between hernia and abdominal aneurysm, have described elevated levels of elastase and significantly higher prevalence of inguinal hernia in these patients with aneurysm suggesting systemic fiber degeneration. Other authors [67], also in agreement, have reported significantly higher circulating serum elastinolytic activity in patients with direct hernia.

Taking into account our findings and those of other authors, in relation to the biological factors involved in herniogenesis, we could conclude that the different elements of the connective tissue extracellular matrix play an important role in the genesis of inguinal hernias, and especially in one type, the direct hernia.

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4 Classification of Inguinal and Abdominal Wall Hernia

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4.1 Inguinal Hernia Classification

Since 1840, when Hesselbach used the inferior epigastrics vessels as the defining boundary between indirect and direct hernias, surgeons have always tried to classify the inguinal hernias. This first classification resisted for years; nowadays the interest in a more accurate and scientific classification of groin hernias is increasing. The general opinion is that one standardized system must be adopted, and since 2009 the EHS recommended that its classification system should be used [1]. The primary objective of any classification system is to stratify the pathology in study (groin hernia) for severity in order to allow reasonable comparisons between treatment strategies [2]. Moreover, a classification must be simple and easy to use. Several operative techniques with their variations for herniorrhaphy have been described, but no one classification system can satisfy all presently. The EHS overpass this problem, developing a brand new classification system by consensus [2–9]: in effect an expert panel analyzed the known systems to date and proposed classification that resembles largely the Aachen classification [10]. This latter makes a distinction between the anatomical localization (indirect or lateral vs. direct or medial) and the size of the hernia orifice defect in cm (<1.5, 1.5–3, >3 cm) (Table 4.1). Moreover Miserez et al. [2] decided to modify to some minor aspects this classification, proposing the "index finger" rule as the reference in open surgery (normally the size of the tip of the index finger is mostly around 1.5–2 cm). This size is also identical to the length of the branches of a pair of most laparoscopic graspers, dissector, allowing the surgeon to use the same standardized classification during minimally invasive procedures [11, 12]. For recurrent hernias, a detailed description could be used as proposed by Campanelli et al. [13]. The recurrent hernias are divided into three types:

- Type R1: first recurrence "high," oblique external, reducible hernia with small (<2 cm) defect in nonobese patients, after pure tissue or mesh repair

Table 4.1 EHS groin hernia classification

EHS groin hernia classification		Primary	Recurrent		
	0	1	2	3	×
L					
M					
F					

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- Type R2: first recurrence "low," direct, reducible hernia with small (<2 cm) defect in non-obese patients, after pure tissue or mesh repair
- Type R3: all other recurrences or anyway not easily included in R1 or R2, after pure tissue or mesh repair (femoral, big defects, multirecurrent, non-reducible, obese patient)

For now, the classification system for groin hernia is mired in some controversy and disagreement; one disadvantage could be that the EHS system was not developed to classify hernia types preoperatively; moreover a flow chart to inform decision-making about the complex cases would be helpful. However, the EHS system as classification system is supported by several available evidence and expert opinion; but the major objective to achieve is to convince all surgeons performing hernia surgery to report the class of the groin hernia systematically in the operative report. Ideally, these data should be collected in a prospective nationwide registry securing patient and surgeon anonymity (http://www.herniaweb.org/).

4.2 Primary and Incisional Abdominal Wall Hernia Classification

Since 2000, several authors have proposed classification for incisional hernias, but none of them are widely accepted in literature [11, 12]. After the publication, in 2007, of a simple classification for groin hernias by EHS [2], in 2009 Muysoms et al. [13] proposed a classification of primary and incisional abdominal wall hernias. The classification allows to describe hernias in a standardized way, improving the possibility of comparing different studies and their results. We all speak the same language which is easier to collect different results of several techniques described in literature, in order to develop evidence-based guidelines using this classification. The first question was to reach the agreement on separating "primary abdominal wall hernias" (the ventral hernias, non-incisional) and other "incisional abdominal wall hernias"; a consensus has been found on avoiding the word "primary incisional hernia" that should not be used. Moreover, there was a consensus to exclude "parastomal hernias" from this classification: they make up a distinct group, with specific properties and treatment options [14].

4.2.1 Classification of Primary Abdominal Wall Hernias

For these hernias there is agreement on the use of localization and size as two variables.

Localization of the hernia: Two midline (epigastric and umbilical) and two lateral hernias (spigelian and lumbar) are identifiable entities with distinct localizations.

Size of the hernia: Cutoff values of 2 and 4 cm were chosen to describe three subgroups according to size: small, medium, and large.

Taxonomy: nominative description (epigastric, umbilical, small, medium, large) (Table 4.2).

4.2.2 Classification of Incisional Abdominal Wall Hernias

Definition: "any abdominal wall gap with or without a bulge in the area of postoperative scar perceptible or palpable by clinical examination or imaging" [12].

Localization: The abdomen was divided into a medial or midline zone and a lateral zone.

Medial or midline hernias: The borders of this area are defined as cranially the xyphoid, caudally the pubic bone, and laterally the lateral margin of the rectal sheath. An easily memorable

Table 4.2 EHS classification for primary abdominal wall hernias [Muysoms]

EHS primary abdominal wall hernia classification	Diameter cm	Small <2 cm	Medium ≥2–4 cm	Large ≥4 cm
Midline	Epigastric			
	Umbilical			
Lateral	Spigelian			
	Lumbar			

classification from M1 to M5 going from xyphoid to pubic bone was proposed (Fig. 4.1).

- M1: subxyphoidal (from the xyphoid till 3 cm caudally)
- M2: epigastric (from 3 cm below the xyphoid till 3 cm above the umbilicus)
- M3: umbilical (from 3 cm above till 3 cm below the umbilicus)
- M4: infraumbilical (from 3 cm below the umbilicus till 3 cm above the pubis)
- M5: suprapubic (from pubic bone till 3 cm cranially)

If hernias are extending over more than one M zone, it was decided to mark every zone in which the hernia was located when using the grid for incisional hernias (Fig. 4.1). Different hernia defects caused by one incision will be considered as one hernia. If the different defects were caused by two different incisions, they should be considered two different hernias.

Lateral hernias: The border of this area is defined as cranially the costal margin, caudally the inguinal region, medially the lateral margin of the rectal sheath, and laterally the lumbar region. Thus, four L zones on each side are defined as (Fig. 4.2):

1. L1: subcostal (between the costal margin and horizontal line 3 cm above the umbilicus)

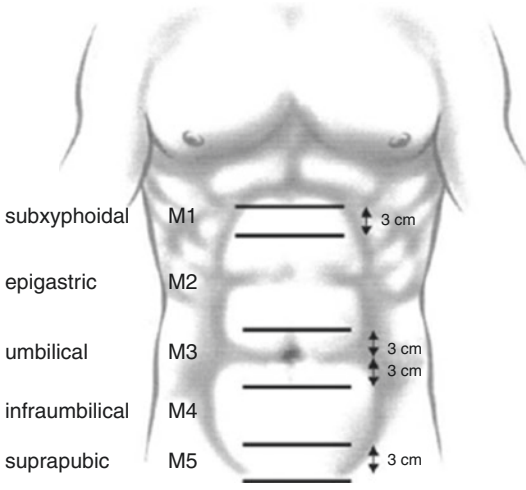

Fig. 4.1 Five zones were defined to classify midline incisional hernias

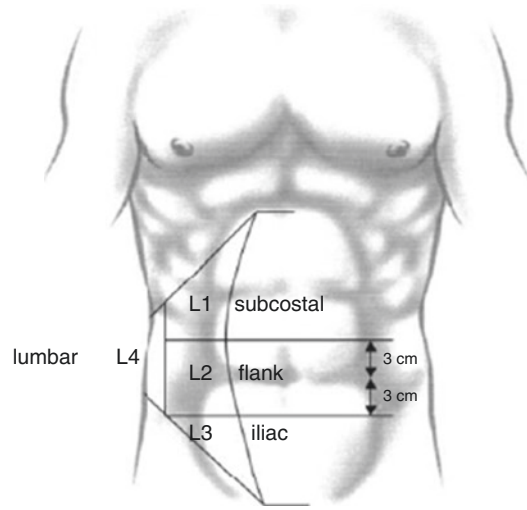

Fig. 4.2 Four zone lateral of the rectal muscle sheaths were defined to classify lateral incisional hernias

2. L2: flank (lateral to the rectal sheath in the area 3 cm above and below the umbilicus)
3. L3: iliac (between a horizontal line 3 cm below the umbilicus and the inguinal region)
4. L4: lumbar (laterodorsal of the anterior axillary line)

Size of the hernia: The width of the hernia defect alone was insufficient to describe the hernia defect size adequately. Muysoms [13] proposed that width and length should be used. The width was defined as the greatest horizontal distance in cm between the lateral margins of the hernia defect on both sides. In case of multiple hernia defects, the width is measured between the most laterally located margins of the most lateral defect on that side (Fig. 4.3). The length of the hernia defect was defined as the greatest vertical distance in cm between the most cranial and the most caudal margin of the hernia defect. In case of multiple hernia defects from one incision, the length is between the cranial margin of the most cranial defect and the caudal margin of the most caudal defect (Fig. 4.3).

Taxonomy: To avoid confusion with primary abdominal wall hernias (small, medium, large), a coded taxonomy was chosen instead of a nominative description:

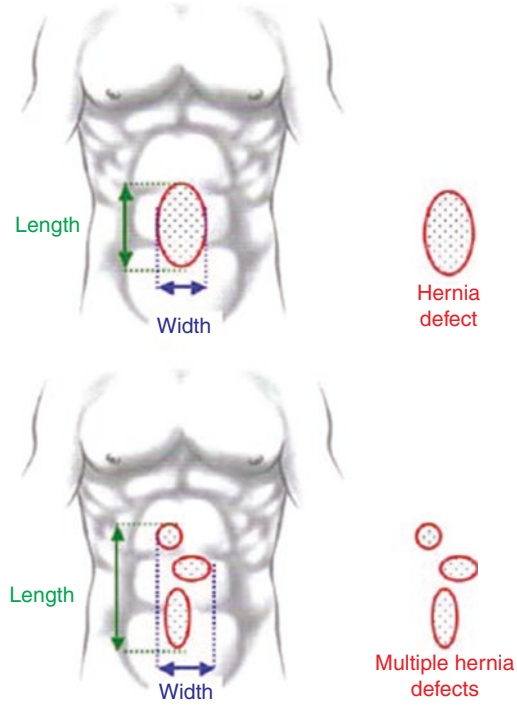

Fig. 4.3 Hernia defect surface can be measured by combining width and length in a formula for an oval, thus trying to make an estimation of the real surface in cm^2

- W1 < 4 cm
- W2 ≥ 4–10 cm
- W3 ≥ 10 cm (Table 4.3)

Table 4.3 EHS classification for incisional abdominal wall hernias

EHS incisional hernia classification					
Midline	Subxyphoidal	M1			
	Epigastric	M2			
	Umbilical	M3			
	Infraumbilical	M4			
	Suprapubic	M5			
Lateral	Subcostal	L1			
	Flank	L2			
	Iliac	L3			
	Lumbar	L4			
Recurrent incisional hernia		Yes	O	No	O
Length:	cm	Width:		cm	
Width cm	W1	W2		W3	
	<4 cm	≥4–10 cm		≥10 cm	
	O	O		O	

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Diagnostic Tools in Hernia Disease

5

Paul Tenzel, Jordan Bilezikian,
and William W. Hope

5.1 Introduction

Most inguinal and ventral hernias can be diagnosed using a thorough history and physical examination. Patients are usually referred to a surgeon for diagnosis confirmation and a discussion of treatment options. However, additional diagnostic imaging may be necessary to identify an occult hernia or to plan the operation. In this case, the surgeon has many choices depending on the hernia type or clinical problem and the information that is needed. In general, additional diagnostic tools include ultrasound, computed tomography (CT) scanning, and magnetic resonance imaging (MRI) with other adjuncts for inguinal hernias including herniography. Each imaging modality has strengths and weaknesses. Imaging choice is impacted by the local hospital environment and radiology department.

5.2 History and Physical

Patients with a hernia often complain of feeling a bulge. In this case, the surgeon should confirm hernia presence with a physical examination (Fig. 5.1). In some cases, an occult hernia (one that is difficult to detect) is present. This can be due to the small hernia size or other patient characteristics such as obesity. In this case, additional diagnostic imaging should be obtained.

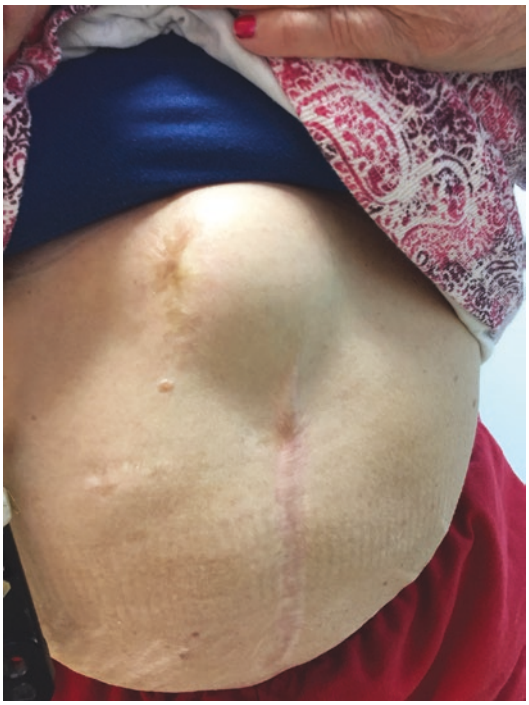

Fig. 5.1 Ventral hernia shown on physical exam

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5.3 Diagnostic Tools for Inguinal Hernia

5.3.1 Imaging in Inguinal Hernias

In most cases, a history of groin pain and an obvious inguinal bulge are all that are required to diagnose an inguinal hernia. In this case, the next step is operative repair. Diagnosis is less clear when there are no physical exam observations consistent with inguinal hernia. An occult inguinal hernia can be too small to detect on physical exam but can produce symptoms consistent with a groin hernia such as a feeling of a bulge or pain. Without physical exam evidence, imaging is crucial in diagnosis, because there are many causes of pain that should not be treated using surgery.

5.3.2 Ultrasound

Ultrasound is usually the first modality used to diagnose occult inguinal hernias because it is easily accessible and relatively inexpensive. An inguinal hernia ultrasound with and without Valsalva maneuver (Fig. 5.2), not a pelvic ultrasound, will provide the best information for accurate diagnosis of an occult inguinal hernia. The patient can be moved into different positions such as lying down and standing which can often aid in diagnosis of the hernia; as in some positions, the protrusion through the hernia defect may be more pronounced (Fig. 5.3). Although the dynamic nature of ultrasound is a distinct benefit, this characteristic also makes its accuracy operator dependent.

Although ultrasound is the first-line imaging option for diagnosing an inguinal hernia, it is far from perfect. A recent meta-analysis comprised of five ultrasound studies totaling 716 patients showed that ultrasound had a sensitivity of 86% and specificity of 77% [1]. Though these numbers may seem reasonable for diagnosis, two recent studies reported that ultrasound has a low positive predictive value after the patient is evaluated in the operating room. The first study contained 116 patients who underwent surgery after a positive ultrasound and yielded only a 74% positive predictive value [2]. This correlated with another study of 118 patients who at the time of

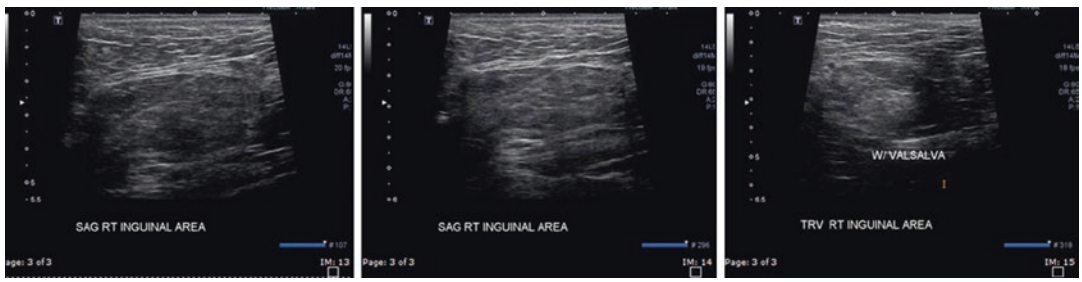

Fig. 5.2 Ultrasound image showing of right groin showing fat protruding through a hernia defect that is more pronounced with Valsalva

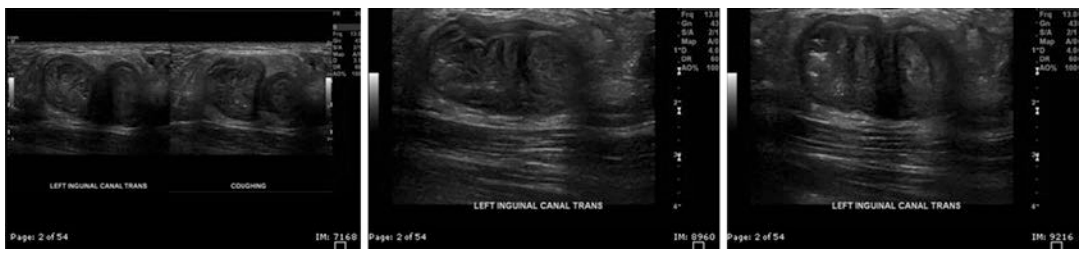

Fig. 5.3 Ultrasound image showing bowel protruding through a left inguinal hernia

operation had a 70% positive predictive value for presence of a hernia. The same study followed 141 patients with a negative groin ultrasound for a median of 3 years, and no patients were later diagnosed with a hernia [3]. The most recent study on the subject by Miller showed a sensitivity of 0.33 and specificity of 0.0 [4]. These data indicate that ultrasound may be a better imaging method to help rule out a hernia diagnosis than to determine the need for surgery.

5.3.3 CT Scan

CT scan is also used to diagnose occult inguinal hernias. It is widely available, and many surgeons are accustomed to reading CT scans, which is not the case with most other imaging options. A CT scan facilitates evaluating the entire abdomen, which can occasionally identify other causes of pain or abnormalities. In a study comparing CT and herniography, CT identified bone spurs as the cause of pain in 2 of the 51 patients evaluated [5].

Despite these advantages, the usefulness of CT for inguinal hernia diagnosis is very limited. Studies using CT show a fairly low sensitivity and specificity but a fairly high positive predictive value for patients that undergo surgery. Recent data on the subject showed a sensitivity of 0.54, a specificity of 0.25, but a positive predictive value of 86% in 39 patients who underwent CT and subsequent surgery [4]. Another study evaluated 158 patients with groin pain. In these patients, 49 hernias were diagnosed via CT, and the patients were taken to surgery for evaluation and hernia repair. This study showed a positive predictive value of 92% and a negative predictive value of 96% [6]. These data indicate that CT is not the best option for the initial diagnosis of an occult hernia; however, when a hernia is identified on CT, the patient can proceed to surgery for hernia repair.

Although CT may not be the best option for the diagnosis of occult inguinal hernias, it can be useful for inguinal hernias in certain clinical circumstances such as when other intra-abdominal pathology is suspected or cases of difficult to diagnose hernias such as femoral and obturator hernias (Figs. 5.4, 5.5, and 5.6).

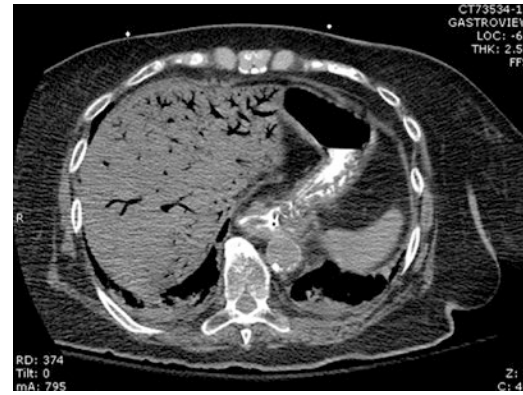

Fig. 5.4 Computed tomography scan showing portal venous gas from incarcerated right femoral hernia causing a bowel obstruction

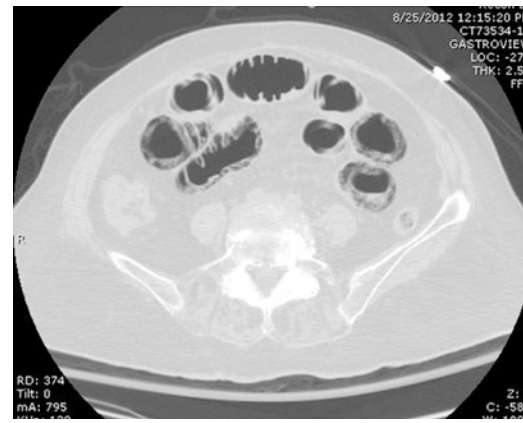

Fig. 5.5 Computed tomography scan showing pneumatosis from incarcerated right femoral hernia causing a bowel obstruction

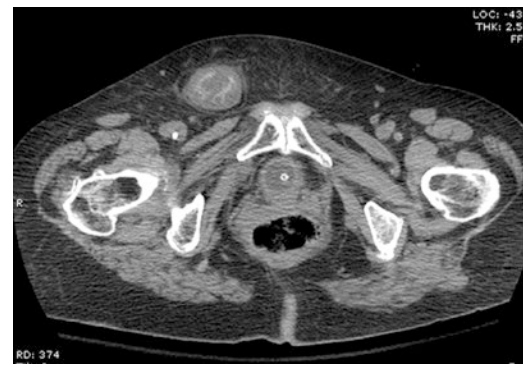

Fig. 5.6 Computed tomography scan showing incarcerated right femoral hernia causing a bowel obstruction which lead to ischemic intestine, pneumatosis, and portal venous gas

5.3.4 MRI

MRI is useful in diagnosing occult inguinal hernias; however, it is not without disadvantages. It is more expensive than ultrasound or CT and also takes the most time to complete. Generally, surgeons are not as skilled at reading MRIs compared with reading CTs; however, MRI has several benefits. Like CT, MRI can be used to evaluate the entire pelvis. Because of the ability to closely assess the bones and soft tissues in the pelvic region, MRI is useful to diagnose hernias and other musculoskeletal etiologies for groin pain (Figs. 5.7 and 5.8).

There is increasing evidence that MRI should be the initial study to evaluate suspected occult inguinal hernias. A study by Miller compared the use of CT, ultrasound, and MRI in 34 patients and determined that MRI was the best option for diagnosing occult inguinal hernias. The study yielded a sensitivity and specificity of 0.91 and 0.92, respectively [4].

5.3.5 Herniography

Ducharne first described herniography, also known as peritoneography, in Canada in 1967 [7]. Herniography consists of injecting iodinated contrast into the peritoneum and imaging the area with X-ray or CT to evaluate possible hernia defects. This imaging modality is the most invasive of the options discussed. Because this procedure is done with X-ray or CT, it exposes the patient to radiation. Despite these negatives, it is considered one of the most accurate tests used to diagnose hernias; however, it is not widely used probably because of the lack of comfort and familiarity with the study both by surgeons and by the radiology teams that would perform them

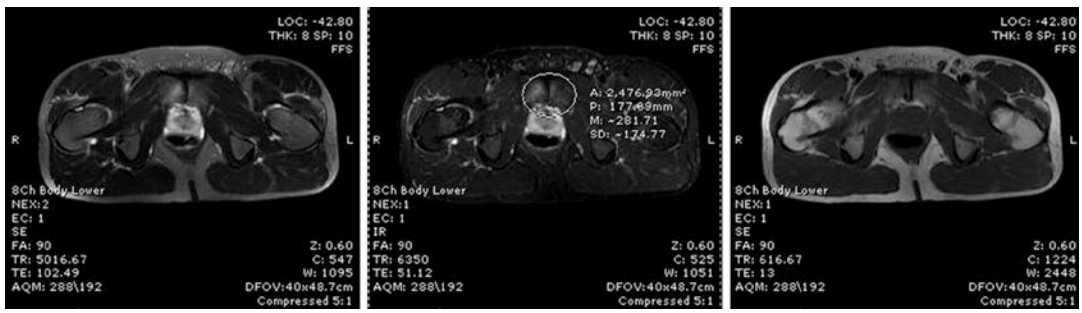

Fig. 5.7 MRI for chronic groin pain in a runner revealing mild degenerative changes of the pubic symphysis with parasymphyseal bone marrow edema suggestions stress/reactive edema due to repetitive stress

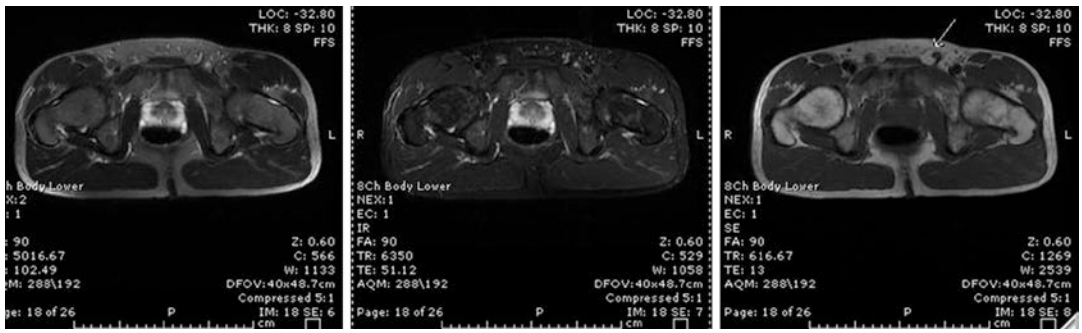

Fig. 5.8 MRI showing small fat containing left inguinal hernia

and the emergence of other more commonly used modalities such as ultrasound, CT, and MRI. Although invasive, herniography is a fairly safe procedure. In a large review of 17 studies including 1538 patients, only three patients had complications that required hospital admission (a 0.19% major complication rate) [8]. Another retrospective study evaluated 117 herniographs performed at one hospital and identified no complications recorded [9].

Multiple studies have shown that herniography is the most accurate imaging modality. A large review by Robinson compiled data from 16 studies and convincingly supported using herniography more often to diagnosis occult hernias compared with ultrasound and CT. The pooled data showed a sensitivity of 91% and a specificity of 83% for herniography, which was much higher than the study's findings for CT scan [1].

5.3.6 Diagnostic Laparoscopy

Because diagnostic laparoscopy is an invasive procedure, it should be very seldom used in the diagnostic algorithm for inguinal hernias. However, it is useful to evaluate for an occult hernia when imaging is non-confirmatory or cannot be obtained. Diagnostic laparoscopy facilitates identifying hernias and other intra-abdominal pathology. Because female pelvic pain can be related to gynecologic issues, it is sometimes helpful to have an obstetrician/gynecologist available for these cases.

5.4 Summary and Recommendations for Diagnostic Tools in Inguinal Hernia

Most inguinal hernias can be diagnosed using a thorough history and physical examination. When the patient feels a bulge that is not felt during a clinical exam, an ultrasound is probably the most useful initial test. When the patient's symptoms are not consistent with a hernia, no bulge is felt on physical exam, or the surgeon suspects other general surgical/intra-abdominal issues, a CT scan is likely the best test to identify intra-abdominal pathology. When there is concern for an occult hernia, musculoskeletal injury/core muscle injury, or pain related to previous hernia repair, an MRI is likely the best option. An MRI should be done using special protocols and should involve a radiologist comfortable with and interested in these techniques/imaging modalities.

5.5 Diagnostic Tools for Ventral Hernia

The principal imaging modalities for the diagnosis of ventral and incisional hernias and preoperative planning for their repair are ultrasound, CT, and MRI. Given their advantages and disadvantages, each has a role in specific clinical scenarios to produce favorable outcomes.

Ultrasound is the quickest, least expensive technique for detecting small ventral or incisional midline or lateral hernias. There were many different institution-based methods for the use of ultrasound until 2013 when Beck et al. published a standardized method called dynamic abdominal sonography for hernia (DASH). In this study, the DASH method achieved a sensitivity of 98% and specificity of 88% [10]. This method uses a standard linear ultrasound probe and requires the user to make five vertical passes starting at the midline and alternating laterally in parallel lines (Figs. 5.9 and 5.10). In a subsequent study, the DASH method was shown not only to have diagnostic ability but also to accurately characterize hernias, even very large defects ($\geq$10 cm in diameter) and even in obese populations with an average BMI of 39.2 kg/m^2 [11]. Historically, ultrasound has had several barriers to widespread use. One of the primary issues was difficulty in obtaining reliable image quality for obese patients. The DASH method may provide a solution to this problem for certain obese patients. Ultrasound has many benefits and can be a quick and relatively cost-effective way to diagnose smaller hernias; however, it still has not gained wide acceptance in the preoperative planning of known hernias or in patients with obese abdomens.

Fig. 5.9 The use of dynamic abdominal sonography for hernia (DASH) to evaluate for a ventral hernia

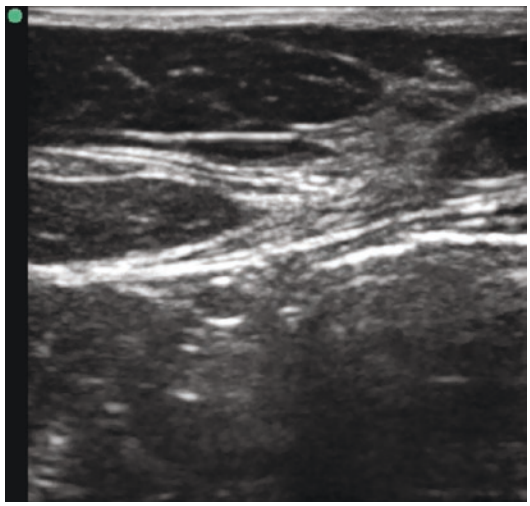

Fig. 5.10 Layers of the abdominal wall seen on dynamic abdominal sonography for hernia (DASH)

CT is the most widely used imaging modality for the characterization of known ventral hernias and has the benefit of being a relatively quick study that produces images with excellent image quality for many different types of ventral hernias

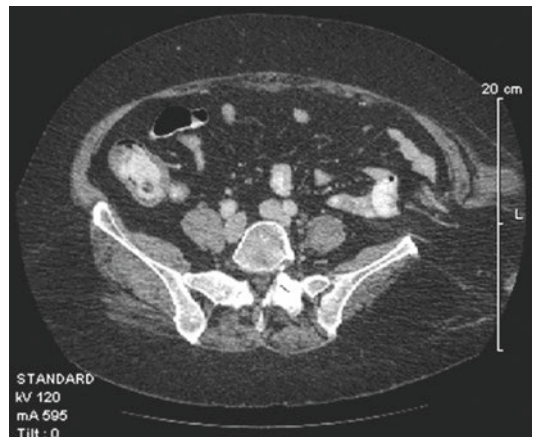

Fig. 5.11 Computed tomography scan showing lumbar hernia

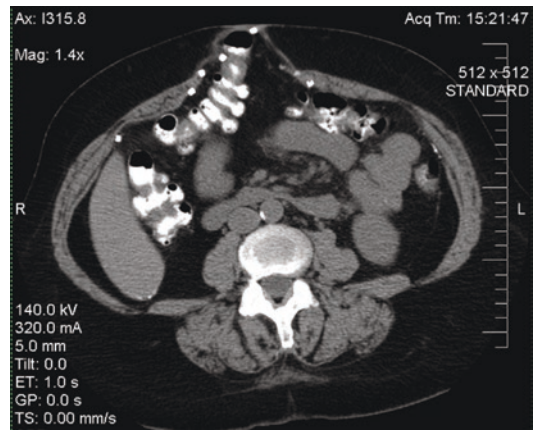

Fig. 5.12 Computed tomography scan showing Spigelian hernia

(Figs. 5.11, 5.12, 5.13, and 5.14). In contrast to ultrasound, the images can characterize large defects and can be used with severely, morbidly obese patients. Preoperative planning has been enhanced by CT measurements of ventral hernia defect size and abdominal wall thickness, which have been used to predict wound complications and the need for component separation [12]. Prior techniques on estimating the need for component separation relied on hernia location, and unique variabilities in the patient's anatomy were not considered. In a retrospective review of patients who underwent abdominal wall reconstruction, Franklin et al. demonstrated that CT could be used to predict midline approximation using

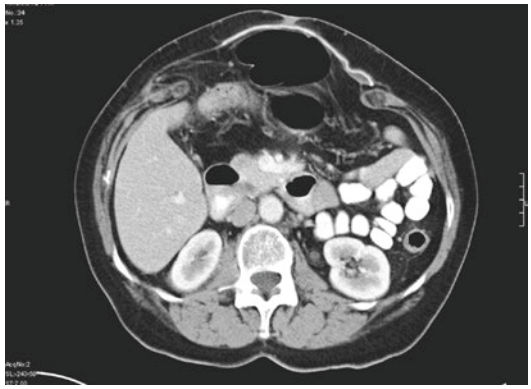

Fig. 5.13 Computed tomography scan showing recurrent hernia with mesh being pushed into hernia sac

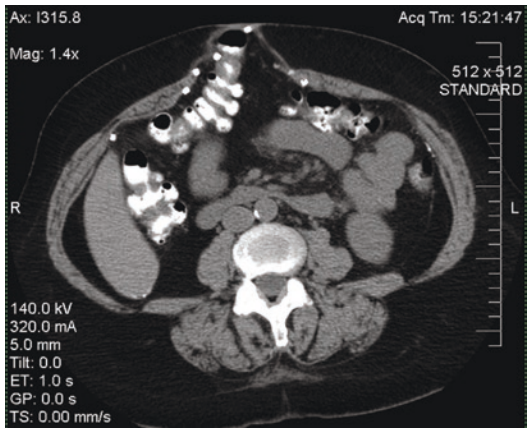

Fig. 5.14 Computed tomography scan showing recurrent hernia and tack fixation in hernia sac

abdominal wall defect ratios and hernia defect areas [13]. The predictive value of CT imaging is very important in preoperative planning to avoid bridged repairs. A recent investigation into a quantitative anatomical labeling protocol was undertaken to predict the need for mesh bridge closure and was able to more accurately predict this than the metrics used in the European Hernia Society Classification for Ventral Hernia (EHSCVH) [14]. Calculating loss of domain is a challenge for the preoperative assessment of ventral hernias. CT 3D reconstruction continues to improve its predictive capacity and has been shown to predict hernia area and volume, which may contribute to more accurate preoperative risk assessment of loss of domain and risk of abdominal compartment syndrome [15]. Unfortunately, CT requires exposure to ionizing radiation; however, the excellent image quality and recent advances in 3D reconstruction have facilitated better characterization of large, complex hernias and assessment of potential loss of domain while attempting to avoid bridged repairs.

MRI has shown some utility in the assessment of patients with adhesions to mesh after ventral hernia repairs and could be of value in patients requiring complex mesh repairs when explantation of mesh is being considered. MR has been shown to detect adhesions between both bowel and the abdominal wall in patients who have a history of both laparoscopic and open VHR [16]. Functional cine MRI has been used to evaluate intra-abdominal adhesions and preoperative planning for mesh explantation. This method is used to detect "visceral slide" by comparing images when the patient is at rest and when performing the Valsalva maneuver. Lienemann et al. demonstrated that when this method was compared with intraoperative findings in a group of 27 patients, the sensitivity was 87.5%, and the specificity was 92.5% [17]. In a larger retrospective study enrolling 90 patients, similar results were obtained in which the overall MRI accuracy was 89% [18]. While cine MR has the benefit of visualizing ePTFE mesh, it has not been shown to adequately visualize polypropylene mesh [19]. There are benefits in the appropriation of MR in the analysis of complex ventral hernias, patients with adhesions or abdominal wall dysmotility, or when explantation of synthetic mesh is considered. However, MRI should be used judiciously and should not be used for routine classification of hernias due to cost, length of exam, and marginal improvements in picture quality compared with CT.

5.6 Summary and Recommendations for Diagnostic Tools in Ventral/Incisional Hernia

Most simple ventral/incisional hernias in non-obese patients can be diagnosed using a thorough history and physical examination.

Table 5.1 Advantages and disadvantages of imaging modalities for diagnosing ventral/incisional hernia

	Advantages	Disadvantages
Ultrasound	– Good for diagnosis and characterization of small, simple ventral or incisional hernias – Cost effective – Time effective – Noninvasive – No ionizing radiation – Quick to perform – Rapid interpretation	– Difficult to use in morbidly obese patients – Difficult to characterize complex or recurrent hernias – Cannot visualize prior synthetic mesh – Image quality not as good for preoperative planning as CT or MRI – Comfort of operator carrying out exam – Minimal detection of adhesions
Computed tomography	– Excellent image quality – Good for diagnosis and characterization of complex or recurrent hernias – Facile use in morbidly obese patients – 3D imaging to better classify loss of domain and avoid bridged repairs	– Ionizing radiation – Not cost-effective to use for initial diagnosis of clinically unapparent hernias – Cannot be done in the office compared with DASH – Cannot visualize adhesions or mesh
Magnetic resonance	– Better image quality than CT – Can image ePTFE mesh – No ionizing radiation – Cine MRI proving advantageous for preoperative planning of ventral hernias with known adhesions	– Not cost-effective for the routine use of simple hernia diagnosis or characterization – Not time effective for the routine use of simple hernia diagnosis or characterization – Cannot visualize polypropylene mesh

Table 5.1 is a list of advantages and disadvantages of the various diagnostic technologies. Due to the complex nature of incisional hernias, imaging is often warranted. The well-described DASH technique gives the surgeon a reproducible and standardized way to use ultrasound for diagnosing ventral/incisional hernias; however, it hasn't gained widespread acceptance. Because of the many advantages associated with this technique, we encourage surgeons to learn about the DASH technique and to use this as a first-line diagnostic tool in appropriate patients when the technology and training are available. CT scanning is likely the most common imaging tool for diagnosing ventral/incisional hernias, because it not only helps with diagnosis but also with operative planning and can help identify other intra-abdominal pathology or previous mesh in some cases. Another benefit of CT is that most surgeons are skilled in reading CTs. Because of these advantages, for complex cases or when ultrasound is not available, CT is likely the best option. Although MRI has some indications for diagnosing ventral/incisional hernia, unless your center/hospital/radiology department has a special interest in this technology, it should be used rarely and only in special circumstances.

Conclusion

Surgeons should understand the various imaging and diagnostic tools for inguinal and ventral/incisional hernias. Although history and physical examination will most certainly be the mainstay for diagnosis in most patients, surgeons interested in hernia disease should learn about new diagnostic technologies and should become skilled in the DASH technique and in reviewing imaging studies. Surgeons should work closely with their local institutions and specifically their radiology departments to successfully use these tools in appropriate patients.

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6 Materials, Devices and Gadgets for Hernia Surgery

David L. Sanders, Kelly-Anne Ide, and Bassem Amr

6.1 Prosthetic Mesh Materials

6.1.1 Introduction

Knowledge regarding the biological basis of hernia development has progressed rapidly, and as such the operative techniques and the use of prosthetics for surgical repair have experienced equally dramatic evolution. Although exact figures are unknown, it is estimated that more than 20 million prosthetic meshes are implanted worldwide each year [1, 2]. The use of a prosthetic mesh reduces recurrence rates in comparison with suture repairs, from 8 to 3% [1, 3, 4] in inguinal hernia repairs and from 12–54% to 2–36% for incisional hernias [5].

There are numerous prosthetics available on the market today, and the choice of which to use can be challenging. This chapter aims to compare the prosthetic meshes and fixation devices currently available.

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6.1.2 History of Prosthetics in Hernia Surgery

Prosthetic materials have been used in hernia surgery since the early twentieth century [6] and, thanks to technological advances, have undergone major improvements since their introduction.

The first prosthetic meshes were manufactured using metal, with Phelps, Goepel and Witzel using silver filigrees in the 1900s. These silver wire braided meshes were rigid and hence fragile and caused a toxic silver sulphate to form on their surface [7–10]. They were later modified to contain braided stainless steel [7–9]. Douglas and Throckhmorton in 1948, and later Koontz and Kimberly, utilized tantalum gauze, but it was still prone to fragmentation. In addition, it had extremely high infection rates [11–13]. Despite this metallic prosthetics remained in use until the late 1980s [14–16].

Cumberland later trialled nylon meshes, which fell apart, and prefabricated Perlon meshes which caused a severe inflammatory response [17–19]. Biomaterials, including nylon, polyvinyl sponge (Ivalon), silicon, Orlon cloth and Teflon, were developed in the mid to late twentieth century; however, after unsuccessful animal models and clinical trials, they were abandoned [20].

With the need for a suitable mesh still unmet, and with tantalum and steel becoming precious metals during World War II, manufacturers turned to plastics such as polypropylene, polyester and

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polytetrafluoroethylene (PTFE). With promising results, they gained favour amongst surgeons and paved the way for the modern meshes available today [19, 21, 22].

6.1.3 Pathophysiology of Prosthetic Mesh Incorporation

The perfect hernia repair would restore the normal functional anatomy and prevent hernia recurrence by providing biomechanical strength.

In order to understand the role of the prosthetic mesh in hernia surgery, it is crucial to understand the biological principles of wound healing and the pathophysiology of foreign body reaction. It was initially thought the meshes would act like a bridge to reinforce the abdominal wall, but with increasing understanding of wound healing and the foreign body reaction, it became apparent that meshes act more like a scaffold for the patient's own tissue to grow through, hence providing biomechanical strength.

6.1.3.1 Wound Healing Process

The process of wound healing and scar formation is a dynamic process which involves three phases: the inflammatory phase, the proliferative phase and the remodelling phase. These are further divided into multiple steps including coagulation, inflammation, angiogenesis, epithelialisation, fibroplasia, matrix deposition and contraction [23].

These processes are mediated by blood-borne platelets, monocytes, macrophages and polymorphonuclear leukocytes. There are also fibroblasts, endothelial cells and smooth muscle cells that, together with the circulating inflammatory cells, elicit a complex cascade of events resulting in the activation of inflammatory cells and the production of growth factors (platelet-derived growth factor, fibroblast growth factor, transforming growth factor beta, insulin-like growth factor and epidermal growth factor) which augment the wound healing process [23].

Collagen plays an important part in the healing process and scar formation, with collagen synthesis remaining elevated for several months in the area surrounding the wound. Initially it is secreted as a monomer from fibroblasts and smooth muscle cells. It then polymerizes to thick insoluble fibres in the extracellular space. The process of collagen remodelling begins approximately at 3 weeks postoperatively. During this process, collagen is remodelled into mature collagen (type 1 collagen) as a thick and compact interlocking network of fibres that are parallel to one another. During this remodelling phase, the bursting strength of the wound continues to increase for up to 6 months and is thought to reach an equivalent of 95% of its peak strength by 12 weeks [24]. Ultimately, the healed tissue regains only 80% of its native strength [25].

It has been suggested that patients with abnormal connective tissue disorders, namely, high levels of type 3 collagen which is thinner and more flexible, altered matrix metalloproteinase activity and altered fibroblast activity, are more likely to develop hernias and are more prone to recurrence [26–30]. The presence of prosthetic material promotes tissue ingrowth and scar formation providing wound strength and mechanical reinforcement.

6.1.3.2 The Foreign Body Reaction

Although the prosthetic meshes are designed to be physically and chemically inert, non-immunogenic and non-toxic, they still trigger a foreign body reaction [31].

The process of foreign body reaction aims at forming an artificial 'outside world', isolating the prosthetic mesh (foreign body) from the local host tissues. The same principle is thought to be responsible for the formation of prototypic granulomas in tuberculosis [32]. In contrast to solid biomaterials, the process of fibrosis in mesh structures is not usually associated with the formation of a capsule but with the progressive ingrowth of fibrous tissue [33–35].

The foreign body reaction is a dynamic process that starts within hours following mesh insertion and is due to adsorption of host proteins by the prosthetic mesh [36–40]. This results in

protein replacement by other proteins of increasing molecular weight, which follow a series of conformational changes [41]. This is strongly affected by the mesh's hydroelectric surface characteristics of attracting or repelling the proteins [42]. The nature and extent of these changes influence the magnitude of the inflammatory response [36–38, 41].

Animal studies show that tissue ingrowth, which is part of the inflammatory response, begins within 2 weeks and increases in strength over the following 12 weeks [33, 40, 42, 43]. The extent and velocity of ingrowth depends on the properties of the mesh [6, 24, 35, 43]. Collagen ingrowth provides a long-term adhesive strength [24]. Whilst it produces a strong mechanical barrier, florid ingrowth can also be detrimental to abdominal wall function.

In humans, Welty et al. used a 3D stereography and ultrasound to examine and measure the abdominal wall following mesh repair [44]. Patients with small-pore monofilament meshes, (which promote fibrosis,) had higher levels of pain and paraesthesia than those with large-pore monofilament meshes (which have lower rates of fibrosis). The abdominal wall stiffness was increased in all patients, but the extent of stiffness increased with the amount of mesh material present and decreased with pore size [44]. These findings have been supported by several rabbit models, which have shown decreased compliance with extensive mesh ingrowth [45–47]. In a study by Novitsky, the reduced weight polypropylene and oxidized regenerated cellulose mesh have induced a small, significant change in the compliance of the tissue adjacent to the mesh area ($P = 0.0001$) [46].

Furthermore, in situations where the mesh is in contact with the abdominal viscera, mesh ingrowth is not desirable as it results in adhesions and possible fistula formation [35, 48, 49]. Hernia recurrence has been attributed to the amount of the chronic inflammation and the progressive fibrosis that happens in some patients and results in mesh shrinkage [50–52]. In an animal study on dogs, Klinge and his colleagues have found that meshes that contain more polypropylene tend to shrink to about 30–50% of their original size after 4 weeks [50]. This was also shown by another animal study by Gonzalez [51]. In this study, it was found that the mean area covered by the polyester meshes (87 ± 7 cm^2) was significantly larger than the area covered by the heavyweight polypropylene meshes (67 ± 14 cm^2) ($p = 0.006$).

In summary, meshes should aim to encourage sufficient ingrowth (preferentially type 1 collagen) to allow adequate mechanical strength to prevent recurrence, but not so much as to reduce abdominal wall compliance and cause pain, adhesion formation or unpredicted mesh shrinkage.

6.1.4 The Ideal Prosthetic Mesh

Currently, it is difficult to find a prosthetic mesh that offers a perfect solution for all types of hernia repair, despite the several attempts to describe the ideal mesh [6, 53–57]. The characteristics of the ideal mesh are divided into five key sections, namely, biocompatibility, infection risk, handling, socioeconomics and longevity, as defined by 'Sanders–Kingsnorth' criteria of ideal mesh [58] (Table 6.1).

The choice of the prosthesis is largely based upon surgeon experience and personal preference, in addition to the available resources. The selection of the mesh should, however, be tailored to the position of the hernia, proximity to bony prominences, size of the defect, the normal function of the patient and their comorbidities. This should be supported by the evidence-based decision tree of the most appropriate repairs for particular types of scenarios.

6.2 Mesh Properties

In order to differentiate between different prosthetics used in hernia surgery, it is important to discuss the variables that exist in mesh design. These include whether the material is synthetic or biological, absorbable or non-absorbable, its molecular weight and the size of its pores.

Table 6.1 'Sanders–Kingsnorth' properties of the 'ideal' mesh [58]

Biocompatibility	Must not do any harm
	Should reinforce and resist mechanical strains
	Should allow normal physiological function
	Should be physically and chemically inert
	Should produce a controlled/predicted biological response
	Should be noncarcinogenic
	Should not produce a state of allergy or hypersensitivity
	Should not migrate/dislocate from tissues
	Should not adhere to viscera
Infection-risk	Should be resistant to infection
	Should not transmit infectious diseases
Handling	Should be easily implantable
	Should be easy for the surgeon to handle
	Should not restrict future surgical access or radiological imaging
Socioeconomics	Should be easy to manufacture
	Should be easy to sterilize
	Should be widely available
	Should be inexpensive
Longevity	Should maintain all of the characteristics of the above in the long term

6.2.1 Materials

The polymer type refers to the material that the mesh is constructed from. Broadly speaking polymers could be either plastics (synthetics), biological materials or a combination.

6.2.1.1 Plastic (Synthetic) Meshes: Non-Absorbable

The term plastic refers to any of the numerous organic, synthetic or processed materials that are mostly high-molecular-weight thermoplastic polymers, which can be modelled, casted, extruded, drawn or laminated into objects, films or filaments.

Three polymers have dominated within plastic mesh construction—polypropylene (PPM), polyester and expanded polytetrafluoroethylene (ePTFE). More recently other plastic polymers, namely, cPTFE (condensed PTFE) and polyvinylidene fluoride (PVDF), have been used.

Fig. 6.1 PPM

Polypropylene Mesh (PPM)

PPM (Fig. 6.1) is derived from propylene through controlled polymerization. The propylene is derived from propane gas, a technique pioneered by the Italian scientist Giulio Natta [59].

Using a regulating metre, the liquid polymer is extruded as a monofilament of predetermined width and strength. PPM is fashioned by braiding the filaments to form fibres, which are then knitted together to create a hydrophilic mesh.

Different forms of PPM are created by changing the size of the fibres and the knitting design.

Usher popularized PPM for use in hernia surgery in 1962, when a polypropylene version of Marlex® (Bard), subsequently known as Bard® mesh (initially made of polyethylene), was developed [19, 60]. This had the advantage of being amenable to sterilization via autoclaving. Several mesh manufacturers now produce a PPM (Tables 6.5, 6.6 and 6.7).

Polyester Mesh

This is a polymer of ethylene glycol and terephthalate. It was developed in 1941 by Whinfield and Dickinson [59]. Similar to polypropylene, the raw material is melt extruded to produce fibres, which can be woven or bonded to produce threads, or assembled into sheets of material, which are again hydrophilic in nature.

The first monofilament polyester mesh was popularized by DuPont and was called Dacron® [59]. Subsequently a multifilament polyester

mesh called Mersilene® (Ethicon) was produced, and later a collagen-coated polyester mesh called Parietex Composite™ (Covidien™) was developed. Polyester meshes have not been as widely adopted worldwide as PPM; however, in France, Italy and Belgium, they are commonly used with satisfactory results [22, 61, 62].

Compared to PPM, polyester meshes are characterized by rapid fibroblastic infiltration and tissues fixation with less mesh shrinkage [51]. However, polyester meshes have a higher rate of adhesion to viscera if placed in the intra-abdominal position without collagen coating [62] and degradation or loss of strength over time [63]. They may also have higher infection rates, although the evidence is mixed [64]. Larger scientifically robust studies are required however to evaluate the use of polyester mesh on a wider scale [59, 62].

ePTFE

This is a hydrophobic, laminar, microporous prosthetic material with negative charge. It is composed of compact nodules interlinked by fine fibres, the length of which determines the materials internodal distance and pore size range. Polytetrafluoroethylene (PTFE) was first used for hernia repair by Harrison in 1957 [65], but its use was abandoned after initial promising results due to its poor performance [66]. The process of expanding PTFE was refined by Gore®, and the first mass-produced ePTFE prosthesis for hernia surgery was the Gore® Soft Tissue Patch® (STP) [300]. The material has a good biological tolerance with minimal inflammatory reaction compared with PPM or polyester mesh [67–72]. It therefore has advantages when the mesh is placed in the intraperitoneal position in contact with the viscera [73, 74] and as a result has been the most commonly used prosthetic for laparo-endoscopic or intraperitoneal mesh placement [75]. It does, however, have poor tissue incorporation and high recurrence rates of 18–30% in small trials [76, 77]. In order to overcome these problems, modifications have been made to ePTFE via introduction of multiple perforations in the ePTFE patch, and hence MycroMesh® (Gore®) was produced [72]. Experimental studies showed no biomechanical benefits and greater adhesions on the peritoneal surface over the conventional ePTFE mesh [78], so further modifications created a dual layered mesh with a corduroy surface to encourage ingrowth on one side and a smooth surface on the peritoneal side (DualMesh® (Gore®). Once again, experimental studies showed little difference compared to conventional ePTFE [79, 80]. Copolymerization of ePTFE with other polymers, such as PPM, has produced more promising results [81, 82].

Another disadvantage of ePTFE lies in its behaviour in the presence of infection. Several studies have shown that ePTFE is more susceptible to infection than other biomaterials [83–87] and that in the presence of infection most ePTFE implants will need to be removed [88, 89]. In order to overcome this issue, the prostheses were pretreated with antimicrobial agents, and new meshes (DualMesh® Plus and MycroMesh® Plus (Gore®)) have been manufactured, and their in vitro efficiency has been demonstrated [90].

In order to combine the reported inertness of ePTFE with the benefit of the tissue ingrowth observed with macroporous PPM and polyester meshes, Gore® developed a novel macroporous non-expanded PTFE mesh, known as INFINIT® mesh (Gore®). Unlike ePTFE prostheses, this mesh is intended for extraperitoneal hernia repair only. In an animal study examining its mechanical and histological properties, INFINIT® mesh showed comparable characteristics to PPM in terms of strength and tissue ingrowth [91]. There is currently no clinical trial data to support its use over other prosthesis.

cPTFE

This is a non-woven, macroporous material that is fashioned by a PTFE condensing process. The concept is that it combines the open mesh design required for tissue integration and in vivo implant flexibility, with the inherent property of laminar ePTFE in generating an organized neoperitoneum [92]. Compared to the ePTFE, the cPTFE

has shown promising results in terms of mesh integration with reduced visceral adhesions and reduced infection risk [92–94] but has no long-term results available. MotifMESH™ (Proxy Biomedical) and Omyra® (Braun) and Omyra® (Braun) (Fig. 6.2) are currently available in the market.

PVDF

This is a non-absorbable fluoropolymer. Its sutures have been widely used in cardiothoracic and orthopaedic surgery [95, 96], and very promising results have been confirmed by in vitro and in vivo studies of meshes [97–100]. In comparison with PPM and polyester meshes, PVDF meshes have shown similar tensile strength and surface characteristics with more resistance to hydrolysis, degradation and stiffening [100].

Compared to PPM, PDVF was found to have superior integration using rat models [100]. The inflammatory process was less intense with PVDF compared to lightweight large-pore PPM. The collagenous capsule was limited to the perifilamentary region rather than producing a scar plate that incorporated the entire mesh. Berger et al. studied the use of PVDF/PPM (DynaMesh®—Fig. 6.3) composite mesh in laparo-endoscopic (IPOM) incisional hernia repair and parastomal hernia repair in 344 consecutive patients [101–103]. They concluded 0.3% recurrence in the incisional hernia group and 2% recurrence in the parastomal hernia group. Unfortunately, in a small retrospective review of 29 laparo-endoscopic (IPOM) incisional hernia repairs with DynaMesh®, extremely high complication rates were encountered [104]. Six patients (20.6%) required repeat surgery, five due to development of adhesions and one due to mesh infection. Two further patients, who had subsequent surgery for unrelated reasons, were also reported to have adhesions to the mesh. There is currently a lack of clinical data and long-term data to support the use of PVDF ahead of other prostheses.

Fig. 6.2 Omyra® Mesh (Braun)

6.2.1.2 Plastic (Synthetic) Meshes: Absorbable

Polyglycolic Acid

This is a popular absorbable suture material. The best-known polyglycolic acid mesh is Dexon® (Syneture) that was first introduced in 1983. It

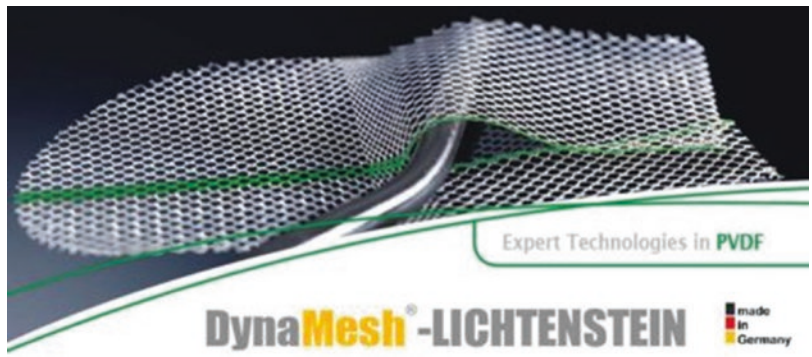

Fig. 6.3 DynaMesh®

can be cut to any size without fraying and is completely absorbed within 90–180 days [105–107]; however, 2–10 weeks post implantation, its mean tensile strength decreases by 50% [108]. The polyglycolic acid mesh is not widely used as there are mixed views as to whether the fibrous ingrowth into the mesh is sufficient to achieve permanent repair [75, 83, 106].

Polyglactin 910

This is polyglycolic acid copolymerized with lactic acid. It is available in the market as Vicryl® (Ethicon). Evidence suggests that the rate of absorption of Vicryl® is more variable than Dexon® [108]. Compared with Dexon®, Vicryl® meshes invoke less collagen ingrowth and less adhesions and are frequently associated with early recurrences [60, 91]. It was therefore used in the intraperitoneal hernia repair, but the subsequent development of improved composite meshes has resulted in its infrequent use in today's practice [75].

6.2.1.3 Plastic (Synthetic) Meshes: Bioabsorbable Meshes

This new generation of meshes was designed as part of an attempt to reduce the complications encountered with traditional synthetic meshes, predominantly postoperative pain. It was also believed that non-permanent prostheses might be suitable for use in contaminated areas and intraperitoneal placement. At present, there is limited clinical information to support or refute these hypotheses.

The *Bio-A* is made of trimethylene carbonate and polyglycolic acid, and it is supplied as a flat sheet that could maintain about 70% of its original tensile strength for 3 weeks. Studies have shown high efficacy for complex situations [109]. Another example is the *Safil mesh* (Fig. 6.4) that is made of polyglycolic acid and could maintain 50% of its tensile strength at 20 days. It is absorbed 60–90 days post insertion, and hence the infection rate is low.

TIGR Matrix mesh (Fig. 6.5) is made of polyglycolic acid and polylactic acid absorbable fibres. Compared to conventional mesh implants, it maintains its tensile strength for the initial

Fig. 6.4 Safil mesh (B Braun)

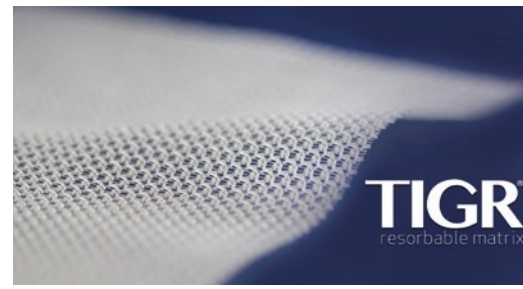

Fig. 6.5 Tigr mesh (Novus Scientific)

6–9 months post insertion. The process of absorption of the mesh starts by degradation of the polyglycolic acid fibres, and 9 months later the polylactic acid fibres disappear.

Phasix is another example of bioabsorbable meshes that is made from poly-4-hydroxybutyrate (P4HB). It is completely absorbed about 52 weeks post insertion. The variant Phasix ST is available as a flat mesh sheet that is coated with carboxymethylcellulose and hyaluronic acid.

6.2.1.4 Composite/Hybrid Meshes

This is a relatively new concept in mesh development. There are clear reasons to use a permanent material in the repair of fascial defects. There are equally real reasons to consider the use of products that are not permanent but seek to increases the levels of collagen deposition to enhance the healing process. These composite meshes seek to capitalize on the benefits of both of these concepts (see Table 6.6). Following mesh implantation, the absorbable fibres will degrade leaving the non-absorbable fibres for long-term support. The added surface properties facilitate mesh placement especially in laparo-endoscopic hernia surgery as they are considered safe to place in contact

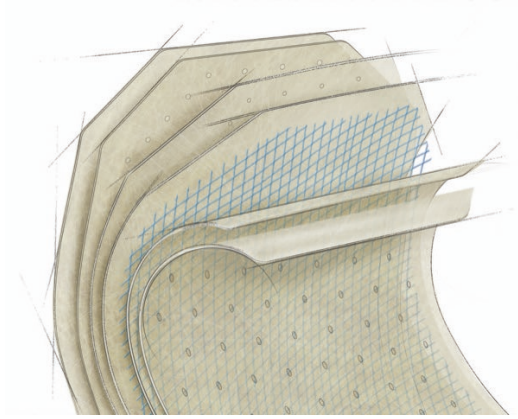

Fig. 6.6 Zenapro® (Cook Medical)

with the viscera. Long-term data is still required to validate this claim. An extra marker (mesh indicator) is added to the mesh surface to help with mesh orientation. There is relatively little data on the actual results of the use of these materials, but these will undoubtedly be researched in the future. Some commonly used examples include OviTex® (TELA Bio), Synecor® (Gore®) and Zenapro® (Cook Medical—Fig. 6.6).

6.2.1.5 Biological Meshes

The term xenogenic graft is used to describe biological tissue grafts from animal sources (porcine or bovine), whilst the term allogenic graft is used to describe grafts from humans.

They are usually made either from dermis, submucosa of the small intestine or the pericardium and were initially introduced for the purpose of hernia repair in infected or contaminated sites.

The process of manufacturing and preparation starts by rendering the grafts acellular through various decellularization methods that employ enzymatic, chemical or physical processes. They are then subjected to sterilization techniques including gamma irradiation, ethylene oxide gas and hydrogen peroxide plasma [110]. The end result is a collagen-rich scaffolding that allows cellular ingrowth, tissue remodelling and neovascularization; however, the specific manufacturing processes that yield modified collagen matrices vary significantly between different products [80].

Fig. 6.7 Permacol® All rights reserved. (Used with the permission of Medtronic)

The early results of using the biological meshes were very promising; however, several complications have been reported following its use in hernia repair including degradation, laxity, lack of integration and hernia recurrence [111, 112]. A failure rate of 8% at 19 months for grafts made from submucosa of the small intestine used for incisional hernia repair has been demonstrated [113]. By comparison an aggregate failure rate of 15% at 12 months has been reported for non-cross-linked acellular human dermis grafts and 8% at 15 months for cross-linked porcine dermis [113]. However there are multiple confounding factors in these studies including differing repair techniques and a predominance of their use in infected fields [113]. It has been suggested that when these grafts are used as a fascial bridge, the rates of recurrence are highest (80% recurrence rate compared to 5% recurrence rate when used as an onlay graft) [114, 115]. The primary use of biological meshes has been for complex abdominal wall reconstruction and in infected operative fields; however, a recent systematic review found no benefit in potentially contaminated wounds over synthetic meshes. In fact they noted increased recurrence rates (30% vs. 9%) in definitely contaminated hernias repaired with biological meshes compared to synthetic meshes [116].

Another systematic review investigated the efficacy of biological meshes but found mostly case studies which failed to provide any consistent data regarding recurrence rates (ranging from 0 to 80%) or complications [113]. Two examples are Permacol® (Medtronic—Fig. 6.7) which is a cross-linked biology and Strattice® (Acelity) which is non-cross-linked.

6.2.1.6 Cross-Linked Vs. Non-Cross-Linked

In order to delay the degradation process of the collagen by the collagenase enzyme, some biomaterials are cross-linked aiming at increasing the stability of the collagen [117, 118]. Yet it has been suggested that cross-linking leads to non-incorporation of the graft and preclusion of immune cell penetration [110, 117]. Some studies have compared the use of both cross-linked and non-cross-linked meshes in hernia surgery. It was suggested that the cross-linked materials might be more durable in the remodelling process as evident by the increased thinning in non-cross-linked biomesh [119]. This is in agreement with an animal study that has suggested that it is safe to use cross-linked biomesh in repair of ventral hernia [120].

The use of biological meshes has been limited in clinical practice by its significantly higher costs.

6.2.2 Mesh Construction

Synthetic meshes are fabricated from monofilament or multifilament materials that can be woven, knitted or shaped into flat sheets; however the multifilament materials are associated with increased risk of bacterial adhesion in vitro and in vivo [90, 121, 122], presumably due to their increased surface area.

With advances in technology and increased popularity of laparo-endoscopic intraperitoneal mesh repairs, meshes constructed using copolymerization and coating of meshes have been increased in order to reduce adhesion formation.

Broadly speaking, these modifications can be classified into two methods [123]. The first process involves treating the prosthesis to create an appropriate interface between the biomaterial and the visceral peritoneum. These treatments are usually absorbable barriers or chemical solutions. Examples include the use of gelatin films [124], Interceed® [125], carboxymethylcellulose [126], polyethylene glycol [127] and hyaluronate [127]. The second process involves a physical barrier usually in the form of a non-absorbable biomaterial. Experimental animal studies show contradictory results; a mesh superior to another in terms of adhesion in one study may be inferior to the same mesh in another study (Table 6.2).

6.2.3 Mesh Weight and Pore Size

There is no agreed definition for ‘lightweight’ or ‘heavyweight’ meshes, they are more industrial terms. Alternatively, the terms small- and large-pore meshes have been used. The weight of the mesh depends on the amount and the weight of the polymer used [128]. In 2010, it was stated that the term ‘lightweight’ is not simply a descriptive term of a low-weight product nor a cut-off value of the weight per square metre or specific pore size [54]. Lightweight meshes typically refer more to meshes with a larger pore size, resulting in smaller surface area. The lower amount of material present in lightweight mesh should lead to decreased foreign body reaction and fibrosis [129, 130]. It has been suggested that the increased flexibility of lightweight meshes should result in a better activity profile postoperatively [131]. The strength of lightweight meshes has been questioned especially in the large hernia defect repair and the risk of sutures tearing out of the mesh [128].

In comparison with lightweight meshes, heavyweight meshes have an increased surface area resulting in intense inflammatory reaction with a tendency to shrink. Heavyweight meshes are stiffer, which interfere with the normal abdominal movements [132]. Some surgeons have blamed the heavyweight meshes for high complication rates such as pain, adhesions and fistula formation, especially with intraperitoneal mesh repairs [133] as well as extraperitoneal repairs [75], but there is a discrepancy between this clinical claim and the published data [54].

Porosity also appears to be important factor in infection resistance. If pore sizes are less than 10 microns, macrophages and neutrophil granulocytes are unable to pass through the pores [134].

6.2.4 Tensile Strength and Elasticity

A healthy adult can generate a maximum intra-abdominal pressure of approximately 170 mmHg

Table 6.2 Experimental studies comparing adhesion formation of different prosthetic materials

Year	Author	Animal	*N*	Meshes	Open/Lap	Fewer adhesions	More adhesions	Timescale
1983	Jenkins et al. [124]	Rats	41	PPM (Marlex®)	Open	Vicryl®	PPM (Marlex®)	1, 2, 4, 8 weeks
				Vicryl®			PPM (Marlex®) + Gelfilm®	
				ePTFE				
				Silastic				
				PPM (Marlex®) + Gelfilm®				
1993	Naim et al. [125]	Rats	–	PPM + ePTFE	Open	PPM + Interceed®	–	–
				PPM + Interceed®				
				PPM + Poloxamer				
1996	Bellón et al. [78]	Rabbits	24	PPM (Marlex®)	Open	ePTFE (MycroMesh®)	PPM (Marlex®)	14, 30, 60, 90 days
				ePTFE (MycroMesh®)				
1997	Baykal et al. [128]	Mice	72	PGA	Open	PGA	PPM	5, 14 days
				PPM				
1998	Dasika and Widmann [129]	Rats	47	PPM	Open	Vicryl®	PPM	1, 2, 3 months
				Vicryl®		PPM + Vicryl®		
				PPM + Vicryl®				
1999	Bellón et al. [130]	Rabbits	48	ePTFE (STP®)	Open	ePTFE (STP®)	–	14, 30, 60, 90 days
				PPM (Marlex®)		Lyodura®		
				PPM (Prolene®)				
				Lyodura®				
2000	Vrijland et al. [48]	Rats	44	PPM	Open	PPM + Fluorosoft®	PPM + Vicryl®	60 days
				PPM + Vicryl®				
				PPM + Fluorosoft®				
2000	Bellón et al. [131]	Rabbits	8	ePTFE (MycroMesh®)	Open	–	PPM (Marlex®)	3, 7 days
				ePTFE (DualMesh®)				
				ePTFE (STP®)				
				PPM (Marlex®)				
2002	Bellón et al. [132]	Rabbits	14	ePTFE (DualMesh®)	Open	ePTFE (DualMesh®)	ePTFE (CV-4®)	14 days
				ePTFE (CV-4®)				
2002	Zieren et al. [133]	Rats	40	ePTFE (DualMesh®)	Open	No difference	No difference	14, 90 days
				Polyester composite				

2003	Van't Riet et al. [134]	Rats	91	PPM PPM + Icodextrin Sepramesh® Parietex™	Open	Sepramesh® Parietex™	PPM PPM + Icodextrin	7, 30 days
2003	Matthews et al. [135]	Rabbits	20	ePTFE (DualMesh®) PPM (Marlex®)	Open	ePTFE (DualMesh®)	PPM (Marlex®)	1, 3, 9, 16 weeks
2004	Borrazzo et al. [136]	Pigs	21	PPM ePTFE (DualMesh®) Sepramesh®	Lap	Sepramesh®	–	28 days
2004	González et al. [137]	Rats	80	PPM (Parietene®) Parietex Composite™ Parietene Composite® Composix®E/X Sepramesh® ePTFE (DualMesh®)	Open	Parietex Composite™ Parietene Composite® Composix®E/X ePTFE (DualMesh®)	PPM (Parietene®) Sepramesh®	21 days
2004	Butler and Prieto [138]	Guinea pigs	19	PPM (Prolene®) PPM (Prolene®) + AlloDerm®	Open	PPM (Prolene®) + AlloDerm®	–	4 weeks
2005	Kayaoglu et al. [139]	Rats	60	PPM (Surgipro™) ePTFE (DualMesh®) Sepramesh® Vypro II® Parietex Composite™	Open	ePTFE (DualMesh®) Sepramesh®	–	4 weeks
2005	Matthews et al. [140]	Rabbits	30	ePTFE (DualMesh®) Composix®E/X Sepramesh®	Open	ePTFE (DualMesh®)	–	1, 3, 9, 16 weeks
2005	Demir et al. [141]	Rats	30	PPM (Bard® Mesh) Composix®E/X PPM (Bard® Mesh) + Interceed®	Open	PPM (Bard® Mesh) + Interceed®	–	14 days
2005	McGinty et al. [142]	Pigs	8	PPM (Prolene®) ePTFE (DualMesh®) Parietex Composite™	Lap	Parietex Composite™	–	28 days
2005	Konstantinovic et al. [143]	Rats	48	PPM (Marlex®) Surgisis®	Open	PPM (Marlex®) (30 days) Surgisis® (90 days)	–	30, 90 days

(continued)

Table 6.2 (continued)

Year	Author	Animal	*N*	Meshes	Open/Lap	Fewer adhesions	More adhesions	Timescale
2006	Sikkink et al. [144]	Rats	60	PPM (Prolene®) PPM (Prolene®) + Hyalobarrier® gel PPM (Prolene®) + Tissucol® ePTFE (DualMesh®) Sepramesh® Parietene Composite®	Open	Sepramesh®	PPM (Prolene®)	2 months
2006	Dilege et al. [145]	Rats	30	PPM (Prolene®) PPM +Interceed® Sepramesh®	Open	PPM + Interceed® Sepramesh®	PPM (Prolene®)	28 days
2006	Burger et al. [146]	Rats	200	PPM (Prolene®) ePTFE (DualMesh®) Ultrapro® Timesh® Sepramesh® Parietex Composite™ Proceed® Tutomesh®	Open	Sepramesh® Parietex Composite™	–	7, 30 days
2006	Harrell et al. [147]	Rabbits	60	ePTFE (DualMesh®) Composix®E/X Proceed® PPM (Marlex®)	Sequential lap	ePTFE (DualMesh®)	PPM (Marlex®)	16 weeks
2007	Kiudelis et al. [148]	Rabbits	42	PPM (Prolene®) Mersilene® PPM + Vicryl® ePTFE Bard® Proceed®	Open	ePTFE Bard® Proceed®	PPM (Prolene®) Mersilene® PPM + Vicryl®	30 days
2007	Jacob et al. [149]	Pigs	10	Proceed® Parietex Composite™ PPM	Lap	Parietex Composite™	PPM	28 days
2007	Voskerician et al. [93]	Rats	–	cPTFE (MotifMESH™) ePTFE (DualMesh®) Composix™ PPM (Marlex®) Proceed®	Open	cPTFE (MotifMESH™) Composix™	PPM (Marlex®)	1, 3 months

2007	Novitsky et al. [46]	Rabbits	20	PPM (Marlex®) ePTFE (DualMesh®) Composix® E/X Proceed®	Open	ePTFE (DualMesh®)	PPM (Marlex®)	1 year
2007	Bellón et al. [150]	Rabbits	24	Parietex Composite™ Sepramesh® PPM-PU 99	Sequential lap	Parietex Composite™ PPM-PU 99	Sepramesh®	3, 7, 14 days
2007	Miwa et al. [53]	Rats	20	PPM Composix® E/X	Open	Composix® E/X	PPM	3 months
2008	Marcondes et al. [151]	Rabbits	24	PPM (Surgipro™) Sepramesh® Composix®E/X	Lap	Sepramesh®	PPM (Surgipro™)	28 days
2008	Matin-Cartes et al. [152]	Pigs	10	PPM ePTFE (DualMesh Plus®) PPM + fibrin glue ePTFE (DualMesh Plus®) + fibrin glue	Open	PPM + fibrin glue ePTFE (DualMesh Plus®) + fibrin glue	PPM ePTFE (DualMesh Plus®)	5 weeks
2008	Junge et al. [97]	Rats	40	PVDF + PPM (DynaMesh®) Parietene Composite® ePTFE (DualMesh®) PPM	Open	Parietene Composite®	PPM	30 days
2008	Conze et al. [98]	Rabbits	–	Co-PVDF® PPM (Prolene)	Lap	No difference	No difference	7, 21, 90 days
2008	Schug-Pass et al. [153]	Pigs	6	PPM (TiMesh® Light) PPM (TiMesh®) + SurgiWrap®	Lap	No difference	No difference	3 months
2008	Prieto-Diaz-Chavez et al. [154]	Rats	40	PPM + fibrin glue PPM	Open	PPM + fibrin glue	PPM	–
2009	Junge et al. [97]	Rats	40	PVDF + PPM PPM + Col ePTFE (DualMesh®) PPM	Lap	PVDF + PPM PPM + Col	PPM ePTFE (DualMesh®)	30 days
2009	Emans et al. [155]	Rats	–	PPM (Prolene®) Proceed® PPM + NVP/BMA	Open	Proceed® (7 days) PPM + NVP/BMA (30 days)	PPM (Prolene®)	7, 30 days

(continued)

Table 6.2 (continued)

Year	Author	Animal	*N*	Meshes	Open/Lap	Fewer adhesions	More adhesions	Timescale
2009	Pierce et al. [156]	Rabbits	41	C-Qur™ PPM (Prolite Ultra™) Composix® Parietex™ Proceed® Sepramesh® ePTFE (DualMesh®)	Open	C-Qur™	Proceed® Composix®	120 days
2009	Schreinemacheret al. [157]	Rats	–	PPM (Prolene®\0 TiMesh® PPM (Ultrapro®) Proceed® Parietex Composite® c-Qur™	Lap	Parietex Composite® (7 days) C-Qur™ (7 days) No difference (30 days)	–	7, 30 days
2009	Costa et al. [158]	Rats	55	PPM PPM + PAF SIS	Open	SIS	PPM PPM + PAF	–
2009	Ansaloni et al. [159]	Rats	60	PPM PPM-PU 99 PPM + SIS PPM + ePTFE No mesh (control)	Open	PP—PU 99 PPM + SIS	PPM + ePTFE	21, 90, 180 days
2009	Jin et al. [160]	Pigs	9	cPTFE cPTFE + HPM Polyester—collagen composite HPM	Open	HPM Polyester—collagen composite	–	90 days
2010	Voskerician et al. [161]	Rats	20	cPTFE cPTFE + HPM cPTFE + HFL	Open	cPTFE + HPM	cPTFE cPTFE + HFL	30 days
2010	Zinther et al. [162]	Sheep	16	Parietex Composite® PVDF + PPM (DynaMesh®)	Lap	Parietex Composite®	PVDF + PPM (DynaMesh®)	3, 6 ,12, 18 months

2010	Gaertneret al. [163]	Rats	–	PPM (Marlex®) PPM (Surgipro™) Composix® E/X ePTFE (STP®) MycroMesh® ePTFE (DualMesh®) Vicryl® Mesh Vypro II® Parietex Composite™ Sepramesh® AlloDerm® Permacol™ Peri-Guard® Veritas®	Open	Parietex Composite™ Sepramesh®	–	7 days
2010	Gruber–Blum et al. [164]	Rats	32	SurgiWrap® Prevadh® Seprafilm®	Lap	SurgiWrap® Prevadh®	SurgiWrap®	30 days
2011	Rodriguez et al. [165]	Rabbits	18	Parietex Composite™ Sepramesh® Proceed®	Open	Parietex Composite™	Sepramesh® Proceed®	3, 7, 14 days
2011	Fujino et al. [166]	Rabbits	–	PPM + PLLA PPM + Seprafilm®	Open	PPM + PLLA	–	4 weeks
2011	Yao et al. [167]	Rats	93	PPM + PLC PPM + HA + PLC PPM + Collagen + PLC	Open	PPM + Collagen + PLC	PPM + PLC PPM + HA + PLC	30, 60, 90 days

- AlloDerm®—decellularized human dermis (LifeCell™)
- Co-PVDF®—auto manufactured mesh woven with PVDF polymer (Solvay)
- Composix®—nonwoven ePTFE (Bard®)
- Composix® E/X—PPM mesh sewn with polypropylene stitching to a thin sheet of ePTFE (Bard®)
- cPTFE (MotifMESH®)—nonwoven macroporous condensed PTFE (Proxy Biomedical)
- C-Qur™—PPM with an omega-3 fatty acid bioabsorbable coating (atrium)
- PGA—polyglycolic acid
- Poloxamer—triblock copolymers consisting of central hydrophobic block of polyethylene glycol flanked by two
- Hydrophilic blocks of polyethylene glycol
- Polyester composite—polyurethane-covered Dacron mesh (Braun)
- PPM (Marlex®)—monofilament PPM mesh (Bard®)
- PPM (Prolene®)—monofilament PPM mesh (Ethicon)

(continued)

Table 6.2 (continued)

Year	Author	Animal	*N*	Meshes	Open/Lap	Fewer adhesions	More adhesions	Timescale
– ePTFE (CV-4®)—auto manufactured mesh woven out of ePTFE suture thread CV-4 (Gore®)				– PPM (ProLite Ultra™)—PPM (atrium)				
– ePTFE (DualMesh®)—two-layered ePTFE mesh with one smooth surface and one corduroy surface (Gore®)				– PPM + PAF—PPM with a coating of polylactic acid film				
– ePTFE (STP®)—Gore-Tex Soft Tissue Patch, ePTFE with two laminar microporous surfaces (Gore®)				– PPM + PLC—PPM with a polylactide-co-caprolactone coating				
– Fluorosoft®—fluoropassivated polyester (SulzerVacutek®)				– PPM + PLLA—PPM with poly-L-lactic acid film				
– Gelfilm®—absorbable gelatin film (Pharmacia and Upjohn)				– PPM + HA + PLC—PPM with a hyaluronic acid and polylactide-co-caprolactone coatings				
– Hyalobarrier® Gel—sterile transparent and highly viscous gel obtained by condensation of hyaluronic acid (Fidia Advanced Biopolymers SRL)				– PPM + Collagen + PLC—PPM/collagen composite with a polylactide-co-caprolactone coating				
– HFL—human fascia lata				– PPM + NVP/BMA—PPM with N-vinyl pyrrolidone and n-butyl methacrylate coating				
– HPM—human peritoneal membrane				– PPM-PU 99—auto designed prosthesis composed of reticular PPM mesh and a non-absorbable polyurethane film				
– Icodextrin—iso-osmolar biodegradable, 1,4-linked glucose polymer solution (Baxter)				– PPM (Surgipro™)—monofilament PPM mesh (Covidien™)				
– Interceed—oxidized regenerated cellulose (Ethicon)				– Prevadh®—biological anti-adhesive barrier (Sofradim)				
– Lyodura®—lyophilized Dura mater (Braun®)				– Proceed®—PPM, polydioxanone composite with oxidized cellulose coating (Ethicon)				
– Mersilene—polyester mesh (Ethicon)				– PVDF + PPM (DynaMesh®)—two-component (PPM + PVDF) monofilament mesh (DynaMesh)				
– MycroMesh®—ePTFE (Gore®)				– Seprafilm®—bioabsorbable translucent membrane composed of carboxymethylcellulose and hyaluronic acid (Genzyme)				
– Parietene Composite®—PPM mesh bonded on one side to a collagen-oxidized film (Sofradim)				– Sepramesh®—PPM mesh coated on one side with a Seprafilm® (Bard®)				
– Parietex Composite™—collagen-oxidized film treated polyester mesh (Covidien™)				– Silastic—polydimethylsiloxone prosthesis (Dow Corning)				
– Permacol™—porcine dermal collagen implant (Covidien™)				– SIS—porcine small intestine submucosa mesh				
– Peri-Guard®—patch made from bovine pericardium (Synovis®)				– SurgiWrap®—bioresorbable adhesion barrier film (Mast)				
– PGA—polyglycolic acid				– Surgisis®—derived from porcine small intestine submucosa (Cook)				
– Poloxamer—triblock copolymers consisting of central hydrophobic block of polyethylene glycol flanked by two hydrophilic blocks of polyethylene glycol				– TiMesh®—PPM with titanium coating (PFM Medical)				

– Polyester composite—polyurethane-covered Dacron mesh (Braun)	– Tissucol®—fibrin glue (Baxter)
– PPM (Marlex®)—monofilament PPM mesh (Bard®)	– Tutomesh®—acellular collagen matrix from bovine pericardium (RTI Biologics)
– PGA—polyglycolic acid	– Ultrapro®—partially absorbable composite PPM/poliglecaprone-25 monofilament mesh (Ethicon)
– Poloxamer—triblock copolymers consisting of central hydrophobic block of polyethylene glycol flanked by two hydrophilic blocks of polyethylene glycol	– Veritas®—acellular bovine pericardium (collagen not cross-linked) (Synovis)
	– Vicryl® (Mesh)—Polyglactin 910 (Ethicon)
	– Vypro II®—PPM/polyglactin 910 composite mesh (Ethicon)

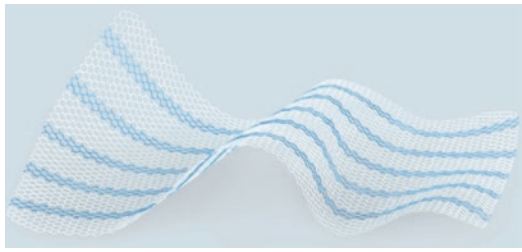

Fig. 6.8 TiMesh®

whilst coughing or jumping [135]. Therefore, meshes used in hernia repair need to tolerate pressure up to at least 180 mmHg before bursting (tensile strength up to 32 N). Moreover, it is important that the strength of meshes is tested in a biaxial fashion. Virtually all meshes tested in vitro are able to withstand this pressure, even the lightweight meshes (e.g. Vypro burst pressure = 360 mmHg [136]). Exceptions are 'ultra-lightweight' meshes, such a TiMesh® extralight (16 g/m^2) (Fig. 6.8), which has a tensile strength of only 12 N [137]; however, in a clinical trial assessing its performance in groin hernia repair, it performed favourably [137].

The natural elasticity of the abdominal wall at 32 N is about 38%. More compliant lightweight meshes have been shown to have an elasticity of about 20–35% at 16 N [136]. Less compliant heavyweight meshes have only half this elasticity (4–16% at 16 N) and therefore may restrict abdominal movement and distension in some patients.

6.2.5 Classification of Meshes

Classification systems are vital in improving the possibility of comparing different studies and their associated results and would enable us to structure evidence-based therapeutic guidelines regarding the use of certain meshes in different clinical scenarios.

The best-documented mesh classification system was created by Amid in 1997 [138] based on mesh porosity (Table 6.3).

In 2012, a German research group, in conjunction with mesh manufacturers, devised an alternative classification system taking into account developments in the prosthetics industry [139].

Table 6.3 Amid mesh classification system [178]

Type	Description
Type I	Macroporous
Type II	Microporous
Type III	Macroporous or microporous components
Type IV	Biomaterials with submicronic pores/sheets

Table 6.4 The German group mesh classification system [179]

Class	Description	Subgroups/ features
Class I	Large pore meshes (textile porosity of >60% or an effective porosity of >0%)	Monofilament
		Multifilament
		Mixed structure or polymer
Class II	Small pore meshes (textile porosity of <60% and without any effective porosity)	Monofilament
		Multifilament
		Mixed structure or polymer
Class III	Meshes with special features	To prevent infection
Class IV	Meshes with films	Meshes without porosity
		Submicronic pore size
		Secondarily excised pores
Class V	3D meshes	
Class VI	Biological	Non-cross-linked
		Cross-linked
		Special features

This classification system differentiates 'major' differences (objectified through randomized controlled trials) and 'minor' differences (not significantly different in randomized controlled trials) between available meshes (Table 6.4).

The classification is intended to be used for analysis of the data from the registry of hernia repairs, as well as implant failures to detect major mesh material-related problems. These classification systems provide useful comparative groups for research purposes; however, none of the current classification systems give a concise hernia-specific overview of which mesh/group of meshes is best for a particular scenario.

Coda and his working colleagues have proposed a classification system based on defining the weight [140]:

1. Ultralight ≤35 g/m^2
2. Light C 35–70 g/m^2
3. Standard C 70–140 g/m^2
4. Heavy C ≥140 g/m^2

This classification involves grouping of simple, composite or combined meshes, which is based on biomaterial composition: simple (prosthetics made of one pure biomaterial), composite (prosthetics made of two or more different layers), combined (prosthetics made of two materials knitted or woven together) and biologic.

6.2.6 Commercially Available Meshes

Some of the commercially available meshes are shown in Tables 6.5, 6.6 and 6.7. Whilst this is a comprehensive list, it is by no means exhaustive and since writing this more meshes will likely be available on the market. For clarity, they are divided into (a) synthetic non-composite meshes, (b) composite meshes and (c) biological meshes. The list is not exhaustive but rather includes the most commonly used meshes in each category. In addition to the meshes listed, many manufacturers produce plugs/hernia systems made of the same material as the flat meshes for hernia-specific repairs.

6.2.6.1 Low-Cost Mesh

Although the use of alloplastic mesh is a commonplace in more economically developed countries, in developing countries the cost of mesh often prohibits its use. In situations, where commercial material is not available or not affordable, large-pore high-density polyethylene mosquito net has been used as an alternative [141–148]. It has been found to have a similar microscopic structure to the commercially available large-pore meshes (Fig. 6.9) and has comparable bursting forces [149]. In two clinical trials assessing the use of mosquito net compared to a commercial hernia mesh, there was no significant difference in the clinical short-term outcome or in the surgeons' comfort in handling the two different materials [141, 143]. The price of the locally bought polyethylene mesh was US$0.0043 as compared to US$108 for the commercial mesh [143]. Some surgeons initially raised concern over the use of nylon mosquito net and the risk of infection and recurrence [53, 150]; however, recent data shows no difference in complication rate or recurrence rate when compared with commercial mesh [151, 152].

6.3 Techniques of Mesh Fixation

6.3.1 Introduction

The assessment of success rate of surgical repair depends on multiple factors that can be broadly classified into two categories: patient-based outcome measures and surgical outcome measures. The patient-based outcome measures include wound complications, recurrence, length of hospital stay, chronic pain and quality of life. Surgical outcome measures include ease of material handling and its implantation, in addition to the operative time. These two categories are further influenced by a number of factors including patient's demographics and comorbidities, the hernia itself (type, size and complexity), surgical technique, the mesh and the method of fixation used in the repair.

The purpose of mesh fixation is to prevent migration that can potentially lead to hernia recurrence. Different fixation methods have been described including sutures, tacking, stapling devices, fibrin sealant, glues and self-fixing meshes; however, this fixation process can be time consuming and costly. Furthermore, significant complications have been attributed to the method of fixation, presumably due to insufficient fixation or nerve and tissue damage [153]. Complications reported include mesh migration and recurrence [154–158], meshoma [159], tack hernias [160], chronic pain [153, 161–165] and infection [166, 167].

The desirable characteristics of a fixation device (or non-fixation technique) are the same as those factors considered previously in relation to meshes, namely, biocompatibility, prevention of recurrence, handling, socioeconomics, infection risk and longevity.

Table 6.5 Commonly used commercially available meshes (synthetic non-composite)

Non-composite meshes		Special characteristics			Mesh and manufacturer	
Non-absorbable	PPM	Monofilament	Heavyweight/small pore	Preshaped	Atrium™ Mesh (Atrium)	
					Bard Mesh® (Bard)	
					Biomesh® P1 (Cousin)	
					Prolene® (Ethicon)	
					Surgipro™ Monofilament (Covidien™)	
					Trelex® Mesh (Meadox)	
					3DMax® (Bard)	
			Lightweight/large pore	Preshaped	Bard Soft Mesh® (Bard)	
					Biomesh® P8 (Cousin)	
					Optilene®/Optilene LP®, Optilene Elastic® (Braun)	
					Premilene® Mesh (Braun)	
					ProLite™ Mesh/ProLite Ultra™ Mesh (Atrium)	
					Surgipro™ Open Weave (Covidien™)	
					3DMax™ Light Mesh (Bard)	
				Coated	C-Qur™ Mesh (Atrium)	Omega-3 fatty acid coating
					TiMesh® ExtraLight/TiMesh® Light/ TiMesh® Strong (PFM Medical)	Titanium coating
		Multifilament			Surgipro™ (Covidien™)	
	Polyester mesh				Fluorosoft® (SulzerVacutek)	
					Mersilene® (Ethicon)	
					Parietex™ (2D, 3D, lightweight monofilament) (Covidien™)	
			Preshaped		Parietex™ (various preshaped and folding meshes) (Covidien™)	
			Sutureless		ParietexProGrip™ (Covidien™)	
	ePTFE mesh				Bard® Dulex™ Mesh	Two-layered ePTFE mesh with one microporous surface and one macroporous surface
					DualMesh® (Gore®)	Two-layered ePTFE mesh with one smooth surface and one corduroy surface
					Gore Soft Tissue Patch® (Gore®)	Two laminar microporous surfaces
					MycroMesh® (Gore®)	Microporous node and fibril structure with regularly spaced macropores
			Antimicrobial coating		DualMesh® Plus (Gore®)	Silver carbonate and chlorhexidine diacetate
					MycroMesh® Plus (Gore®)	

(continued)

	cPTFE mesh		MotifMESH® (Proxy Biomedical)
			Omyra® Mesh (Braun)
	PTFE	Monofilament macroporous	INFINIT® Mesh (Gore®)
	PVDF mesh		Co-PVDF® (Solvay)
Absorbable	Polyglactin 910		Vicryl® (Ethicon)
	Polyglycolic acid		Dexon® (Syneture)
			Safil® Mesh (Braun)

Table 6.6 Commonly used commercially available meshes (composite meshes)

Composite meshes	Aim	Additional component	Mesh and manufacturer
PPM composites	Improved physiological function	Poliglecaprone 25	Ultrapro® (Ethicon)
		Polyglactin 910	Vypro®/Vypro II® (Ethicon)—Vypro = 69% PPM, 31% Vicryl; Vypro II= 50% PPM, 50%Vicryl
	Improved physiological function/reduced adhesions	Poliglecaprone 25 + polydioxanone	Physiomesh® (Ethicon)
	Reduced adhesions	Collagen-oxidized film	Parietene Composite® (Sofradim)
		ePTFE	Bard® Composix® L/P (Bard)
			Bard® Composix® E/X mesh (Bard)
			Relimesh® (Hernimesh®)
		Hydrogel (polyvinylpyrrolidone + polyethylene glycol)	Intramesh® T1 (Cousin)
			Adhesix (Cousin)—sutureless
		Oxidized regenerated cellulose + polydioxanone	Proceed® (Ethicon)
		PVDF	DynaMesh® (DynaMesh)
		Seprafilm® (carboxymethylcellulose and hyaluronic acid)	Sepramesh® (Bard)
Polyester mesh composites	Reduced adhesions	Collagen-oxidized film	Parietex Composite™/Parietex Optimized Composite™ (Covidien™)
		Dimethylsiloxane	Biomesh® A2 (Cousin)—macroporous
			Intramesh® W3 (Cousin)—microporous
Others	Long-term absorbability (up to 60 weeks)	First fibre = glycolide, lactide and trimethylene carbonate Second fibre = lactide and trimethylene carbonate	Tigr® Matrix (Novus Scientific)
	Encourages type 1 collagen	Polyglycolic acid + trimethylene carbonate	Bio-A® (Gore®)
	Reduced adhesions	Bovine gastric submucosa + polypropylene or polyglycolic acid	Ovitex, Ovitex 1S, Ovitex 2S
	Prevents ingrowth on the visceral side	PTFE + polyglycolic acid/ trimethylene carbonate	Synecor
		Porcine small intestinal mucosa + polypropylene	Zenapro

6.3.2 Fixation Methods

6.3.2.1 Suture Fixation

Since the introduction of plastic hernia meshes in the 1950s, sutures have been the most commonly used method for mesh fixation in open hernia surgery. As a result, suture fixation is often used as the control in studies assessing other fixation methods [156–158, 168–190]. The suture variables that exist are related to the suture material used, the suture technique (interrupted vs. continuous), the bite size, the bite placement (in relation to the edge of the mesh and abdominal wall) and the distance between sutures.

Suture Material

Suture material adds to the prosthetic load in hernia surgery, and this may have an impact on the

Table 6.7 Commonly used commercially available meshes (biological meshes)

Biological meshes		Mesh and manufacturer
Porcine small intestinal submucosa	Non-cross-linked	Surgisis® (Cook)
	Cross-linked	Fortagen® (Organogenesis)
Human acellular dermis	Non-cross-linked	AlloDerm® (LifeCell)
		AlloMax (Bard)
		Flex HD® (Ethicon)
Xenogenic acellular dermis	Non-cross-linked	Strattice® (LifeCell)
		Veritas® (Synovis) SurgiMend® (TEI Biosciences) Tutomesh® (RTI Bilogics) XenMatrix (Brennen)
		Peri-Guard® (Synovis)
	Cross-linked	Permacol™ (Covidien™)
		CollaMend® (Bard)

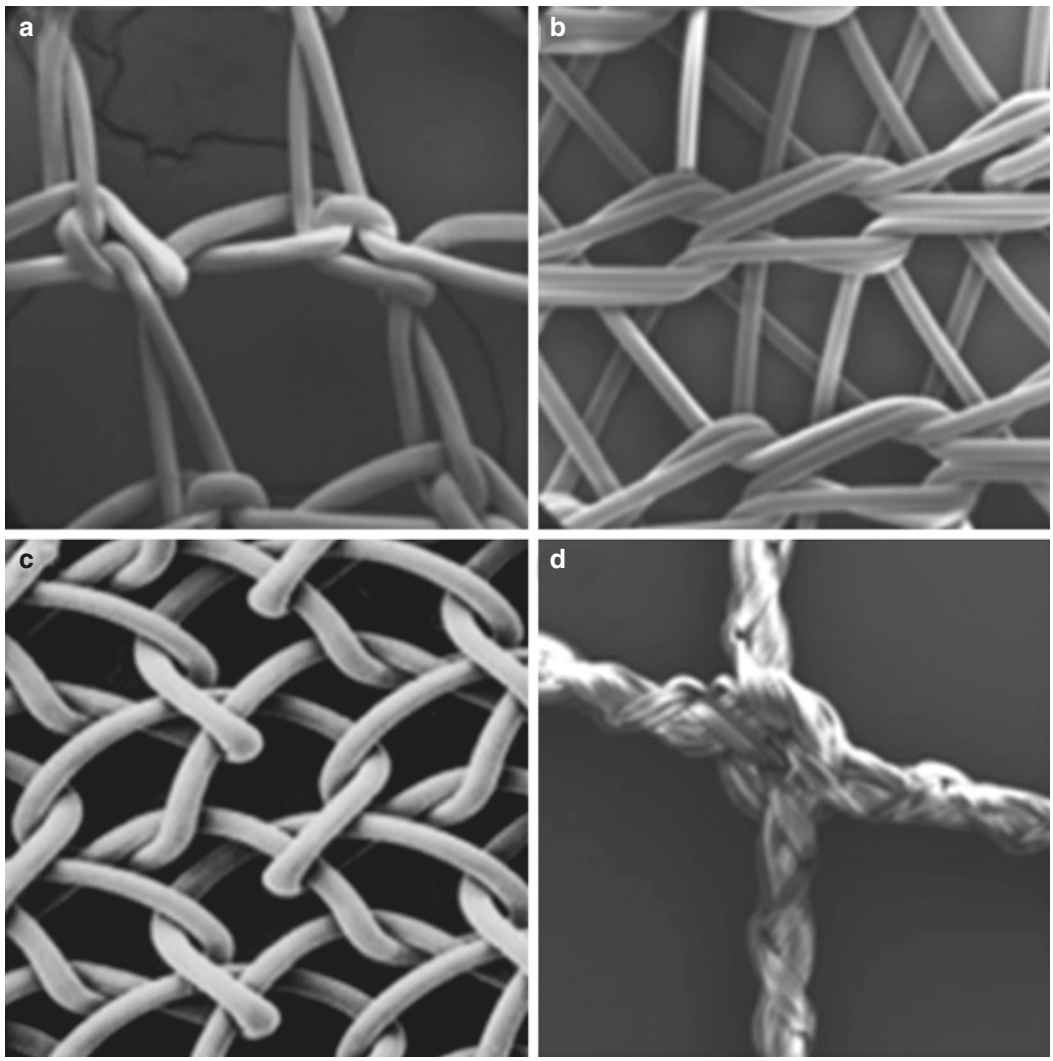

Fig. 6.9 Low-power electron microscopy demonstrating the ultrastructure of polyethylene mosquito net compared to the commercial meshes analysed (JEOL scanning electron microscope 925 original magnification). (**a**) Polyethylene mosquito net, (**b**) ProleneÒ, (**c**) BardÒ mesh, (**d**) VyproÒ, (**e**) UltraProÒ, (**f**) Parietex [189]

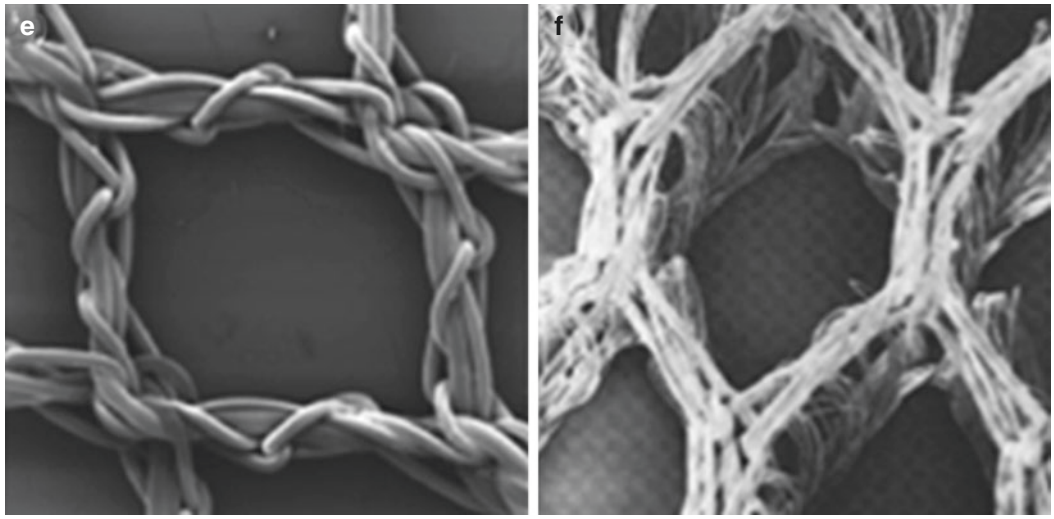

Fig. 6.9 (continued)

rate of mesh infection as well as surgical site infection, which is an important factor contributing to hernia recurrence in addition to morbidity and the costs.

It has been recommended (level of evidence, 2C) to use monofilament non-absorbable or long-term absorbable sutures in mesh fixation. In 2011 a Swedish retrospective review of 82,015 patients concluded that the risk of hernia recurrence following Lichtenstein open inguinal hernia repair is more than double when short-term absorbable sutures were used in mesh fixation compared to non-absorbable and long-term absorbable sutures (RR 2.23, 95% CI 1.67–2.99, p<0.01) [191]. This review was supported by an animal model study comparing polypropylene and polyglactin 910 sutures. At 8 weeks, mesh fixation was found to be significantly greater with polypropylene sutures compared to polyglactin 910 sutures [156].

On the other hand, in 2002 a single surgeon qRCT performed by Paajanen comparing polypropylene and Dexon™ (Syneture) sutures in mesh fixation in 162 inguinal hernia repairs concluded that there is no difference in terms of recurrence, pain or infection with a mean follow-up of 2 years [183].

In assessment of bacterial adherence to suture material, in vitro studies have concluded that there is a significantly high rate of bacterial adherence to the suture material when absorbable braided sutures are used for mesh fixation [166, 192]. In order to overcome this problem, sutures have been treated with antibacterial coating. In vitro and animal model settings have shown that sutures treated with triclosan appear to reduce bacterial adhesion and viability [167, 186].

The choice of suture material does not appear to affect chronic pain, adhesion formation or operative time [156, 183, 191, 193]. There is no evidence to support a particular gauge of suture material over another or one suture needle in preference to another.

In comparison with other fixation techniques, several studies have concluded that suture fixation results in stronger mesh fixation strength compared to tacks or glue [155, 170, 188, 193, 194]. However the clinical significance of this is unclear since the majority of studies comparing suture fixation with tacks, fibrin sealant or glue show no difference in recurrence rates between the groups [168, 172, 173, 180–182]. In a rat model, Karatepe et al. found that in a contaminated surgical field, infection rates were higher when the mesh was fixed with suture material compared to glue [178].

Suture Technique

The technique used for fixing the mesh with sutures depends on the type of the hernia and the mesh position. It is recommended (level of evidence: 5) to avoid bridging the hernia defect with mesh in open hernia surgery. In vitro biomechanical inguinal hernia models have concluded that a closed hernia defect requires significantly greater bursting pressure compared to a bridged defect [158]. In the assessment of continuous vs. interrupted sutures used in mesh fixation, Sekmen et al. have concluded that mesh contraction is lower in the continuous group in rat model [185].

In laparo-endoscopic surgery for inguinal and incisional hernias, it was found that most studies were assessing the use of transabdominal suture technique in mesh fixation with no studies assessing fixation using laparo-endoscopic suturing technique [156, 177, 179, 188, 194–197].

When performing suture fixation, it is widely agreed that transfascial sutures are the gold standard technique. This said, a systematic review of 6,016 patients undergoing laparo-endoscopic repair of incisional hernias concluded that there is a significantly higher rate of surgical site infection in suture fixation [198]. They found no significant difference in recurrence or chronic pain between the two groups.

van't Riet et al. concluded that the optimal distance between transabdominal sutures for fixation of mesh in laparo-endoscopic ventral hernia repair was 1.8cm. The study assessed the strength of mesh fixation using a porcine model without considering the size of the defect and the type of the mesh used in the repair [188]; however, there is enough data to support these findings.

6.3.2.2 Glue Fixation

Surgical glue was originally used during the Vietnam War for traumatic wound closure. Its use in hernia surgery was first described by Farouk et al. in 1996 [199]. It is a synthetic cyanoacrylate-based compound that works by contact-induced exothermic hydroxylation of the monomer to form a stable polymer. In order to assess the use of glue in mesh fixation, several studies have been conducted. Using an animal model, glue was found to be inferior to sutures, tacks [194] or staples [170] in terms of fixation strength. However these findings were opposed by other studies that found no difference between glue and sutures [172, 200]. In the assessment of hernia recurrence following open inguinal hernia repair, there are comparable recurrence rates with glue fixation compared to other fixation methods (level of evidence: 1B). Several studies have concluded that there is no difference between glue fixation compared to either suture or fibrin sealant fixation [168, 172, 173, 176, 182, 201, 202]. In the assessment of acute and chronic postoperative pain, there are lower rates of chronic pain with glue fixation compared to suture fixation in open inguinal hernia repair (level of evidence, 2B). A RCT has concluded that postoperative pain scores and analgesia requirements were lower in the glue group compared to suture group on the first postoperative day [182]. Also, the incidence of chronic pain was less in the glue group (0% vs. 3.39%) [176, 202]. In contrast, another RCT reported no difference in acute or chronic pain between glue and suture fixation (20.1% vs. 15.5%, $P = 0.318$) [168, 173, 201]. In comparison with suture fixation in open inguinal hernia repair, the glue fixation showed no difference in terms of wound infection rates (3.3% vs. 1.3%, $P = 0.448$) [173, 201]. However, using an animal model, it was found that there are lower bacterial adherence rates with glue fixation compared to suture fixation following hernia repair in the presence of infection [178]. In the assessment of operative time, Bar et al. reported a shorter operative time with glue compared to sutures [168], yet Nowobilski reported no difference in terms of cost or length of hospital stay [182]. This finding was supported by Pagane et al. [201]; however, there is insufficient evidence to support these findings.

6.3.2.3 Fibrin Sealant Fixation

Fibrin sealants are biological glues that work by reproducing the final steps of the coagulation cascade. They involve simultaneous application of concentrated human fibrinogen and lyophi-

lized factor XIII that is reconstituted with aprotinin (antifibrinolytic agent) and thrombin that is reconstituted with calcium chloride or distilled water [203]. Its use in hernia surgery was first described by Chevrel et al. in 1997 [204].

For assessment of mesh fixation strength, fibrin sealant was found to be comparable with mechanical fixation techniques (level of evidence, 5) [205]. In vitro biomechanical models, open and laparo-endoscopic, have suggested that the combination of fibrin sealants with sutures generates a significantly higher mesh fixation strength, with bursting pressure of 196mmHg, when compared to the use of sutures alone (bursting pressure 188 mmHg) [157, 206]. This is not true for fibrin sealant alone, with animal models of open and laparo-endoscopic repair finding no difference between fibrin sealant and other mechanical fixation techniques including sutures, staples and tacks [184, 207–210]. Level 1B evidence suggests that recurrence rates with fibrin sealant fixation are comparable with mechanical fixation devices in laparo-endoscopic TAPP [211] and TEP [212] and open inguinal hernia repair [206, 213–216]. Expectedly, fibrin sealant has higher fixation strength at 12 days postoperatively when compared to non-fixation technique [207, 217].

Level 5 evidence suggested that thrombin concentration of 4IU/ml is preferable to 500IU/ml and has higher fixation strength [218].

In the assessment of postoperative incidence of chronic pain in open and laparo-endoscopic (TEP and TAPP) inguinal hernia repair, level 1B evidence shows that fibrin sealant results in lower postoperative chronic pain rates up to 1 year compared to mechanical fixation including staples, tacks and sutures [169, 174, 202, 206, 211, 212, 216, 219]. The TIMELI trial compared fibrin sealant to suture fixation in a randomized control trial of 319 patients undergoing open inguinal hernia repair (Lichtenstein method). At 1 year postoperatively, they found a significantly lower rate of patients with one or more disabling complication (chronic pain, numbness or groin discomfort) in the fibrin sealant group compared to the suture group (8.1% vs. 14.8%, $p = 0.0344$), with a lower analgesic requirement (65.2% vs. 79.7%, $p = 0.0009$) [220]. Conversely a case series reported no difference between fibrin sealant fixation and staples in terms of chronic postoperative pain following TAPP repair of inguinal hernia [213].

The ability of patients to return early to work following TAPP repair of inguinal hernia was found to be faster amongst those who underwent fibrin sealant mesh fixation compared to the staple or anchor mesh fixation (5 days vs. 7–9 days) [216] or suture fixation [169]. Conversely, in TEP repair of inguinal hernia, there was no difference in return to daily activity or length of hospital stay between the fibrin sealant and staple fixation [212].

There is insufficient and conflicting evidence in the literature with regard to the postoperative wound complications, namely, seroma formation and wound infection. Some studies reported deceased incidence of seroma formation following open incisional hernia and TAPP repair of inguinal hernia with fibrin sealant fixation compared to mechanical fixation methods [214, 221]. However, these findings were conflicting with other studies which revealed no difference in seroma formation between these fixation methods [204]. In terms of wound infection, it was found that the use of fibrin sealant might result in reduction in the rate of postoperative infection [204, 222]; however, opposing studies concluded that there was no change in the rate of postoperative infection regardless of the fixation techniques [174, 219, 223]. There is a lack of consistent evidence with regard to operative time, reduced hospital stay and cost effectiveness with fibrin sealant fixation compared to other fixation methods [211–213, 224].

6.3.2.4 Staple Fixation

Titanium surgical staples are uncommonly used for mesh fixation in laparo-endoscopic surgery as well as open hernia repair [181, 213, 225–236]. One of the criticisms of the use of staplers in hernia surgery is the cost compared to sutures [237]. The literature search has revealed conflicting evidence in this subject.

For assessment of the strength of mesh fixation in inguinal hernia repair, level 5 evidence

suggested that mesh fixation strength with staples is higher than no fixation of mesh [207, 223] and is comparable to sutures [170] and fibrin sealant [184].

In regard to the incidence of hernia recurrence following open and laparo-endoscopic (TEP and TAPP) inguinal hernia repair, level 1B evidence has suggested that staple fixation has comparable recurrence rates compared with other fixation techniques including sutures and fibrin sealant [180, 181, 187, 211–214, 219, 238–241].

The incidence of postoperative chronic pain was comparable following open inguinal hernia repair using staple fixation compared to suture fixation (level 2B) [180, 181, 213] and with no fixation [238–241]. However in comparison with fibrin sealant, surgical staples mesh fixation was found to result in higher rates of chronic postoperative pain following open and TEP repair of inguinal hernia (level of evidence, 1B) [206, 211, 212, 219].

Level 1B evidence suggested that there is no difference in postoperative infection rates with staple fixation compared to sutures or fibrin sealant in open or laparo-endoscopic (TEP and TAPP) inguinal hernia repair [180, 181, 187, 213, 219].

Regarding seroma formation, there is a conflicting evidence in the literature with lower seroma rates in the staple fixation compared to fibrin sealant in TEP repair of inguinal hernia repairs [212], however with higher incidence in TAPP [214].

6.3.2.5 Tacks and Anchor Fixation

Tacks are spiral-shaped pins that are made of either a non-absorbable titanium or an absorbable material such as polyester (e.g. AbsorbaTack™ Covidien™). The tacks are shaped like a ship's anchor with two forks rather than a spiral shape. They are made of nitinol, which is a composite of nickel and titanium. The use of surgical tacks has been widely adopted in laparo-endoscopic inguinal and incisional hernia repair where suturing is often technically challenging and time consuming. They can either be positioned in a single row of tacks around the outer border of the mesh, sometimes combined with sutures, or more commonly in 'double crown' fashion as an inner and outer row.

Literature has revealed that the tack fixation technique has comparable results to other fixation methods in terms of fixation strength and the recurrence rates in TAPP and TEP repair of inguinal hernia as well as laparo-endoscopic repair of incisional hernias [154, 156, 193, 195, 216, 242–247]. In laparo-endoscopic incisional hernia repair, there is some concern regarding adhesions, especially with intraperitoneal placement of mesh and the tacks as it comes in contact with the viscera. There is no difference in the literature in terms of adhesion formation between non-absorbable and absorbable tacks (level of evidence, 5) [156]. Similarly, there is no clear difference in adhesion formation between tacks, sutures, staples and fibrin sealant [177, 179].

In terms of postoperative pain, there is conflicting evidence in the literature between tack fixation and no mesh fixation in TEP repair of inguinal hernia [164, 246–248]. Compared with fibrin sealant fixation, tack fixation was found to result in higher pain rates in TAPP inguinal hernia repair [216]. Similarly higher pain rates were found when compared with sutures in laparo-endoscopic incisional hernia repair [195, 196].

Level 2B of evidence has found no difference in wound infection rates with tack fixation compared to fibrin sealant or anchors in laparo-endoscopic (TAPP) inguinal hernia repair [216]. Similarly, there is no difference in wound infection rates when compared to no fixation of mesh in TEP inguinal hernia repair (level of evidence, 3) [249]. There is insufficient evidence with regard to handling of tacks compared to other fixation device, and in laparo-endoscopic incisional hernia repair, there is no difference in operative time with tack fixation compared to transabdominal sutures [246, 249] (level of evidence, 2B).

6.3.2.6 No Fixation

The idea of hernia repairs without mesh fixation approach has emerged to overcome possible complications associated with mechanical fixation methods. This method takes advantage of mesh rigidity when placed in a closed anatomical

space that will eventually be secured by mesh ingrowth, especially the case in TEP inguinal hernia repair and open sublay incisional hernia repair. The recommendation from the International Endohernia Society, along with the published European guidelines in July 2011 on TEP and TAPP inguinal hernia repair, was that all but the largest hernia defects (risk of mesh dislocation or folding leading to inadequate overlap with tissues and hernia recurrence) could be repaired without mesh fixation [250].

Level 1A evidence has suggested that in terms of recurrence rates, there is no difference when comparing no fixation to mechanical fixation in laparo-endoscopic (TEP) inguinal hernia repair [246, 247, 251, 252]. Similar results were found in a meta-analysis of eight RCTs, showing no significant difference in recurrence, chronic pain or length of stay for all laparoscopic inguinal hernia repairs [253]. It is not unexpected that non-fixation of the mesh approach in TEP inguinal hernia repair was found to significantly reduce the operative time and the cost (level 1A evidence) [251, 252].

6.3.2.7 Self-Fixing Mesh

The self-fixing meshes are characterized by a stronger fixation compared to the no-fixation approach and with reduced prosthetic load compared to the mechanical fixation methods.

There are currently two self-fixing meshes on the commercial market. Adhesix® (Cousin Biotech) is a lightweight polypropylene mesh that has one-side coated with a hydrogel synthetic glue. ProGrip™ (Covidien™) is a lightweight polyester mesh that has polylactic acid absorbable hooks on one side of the mesh, acting like 'Velcro' to hold the mesh in place.

Evidence (level 4) has suggested that self-fixing meshes have a recurrence rate comparable with suture fixation in open inguinal hernia repair [254–256]. In an inguinal hernia animal model, it was reported that the ingrowth was better with a self-fixing mesh (Adhesix®) compared with suture fixation [171]. There is limited evidence on their efficacy in laparo-endoscopic repairs; however, two case series demonstrate promising results [257, 258].

Lower rates of chronic postoperative pain were noted following open inguinal hernia repair using ProGrip™ self-fixing mesh [259] or Adhesix® mesh [256] compared to suture fixation. The operative time in open inguinal hernia repair was reported to be shorter with self-fixing meshes compared to suture fixation (23 mins (15–32) vs. 31 min (21–40) $P = 0.01$) [171, 259].

In summary a moderate quality systematic review of 12 RCTs found no significant difference in recurrence rates or infections rates between all fixation methods, and although chronic pain rates were found to be different (sutures 14.7%, glue 7.6%, fibrin sealant 3.7%, self-fixing 18.2%), this was non-significant in 9 out of 12 RCTs [260].

Conclusion

There are several hundred different products on the market that can be used in the repair of different types of hernias; however, the 'ideal' prosthetic product has yet to be found. We are, as yet, unable to predict the most suitable type of mesh for each hernia and patient type. In addition, it should be remembered that the type of mesh and the fixation technique are only two factors amongst a list of important variables that influence the outcomes in hernia surgery.

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Guidelines: Options and Limit

7

Manuel López-Cano and Josep M. García-Alamino

"Clinical freedom is dead, and no one need regret its passing"
J R Hampton
International Journal of Epidemiology 2011;40:848–849

"…until we have quality evidence supporting every clinical recommendation, a degree of clinical freedom is inevitable. Even when the evidence for or against a treatment emerges, the particularization of evidence-based medicine must continue to combine individual clinical expertise (which integrates patient presentation, co-morbidities, preferences, costs and setting) with the best available evidence"
Jon-David R Schwalm and Salim Yusuf
International Journal of Epidemiology 2011;40: 855–858

7.1 Introduction

It has been suggested that the performance of surgical operations is the most complex psychomotor activity that a human being is call upon to perform [1]. The technical action (i.e., surgical procedure), the surrounding circumstances (i.e., health-care process), and the consequences involving another human being as a recipient of the process make the surgical activity of having psychomotor characteristics that are probably not observed in any other human activity. Moreover, all this course of events that define surgery is based on constant decision-making during preoperative, intraoperative, and postoperative phases.

Along with experience and reflection, "surgical evidence" [2] (i.e., data available in the literature regarding a particular problem) is one of the pillars on which decision-making is supported. Thus, a decision can be relatively easy when refers to a well-studied problem with well-established solutions or to a highly variable and difficult decision for different causes [3, 4]. These causes are related to ignorance or lack of knowledge of the available information, uncertainty regarding the value of information, external pressures for the use of some alternatives, lack of resources or services forcing the use of alternatives far from those recommended, availability of resources causing overuse of the recommended options, or simply because values and preferences of patients and/or their families tip the balance in favor of diagnostic-therapeutic decisions that are not in accordance with the best information.

In this context, it is evident that management of the available "surgical evidence" is a key aspect. Initially, it is likely that this would be an easier task, since surgical practice was mostly based on the surgeon's personal experience and judgement. However, during the second half of the twentieth century, basic and clinical research increased exponentially that has continued to the

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present time. Huge volumes of data are unfortunately, and almost inevitably, associated with remarkable difficulties for rapid and effective selection and interpretation of the information that is needed. In order for surgeons to be able to take correct decisions, they should have available "surgical evidence" of quality, which can be readily interpreted and applied to specific scenarios when necessary. The objective of this chapter is not to present an in-depth review of systems or processes related to the selection, classification, or storage of information but only to remember that such an impressive increase of needs and advances have been giving raise to the evidence-based medicine (EBM) [5] and new approaches in the management of scientific information. In this respect, in the 1970s and 1980s, some initiatives emerged in the United Sates, such as the National Institutes of Health Consensus Development Program [6] or the RAND/UCLA Appropriateness Method [7], aimed at identifying and determining which types of care of health-care actions were being overused or underused. These initiatives have evolved both in America and Europe, toward more structured formats [8], leading to syntheses of experiences and development of recommendations articulated in the clinical practice guidelines (CPGs). Publications in PubMed of articles related to CPGs in the field of surgery have shown a progressive increase in the recent years (Fig. 7.1).

7.2 Clinical Practice Guidelines (CPGs)

7.2.1 Definition and Objective

Definition of a CPG most commonly found in the literature is that proposed by the Institute of Medicine [9] in 1990, which reads: "Statements that include recommendations intended to optimize patient care that are informed by a systematic review of the evidence and an assessment of the benefits and harms of alternative care options."

The main purpose of a CPG is to offer clinicians a set of recommendations or guidelines based on the scientific evidence for helping them to make decisions on problems that arise daily in relation to patients, trying to reduce the "gap" between research and practice. However, CPGs are not merely ordering of data (i.e., evidence); they also represent the consensus of experts on a particular topic that interpret complex data, so that rationalizing clinical decisions can contribute to reduce unjustified clinical variability, educating clinicians and patients by offering the best available evidences [9]. In this respect, CPGs combine evidence and experience for definitely improving the populations' health, keeping almost literally the definition of proposed by Sackett et al. [5] of EBM: "Evidence based medicine is the conscientious, explicit, and judicious use of current best evidence in making decisions

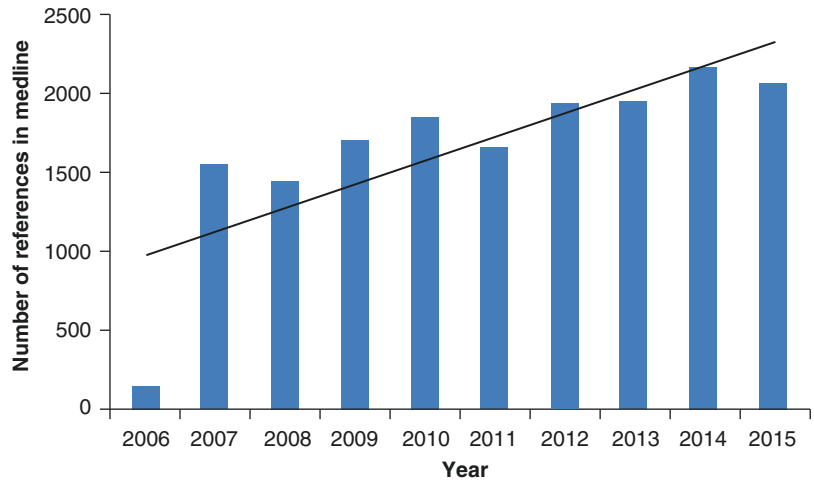

Fig. 7.1 Number of publications in MEDLINE (PubMed) related to CPGs in the field of surgery, increasing from 149 in 2006 to 2069 in 2015

about the care of individual patients. The practice of evidence based medicine means integrating individual clinical expertise with the best available external clinical evidence from systematic research. By individual clinical expertise we mean the proficiency and judgment that individual clinicians acquire through clinical experience and clinical practice."

7.2.2 Types of CPGs

According to the methods used for developing CPGs [10], different types of CPGs are distinguished:

- *Informal consensus development* is exclusively based on expert opinion, derived from a single meeting of experts where consensus is reached through an open discussion of the topic. Participants simply decide what they recommend. Evidence on which recommendations are based is usually cited in the discussion of the document, but with very little or no description of methodological aspects related to data collection and synthesis.
- *Formal consensus development* is based on a structured meeting of a group of experts, of 2 or 3 days duration. Guidelines are developed in a closed session after a plenary session and open discussion, being publicly presented on the third day. Although this approach has a stronger methodological structure in the analytical process than informal consensus, strict methodological criteria that may justify development of guidelines in a single meeting are lacking. Other approaches that have been implemented in an attempt to reach consensus more formally include mailed questionnaires to scientifically relevant experts or delivery of articles to a committee of experts for review of a specific topic, who subsequently assign a score to finally develop recommendations (two-step Delphi technique). Again, in these approaches, the methodology used does not provide a specific link between recommendations and quality of the evidence.
- *Evidence-based guideline development* is the most appropriate approach because final recommendations are developed following systematic, explicit, and reproducible methods in all steps involved in the process. This type of CPG combines a systematic review of the literature (i.e., synthesis and hierarchy of the evidence) with the experience of the members of the group in charge of developing the guideline and with a permanent updating of the information.

7.2.3 Other Tools

Protocols and clinical pathways are other tools for helping clinicians in the decision-making process [11]. Although these instruments are not properly CPGs, they have in common the aim of being of help in daily practice and in decision-making. Thus, a clinical protocol is usually a document that indicates the steps to be followed (previously agreed) in a health-care process, has a normative character, do not present alternative approaches, and may not be based on the best scientific evidence. A clinical pathway describes the different instructions to be followed in particular clinical conditions with a predictable clinical course, establishing the temporal sequence of guidance for all professionals that are going to be involved in the patient's care.

7.2.4 When It Is Necessary to Develop a CPG?

Although it is obvious to remember, the main reason for developing a CPG is when there is a need to improve the quality of care received by the patients [12]. However, there are other more specific aspects that may influence the development of a CPG. It may be necessary for "ordering" variation of clinical practice in some particular conditions. If a particular health-care problem has a high social and economic impact, affecting various health-care levels, and there is no consensus at the time of providing solutions, it may be necessary to develop a CPG. On other

occasions, the clinical problem may be associated with a high morbimortality, and a CPG may be necessary to reduce it, whereas, in other cases, development of a CPG may be justified if diagnostic studies or treatment modalities are costly or can cause adverse events.

7.2.5 Steps in the Development of a CPG

Basic steps in the development of a CPG have been described and defined almost three decades ago [10].

7.2.5.1 Selection of the Problem to Be Evaluated

Selection of the health-care problem to be evaluated is closely related to the aforementioned reason for developing a CPG. The selected topic may be a disease (condition) or a procedure (diagnostic or therapeutic). In any case, "refining" the selected topic is a crucial aspect [13]. The usual way of refining the topic is by a dialogue among clinicians, patients, and potential users and/or evaluator of the guideline. If the question is not refined, the problem may be too broad in scope and difficult to approach [13]. Formal methods have been developed to establish priorities in the selection of topics [14, 15]. However, as previously stated, it is essential to establish a dialogue among all persons involved (patients, clinicians, users, evaluators), including group members responsible for developing the CGP.

7.2.5.2 Group Members

Although the exact number of members forming the group for developing a CPG has not been defined, ideally the group should have at least six but not more than 12–15 members [13] (including members and leaders). This seems reasonable as too few members limit adequate discussion, and too many members make effective functioning of the group difficult. The group usually consists of surgeons and other professionals involved in health care, such as nurses, experts in methodology (epidemiologists, statisticians), and health economists; patients and representatives of the pharmaceutical industry are sometimes included. A multidisciplinary group identifies different "perspective" of the evidence [10]. When presented with the same evidence, single specialty group will reach different conclusions than a multidisciplinary group because the specialty group may be systematically biased in favor of using or recommending procedures in which it has special interest [16, 17]. It is important to include surgeons in the group to contextualize the recommendations in the framework of clinical practice. Once the group members have been established, the role of the leader or leaders includes developing a work timetable adapted to available resources, distribution of tasks among the group members, definition of the guideline structure, planning strategies for diffusion of the guideline, and implementation of the guideline specifying criteria, deadlines, and evaluation methods. An important aspect among participants in developing CPGs is to disclose academic and economic conflicts of interest.

7.2.5.3 Development of the CPG

The process of developing a CPG also includes different phases. Health-care problems addressed in guidelines are commonly quite broad, so that it is important to set the boundaries for diagnostic and/or therapeutic questions to which responses are wanted to be obtained. The identification of possible preventive, diagnostic, or therapeutic interventions involved in the CPG should be decomposed and organized using the PICO strategy [18, 19]. PICO represents an acronym for patient (P), intervention (I), comparison (C), and outcome (O). These four components are the essential elements of the research question and of the construction of the question for the bibliographic search of evidence [20]. The adequate (well-constructed) PICO strategy allows for the correct definition of which information (evidence) is needed to solve the clinical research question and maximizes retrieval of relevant studies in the search of databases, avoiding ineffective literature search. Definition of the outcome, in other words, the measure of the effect of the intervention [18–20], is probably the most important component. Also, the PICO strategy allows selection of the search terms (i.e., biblio-

graphic search for evidence), known as "descriptors" or "keywords," which are used to perform a systematic review of the literature in the most relevant electronic databases, including MEDLINE (PubMed), EMBASE, SCOPUS, Cochrane library, Web of Science, and Google Scholar. For practical purposes, even each question can become a systematic review with its corresponding meta-analysis if appropriate, the search will have no language restrictions [21, 22], and the process for each question will be documented with a flow chart [23]. Selected documents should cover as much as possible the available literature, including all types of studies (randomized controlled clinical trials [RCTs], observational studies, epidemiological studies, cost-effectiveness analyses, book chapters, etc.). All studies identified should be screened by reading the title and the abstract to assess whether information is pertinent to the PICO question. Full-text articles should be obtained for eligible studies. Also, using explicit rather than implicit criteria should improve the reliability of the process [13].

Once relevant studies have been identified, data extracted should be summarized, categorized, and interpreted. Since "definitive" evidence exists for relatively few health-care procedures, deriving recommendations solely in areas of strong evidence would lead to a CPG of limited scope or applicability [13, 24, 25]. However, more commonly the evidence needs to be interpreted into an "opinion" context (clinical, public health, policy, and/or economic context). Therefore, within the guideline development process, a decision should be taken about how opinion will be both used and gathered.

Different methods for categorizing, grading, and interpreting the quality of evidence extracted from the literature and to establish the strength of recommendations are used, sometimes only by the group or organization that developed the guideline [26]. It is not the purpose of this chapter to present a detailed description of these methodologies, but the method used is a crucial factor for the user's confidence in the information provided by the CPG. Since 2000, the Grading of Recommendations Assessment, Development and Evaluation Working Group (GRADE) composed of international epidemiologists, methodologists, and clinician experts developed a system that separates grades for the quality of evidence and for the strength of recommendations, a consensus that can overcome limitations of previous systems [27]. The GRADE system has been adopted by more than 70 organizations worldwide, including the World Health Organization (WHO), Cochrane collaboration, the National Institute for Care and Health Excellence (NICE), or the Scottish Intercollegiate Guidelines Network (SING) [28]. The GRADE system will become the dominant method for classifying the quality of evidence and strength of recommendations of CPGs in the near future [29].

7.2.6 The GRADE Approach

GRADE differentiates from other systems in which it assesses importance of the results of interest for clinicians and patients with a clear separation between quality of evidence and strength of recommendations, applies explicit criteria to raise or upgrade or to reduce or downgrade the quality of evidence independently of the study design, considers patients' values and preferences, and finally follows a structured and explicit process for development of recommendations [28].

Probably, there are two key aspects in the GRADE methodology. Firstly, the system is based on the outcome (extracted from all evaluated studies) because in GRADE not all outcomes are similar or have the same relevance (i.e., critical, important, but not critical) and only the most important outcomes should influence upon assessment of quality of the evidence and strength of recommendations [30]. Secondly, confidence in the available evidence is based on the quality of evidence, defined as confidence that the estimates of an effect are adequate to support a recommendation [31]. The level of the quality of evidence can be "high" (high confidence that the estimate of the effect from the available literature is very close to the true effect), "moderate" (the estimate of the effect is close to the true effect, but there are many substantial differences), "low" (the estimate of the effect may be substantially different from

the true effect), and "very low" (it is very likely that the estimate of the effect is substantially different from the true effect).

On the other hand, different objective factors may affect the quality of evidence, upgrading or downgrading the confidence that can be placed in the estimation of the effect. It is also recognized that the expert opinion influences the evaluation of the available evidence, but it is not considered a type of evidence in itself [28]. Objective factors include (1) limitations in design or conduct (risk of bias) for RCTs (e.g., lack of concealment of the randomization sequence, inadequate blinding, or substantial loss to follow-up, etc.) and observational studies (inappropriate population selection criteria, insufficient control of confounding factors, etc.) [32], (2) inconsistent or heterogeneous results (i.e., results from the various studies extracted from the literature are very different for the same outcome) [33], (3) lack of direct evidence for an outcome being only indirect evidence available [34], (4) imprecise results related to the number of patients analyzed in the different studies, the effect estimator and its confidence interval [35], and (5) suspected publication bias, that is, suspicion that not all studies, primarily those with negative results, have been published, so there is a possibility that the effect may be overestimated [36].

The GRADE system allows the evidence to be combined in a summary of findings (SoF) table, which gives a structured outline of the number of studies for each outcome of interest, quality of evidence, and the results observed in relative and absolute terms. These SoF tables can be generated using a free download software program called GRADEPro [37].

Finally, recommendations and strength of recommendations are established by the GRADE system. According to GRADE, four basic factors influence the strength of recommendations: the risk-benefit balance, quality of evidence, patient values and preferences, and costs and resource utilization [38]. Strength of recommendations has different implications for patients, clinicians, and policy makers. A strong recommendation for patients would be that most people in your situation would want the recommended action and only a small proportion would not; for clinicians, that most patients should receive the recommended action; and for policy makers, that the recommendation can be adopted as health-care policy in most situations. By contrast, a weak recommendation for patients would be that most people in your situation would want the recommended action, but many would not; for clinicians, that different choices would be appropriate for different patients and that doctors must help each patient to arrive at a management decision consistent with his/her values and preferences; and for policy makers, that there is a need for substantial debate and involvement of stakeholders.

Synthesis of the GRADE process is shown in Fig. 7.2.

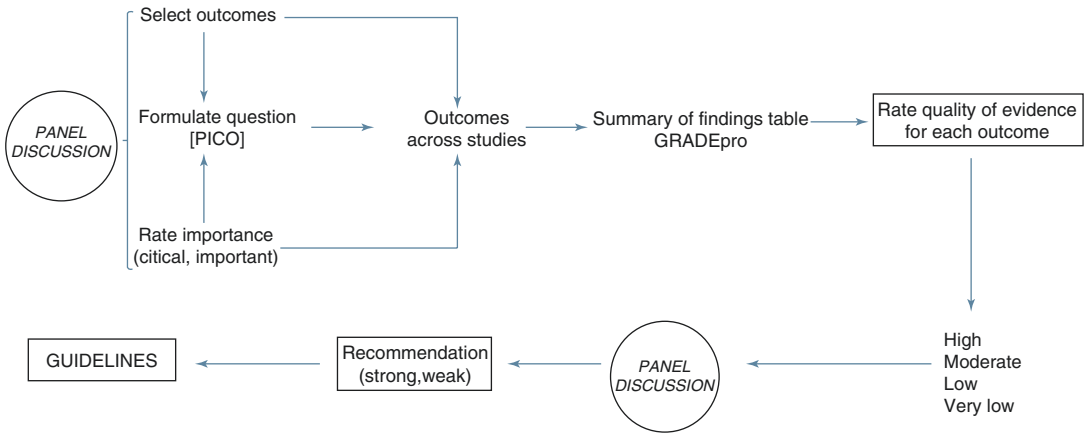

Fig. 7.2 Main steps in the development of CPGs (GRADE system)

7.3 Drafting, Reviewing, and Updating CPGs

The appropriate style, language, and content of a CPG follow a series of general recommendations established for decades by different institutions. The Institute of Medicine [39] recommends CPG structure based on validity, reliability, reproducibility, applicability, and clinical flexibility, clarity, and explicit mention of the multidisciplinary process, as well as references to the documents used. Other institutions, such as the American Medical Association [40], recommended a number of attributes that should characterize a well-written and structured CPG as having as to be written and developed by or in conjunction with medical organizations, should be specified that the guideline was developed with appropriate methods that integrate the findings of the literature with adequate clinical experience, should be as comprehensive and specific as possible, should be based on current information, and should be widely disseminated. Areas in which further research is needed should be explicitly mentioned.

The final draft should undergo a process of external review to ensure validity, clarity, and clinical applicability of the CPG. External reviewers should cover three areas: people with expertise in clinical content, who can review the guideline to verify the completeness of the literature review and to ensure clinical sensibility; experts in systematic reviews or guideline development, or both, who can review the method by which the guideline was developed; and potential users of the guideline, who can judge its usefulness. The Appraisal of Guidelines for Research and Evaluation (AGREE) [41] is probably the most popular tool for the assessment of CPGs. The original AGREE instrument has been updated and methodologically refined. The AGREE II is now the new international tool for the assessment of practice guidelines. The AGREE II is both valid and reliable and comprises 23 items organized into the original six quality domains: (1) objective and purpose, (2) stakeholder involvement, (3) rigor of development, (4) clarity of presentation, (5) applicability, and 6) editorial independence.

The guideline can be updated as soon as each piece of relevant new evidence is published, but it is better to specify a date for updating the systematic reviews that have been the supporting articles of the guideline [13].

7.4 Implementation of CPGs

Unfortunately, there is no single effective way to ensure the use of guidelines in practice [42]. Despite creation of CPGs at national and international levels, guidelines are underused by clinicians at the bedside to improve patient care. Effective implementation of CPGs requires assessment of barriers and facilitators in utilizing guidelines and to develop strategies tailored to local circumstances [43, 44]. Implementation of CPGs and evidence in general requires changes in the system involving both individuals and health-care settings [45–47]. Poor adoption of CPGs has been attributed to physician's attitudes and values, conflicting patient goals and expectations, and organizational characteristics. Specifically, clinicians hesitate to adopt CPGs because of personal opinions, competences, attitudes, personal characteristics, or motivation for change [46]. Also, some doctors may be highly influenced by the opinion of other experts, and sometimes local consensus may facilitate the use of a CPG to a more extent than quality of evidence or dissemination of the CPG [48]. Patients' age, sex, or race can play a role in clinical decision-making. Organization and structure of clinical care settings are important for facilitating material resources (facilities, equipment) and time for implementation of guidelines. Economic measures of the organizational context may favor or prevent implementation of new activities [49]. Finally, as mentioned above, writing of guidelines should be kept simple and recommendations clearly described and with methodological rigor [50, 51].

7.5 Benefits of CPGs

The principal benefit of guidelines is to improve the quality of care received by patients. Potential benefits are extensive not only to patients but also

to health-care professionals and health-care systems [12]. In relation to potential benefits for patients, guidelines that promote interventions of proved benefit and discourage ineffective ones have the potential to reduce morbidity and mortality and improve quality of life [12]. Guidelines available in accessible media (i.e., Internet sites, webs of scientific societies) empower patients to be informed, to consider their personal needs and preferences, and to establish an open dialogue regarding best options and potential outcomes [12]. Guidelines can help patients by influencing public policy, calling attention to services or interventions that may be made available as a response to newly released CPGs.

With regard to health-care professionals, CPGs can improve the quality of clinical decisions, clarifying which interventions are of proven benefit based on a critical and systematic assessment of scientific evidence. They alert clinicians to interventions unsupported by good science, reinforce the importance and methods of critical appraisal, and call attention to ineffective, dangerous, and wasteful practices. Clinicians may turn to guidelines for medicolegal protection or to reinforce their position in dealing with administrators who disagree with their practice policies.

For health-care systems, CPGs are effective in improving efficiency and optimizing expenditures and investments. Implementation of certain guidelines reduces expenses related to hospitalization, prescription drugs, surgery, and other procedures. Adherence to guidelines may also improve public image, sending messages of commitment to quality and excellence [52].

7.6 Potential Limitations of CPGs

The most important limitation of guidelines is that the recommendations may be wrong. Three important reasons have argued. Firstly, scientific evidence in general medicine and surgery, in particular, is often lacking, misleading, or misinterpreted, and only a small subset of what is done in medicine and surgery has been tested in appropriate well-design studies [12, 53]. Secondly, recommendations are influenced by the opinions and clinical experience and composition of the expert development group. The beliefs to which experts subscribe, often in the face of conflicting data, can be based on misconceptions and personal experience that may misrepresent the general situation [54]. Conflicts of interest of guideline developers may also be considered. Thirdly, patient's needs may not be the only priority in making recommendations. Practices that are suboptimal from the patient's perspective may be recommended to help control costs, serve societal needs, or protect special interests (e.g., those of doctors, risk managers, or politicians).

Conclusion

CPGs are not "cookbook medicine" where solutions to all specific health-care problems can be found. The same parties that stand to benefit from guidelines—patients, health-care professionals, and the health-care system—may all be harmed by flawed CPGs [12]. Clinical guidelines are only an option for improving the quality of care and make sense when clinicians are unclear about appropriate practice and when reliable scientific evidence can provide an answer.

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8 Creation, Advantages, and Limits of Registries: The Herniamed Experience

F. Köckerling

8.1 Introduction

Several developments in healthcare, such as progress in information technology and increasing demands for accountability, have led to an increase in the number of medical registries over the recent years [1]. A medical registry is defined as a systematic collection of a clearly defined set of health and demographic data for patients with specific health characteristics, held in a central database for a predefined purpose [1]. Medical registries can serve different purposes—for instance, as a tool to monitor and improve quality of care and as a resource for outcome research [1]. The ultimate aim of the noncommercial project Herniamed, founded in 2009, is to improve quality standards across the entire spectrum of hernia surgery and to implement outcome research projects in hernia surgery [2]. With widespread recognition that surgical outcomes vary by provider, surgeons and hospitals are increasingly being asked to provide evidence of the quality of care that they deliver [3]. Another high priority area for registries is medium to long-term monitoring of specific devices and procedures [4]. Devices may malfunction, break, and cause injury because of misuse or design flaws [4]. Unlike new drugs, devices are commonly incorporated into medical practice without systematic pre-marketing evaluation of their clinical safety [4]. Systematic surveillance by registries can provide a greater level of consumer protection [4].

8.2 Creation of Herniamed

In Germany, around 275,000 inguinal hernia procedures and nearly 100,000 abdominal wall hernia operations are carried out each year. Despite the high frequency of such surgical hernia procedures, the overall results are not at all satisfactory. In Germany, the recurrence rate and the rate of chronic pain following inguinal hernia surgery are more than 10% [2].

The noncommercial, nonprofit project Herniamed was founded in 2009 to implement a quality assurance and outcome research project in hernia surgery. This is a network of surgeons mainly from Germany, Austria, and Switzerland, who have a special interest in hernia surgery. Thanks to the creation of an English language version, it has already been expanded to an international network [2].

From the beginning, the project was strongly supported by the German Hernia Society (DHG) and the Surgical Working Group Hernia (CAH) of the German Society of General and Visceral Surgery (DGAV). The board members of both societies are also board members of Herniamed.

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The cornerstone of the Herniamed project is the Internet-based registry into which all interested hospitals and surgeons can enter data on all hernia operations performed by them, using a scientifically corroborated standard approach [2]. All patient data recorded in the Herniamed registry are entered prospectively into the database with the hernia types being classified as per the valid classification system of the European Hernia Society (EHS). The patient's data are saved only after obtaining his informed consent and can be deleted at any time upon the patient's request. The online-based outcome research and quality assurance project meets the most stringent data protection criteria [2].

As the German Hernia Society (DHG) and the Surgical Working Group Hernia (CAH) have created a certification program of hernia centers, participation in the quality assurance tool Herniamed is obligatory for certified hernia centers involving follow-up of their patients [5].

Hernia centers and their outcome quality gained by participation in the Herniamed quality assurance program are verified and evaluated in regular audits by independent experts appointed by the German hernia societies [5].

As a nonprofit organization, Herniamed is dependent from donations of the medical device industry. To date, participation in Herniamed is at no charge. A benchmark tool allows surgeons or hospitals to compare their results at any time with the total patient population in the registry. A discrepancy in the outcomes is the motivation for measures improving the own surgical quality. Participation in the quality assurance program like Herniamed is therefore an indispensable part of certification demands of hernia centers set by hernia societies.

8.3 Advantages of Registries

8.3.1 Quality Improvement by Registries

In a leading article of the Wall Street Journal, Clifford Ko, a Colorectal Surgeon at UCLA, Director of the National Surgical Quality Improvement Project, gave the following statement: "You can't improve a hospital's quality if you can't measure it" [6].

Registries can provide sound data needed by clinicians and organizations to improve patient safety and quality of care [7]. The national Danish Hernia Collaboration with two annual meetings discussing own results and those of others has led to >50% reduction in reoperation rates [8]. Establishment of a nationwide groin hernia database leads to general improvement in outcomes [8].

Systematic prospective recording of treatment and outcome variables in a national clinical database improved the overall quality of surgical care [9]. One cannot deny that the sharing and comparing of data with similar colleagues and a measurement of one's performance relative to the collective benchmark are likely to improve the safety and quality of healthcare rendered [10]. Clinical-quality registries aim to improve quality of care through benchmarking clinical outcomes and stimulating competition in achieving best practice [7]. In addition to providing information on safety and efficacy of treatment, data from registries can also be used to determine whether care is delivered in line with best practice and evidence-based guidelines [7].

8.4 Registry-Based Research

Randomized clinical trials (RCTs) and meta-analyses are considered to be the gold standard of evidence-based medicine nowadays [11]. The strength of the RCTs rest on its excellent internal validity, which is based largely on the power of randomization to ensure that the only difference between two treatment arms is their exposure to the treatment of interest [12]. But the applicability of RCTs to the care of patients in routine practice is limited [12]. In particular, patients, providers, and concurrent care in the general population are different from those in RCTs, and the generalizability or external validity of RCTs may be limited [12]. Although observational research does not enjoy the same level of internal validity as RCTs, well-designed observational

studies can offer superior external validity and provide a unique opportunity to evaluate treatment and their outcomes in routine practice [12]. Many important clinical questions have not, cannot, and will not be ever addressed in the context of an RCT [12]. In a comparison of observational studies and RCTs, the estimates of the treatment effects from observational studies, and RCTs were similar in most cases [13]. Registries are ongoing prospective observational data-collection exercises from as many eligible patients as possible [7]. Hernia registries are existing in Sweden since 1992 [14]; in Denmark since 1998 [15–17]; in Germany, Austria, and Switzerland since 2009 [2]; in France since 2011 [18]; in Spain since 2012 [19], in Europe since 2012 the international hernia registry EuraHS [20]; and in the United States since 2013 [21]. Registry-based observational studies in hernia repair deliver real-world data from very large patient populations and give answers to important clinical questions never evaluated in RCTs [22]. In a review about data and outcome of inguinal hernia repair in hernia registries, 85 articles from registries were relevant [22]. It can therefore be stated with certainty that, for scientific evaluation of hernia surgery, RCTs and registry-based observational studies are partners in the evaluation of medical evidence [12, 22]. A standardized reporting of outcome in hernia surgery will increase the quality of research by RCTs and registries [23].

8.5 Registries in the Early Scientific Evaluation of Surgical Innovations

By contrast with the formalized approach for drug development, the innovation process in surgery has been unregulated, unstructured, and variable [24]. The Balliol Collaboration encourages the widespread use of prospective databases and registries to document the outcome in the early scientific evaluation of surgical innovations [24]. All scientists engaged in surgical innovations are called upon to support and promote the development of such registries [25]. Surgeons who themselves create innovations should enter data into a registry on patients treated as per the innovative technique [25].

8.6 Cost of RCTs vs. Registries

Over the last several decades, the cost associated with conducting RCTs has increased dramatically [26]. Several factors contribute to higher cost associated with clinical trials [26]. Important barriers to conducting surgical RCTs identify funding sources available to finance RCTs [26]. Surgical grant proposals are less likely to be funded and carry significantly smaller awards compared to nonsurgical proposals [27]. One third of hospital admissions involve surgery, but less than 2% of government funding for medical research goes into surgical areas [28]. The cost per enrolled subject in surgical RCTs range from 400 to 1600$ [26]. The cost per enrolled subject in Herniamed is around 2$. So registries can play an important role as a research tool for underfunded research in the surgical field. By virtue of the ever-expanding number of medical devices used in hernia surgery (meshes, tacks, glues), the surgical techniques are of such a brood variety that they can scarcely be evaluated in RCTs [25]. But by consistently recording details of the different surgical techniques in a prospective registry, any problems or complications related to particular variants of the technique can be identified at an early stage.

8.6.1 Registries in the Postmarketing Surveillance of Surgical Products

To date, surgical meshes are classified as group II medical devices. Class II devices do not require pre-market clearance by clinical studies [29]. Ethicon initiated a voluntary market withdrawal of Physiomesh for laparoscopic use after an analysis of unpublished data from the two large independent hernia registries—Herniamed Registry and Danish Hernia Database [29]. The data from Herniamed Registry are published meanwhile

[29]. The importance of registry data for post-marketing surveillance of surgical products for hernia surgery has been demonstrated in this study [29].

8.7 Nationwide Change of Clinical Practice by Registry Data

Results from Danish and Swedish databases have changed clinical practice nationwide [30]. For example, the standard of recurrent repair after primary open Lichtenstein technique today is laparoscopic [30]. Furthermore, regional anesthesia in elderly patients is not supported by existing evidence [30].

8.8 Published Data from the Herniamed Registry

In a comparison of 10,887 patients with unilateral and 4289 patients with bilateral primary inguinal hernia repair in TAPP technique, the postoperative complication and complication-related reoperation rates were significantly worse for bilateral inguinal hernia [31]. In the comparison of 6700 unilateral with 2695 bilateral primary inguinal hernia repair in TEP technique, a significantly higher intraoperative urinary bladder injury rate and reoperation rate because of postoperative surgical complications was found. Based on the findings of these two analyses from the Herniamed Registry, prophylactic operation on the healthy other groin should not be recommended [32].

Comparison of the perioperative outcome of 10,887 TAPP and 6700 TEP procedures for primary unilateral inguinal hernia repair showed a significantly higher postoperative complication rate for TAPP, mainly seromas, which could be managed conservatively, because the complication-related reoperation rate was not different [33]. The positive impact of the laparo-endoscopic technique on avoidance of impaired wound healing and deep infections with mesh involvement is already so great that antibiotic prophylaxis has no additional benefit in inguinal hernia repair. In contrast, antibiotic prophylaxis should be administered for open inguinal hernia repair [34].

Patients receiving antithrombotic therapy or with existing coagulopathy who undergo inguinal hernia operation have a fourfold higher risk for onset of postoperative secondary bleeding. Despite the extensive dissection required for TEP and TAPP inguinal hernia repair, the risk of bleeding complications and complications-related reoperation appears to be lower [35].

Since significant differences were identified in the therapy and treatment results between umbilical, epigastric, and incisional hernias, scientific studies should be conducted comparing the various surgical techniques only for a single hernia type [36].

The actual recurrence rate after hernia repair needs a follow-up of 10 years for incisional hernias and of 50 years for inguinal hernias. The data collected can be used to give an approximate estimate with a shorter follow-up [37].

Comparison of perioperative and 1-year outcome for laparo-endoscopic repair of primary versus recurrent male unilateral inguinal hernia showed significant differences to the disadvantage of the recurrent operation. Therefore, laparo-endoscopic repair of recurrent inguinal hernias calls for particular competence on the part of the hernia surgeon [38]. Also a significantly less favorable perioperative and 1-year follow-up outcome must be expected for open repair of recurrent inguinal hernia in comparison with open primary inguinal hernia repair [39]. Out of the 2482 laparo-endoscopic recurrent repair operations, 90.5% of patients and, out of the 2330 open recurrent repair procedures, only 38.5% of patients were operated on in accordance with the guidelines of the European Hernia Society. Non-compliance with the guidelines is associated with higher perioperative complication rate and higher risk of recurrence [40].

The higher perioperative complication rate associated with laparo-endoscopic inguinal hernia surgery in patients older than 65 years is of multifactorial genesis and is observed in particular as from the age of 80 years [41].

As confirmed by previously published studies, the data in the Herniamed Registry also demonstrated that the laparo-endoscopic ingui-

nal hernia surgery case load impacted the outcome [42].

In a comparison of 10,555 Lichtenstein with 6833 TEP repair of primary unilateral inguinal hernias in male patients, no significant difference in the recurrence rate in 1-year follow-up could be shown. TEP was found to have benefits compared with Lichtenstein repair as regards the postoperative complication rate, pain at rest, and pain on exertion [43].

Within the group that did not have additional sutures fixation of self-gripping meshes, the length of operations was on average 8 min shorter ($p < 0.001$). No difference could be observed in terms of postoperative complications, chronic pain requiring treatment, and recurrence rate [44].

Unadjusted analysis comparing 7422 TAPP procedures with mesh fixation and 3806 without mesh fixation did not show a significant difference in the recurrence rate. In multivariable analysis, only for medial and combined defects versus lateral was a higher significant effect on recurrence rate identified ($p < 0.001$). With mesh fixation and larger mesh size, it was possible to significantly reduce the recurrence rate for larger medial hernias [45].

TEP and TAPP are equivalent surgical techniques for recurrent inguinal hernia repair following previous open primary operation [46].

Comparing 2047 axial (type I) with 996 paraesophageal (types II-IV) hiatal hernia repairs laparoscopically, significantly higher intraoperative organ injury rates and higher postoperative complication-related reoperation rates to the disadvantage of the paraesophageal hiatal hernias were identified. Paraesophageal hiatal hernia repair also showed significantly more general postoperative complications [47]. Multivariable analysis did not find any evidence that the use of a mesh had a significant influence on the recurrence rate [47].

8.9 Limits of Registries

Incorrect or missing data limits a registry [30]. It is unrealistic to aim for a registry database that is completely free of errors. Some errors will remain undetected and uncorrected regardless of quality assurance, editing, and auditing [1]. Most data errors occurred during recording of the data on the case report form due to inaccurate transcription or nonadherence to data definitions [1]. In the Herniamed Registry the following measurements for optimizing of data entry are used:

1. Signed contract with the hospital/practice administration and the responsible surgeon for data correctness and completeness.
2. Missing data are indicated by the software.
3. Primary documentation on the case report form and controlling by the responsible surgeon before entering of the data into the database.
4. Perioperative outcome is once again reviewed in the 1-year follow-up questionnaire sent to the patient and the general practitioner.
5. Comparison of the own results with the total study population at any time (benchmark tool).
6. As part of the certification process of hernia centers, hernia experts control the data entry during the regular audits and on-site visits.

Apart from data completeness, another principal concern with registries is that of making inferences without regard to the quality of the data. The best safeguard is to match the data against another registry, if possible, and literature data [48]. In the case of Physiomesh, the data from the Herniamed and Danish Hernia Registries and a RCT showed comparable results and led to the voluntary recall by the manufacturer [29].

Observational studies do have important limitations that must be carefully considered when evaluating treatment benefits [12]. The most important limitation is in differentiating between outcomes that are due to adoption of a new treatment and those due to other unrecognized changes in the population under study [12]. Factors that may not be identified or measurable using observational data include changes in disease biology, changes in other aspects of management, and confounding by indication. Although statistical modelling techniques such as propensity score matching, and instrumental variable analyses can mitigate these potential sources of bias, they remain inherent limitations of the study design [12]. However, these limitations do not

render this form of research less valuable than insights provided by RCTs, which have their own limitations [12].

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9 Management of Database in Hernia Surgery

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9.1 Introduction

Surgeons, whether in private practice, in hospital, or at university, have one thing in common: they spend a lot of time with their patients in the OP room and must afterward spend even more time documenting the surgery they have just performed. But, like all other professions, only a limited amount of time is at their disposal each day. When dealing with hernias, surgeons encounter another peculiarity: hernia surgery is a surgery of the commonplace; the diagnosis of hernia is much easier for patients to bear than a diagnosis of cancer; hernias are often considered a "banality", a "trifle"; hernia surgery is regarded as a chance to improve one's body, to regain quality of life. But it is also an existential matter. By virtue of their innocuous status, hernias are accorded scant resources by health insurance companies and public health policy makers, where patients may resist mandatory follow-ups. Against this background, the question of "why" a patient registry or databank for common hernias makes complete sense. This chapter will deal with the "why-a-database?" question and shows that the rationale for their existence rests on four factors: they must (1) pursue a clearly-defined goal (what purpose do they serve?); (2) be fruitful in answering the relevant medical questions (what type of information and how much will be obtained?); (3) collect reliable and complete data (can the data be trusted?); and lastly, but most importantly, (4) gather data that further improves treatment of the patient. If this last factor is missing, the keeping of a hernia registry would be a waste of time.

Much remains to be learned regarding hernia treatment. Randomized clinical trials and cohort studies have been criticized and need to be demonstrated that they can produce meaningful, reliable, and useful results. In the field of hernia surgery, randomized clinical studies have been shown to only rarely generate results of practical value, due mainly to the wide variability in the relevant factors. Moreover, randomized clinical studies can do little to help standardize the wide variability in medical products for treating hernia patients. In recent years, evaluation of prospective registries has gained in importance. For the first time, impressive data on results outside study conditions are available, results that allow conclusions regarding epidemiological and prognostic information. The Swedish and Danish Hernia Registries, in particular, but also EuraHS, the registry of the European Hernia Society, can

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be named as examples. In addition to the "why-a-database?" question, this chapter will examine the limits and dangers of evaluating databanks and discuss practical measures for their management.

9.2 What Is the Goal of Databanks?

In the field of hernia surgery, the first registry was started in about 1980 by Erik Nilsson. The impetus for this pilot project came from the recognition that better results in inguinal hernia treatment had been reported from the USA and Great Britain. To improve treatment, clarity and transparency regarding one's own results were needed. After a few years of the pilot project, clear improvements were evident in complications and recurrences [1]. For Erik Nilsson, participation in a registry was a personal imperative: "Only if the surgeon wants to improve his results does participation in a registry make sense."

Much has happened since the founding of the Swedish Hernia Registry. Prospective databases pursue three main goals: research on hernia treatment, long-term surveillance of medical product performance, and economic-political regulation of the healthcare system.

In the past 10 years, "quality assurance" has become fashionable, practically attaining the status of a self-evident truth. It is advocated with religious zeal. It has its origins in industrial production, from where it has found its way into medical quality control. Industry, with its largely mechanical view of things, standardized processes, demands for low variability in its results, and awareness of its liability for product malfunctions, has evolved a very efficient system for monitoring production with an eye to the end product. But what is quality assurance as it pertains to people, patients, doctors, health insurance companies, and healthcare policy makers? Before defining quality assurance, let's take a look at what exactly "quality" means. For the philosopher Immanuel Kant (1720–1804), quality is one of the four categories of judgement, along with quantity, relation, and modality, and is not in itself an existing actuality. Wolfgang Lienemann (University of Berne, Switzerland) defines quality as "… a form of judgement by means of which something is attributed [to something], it is not anything that belongs to things by their nature." Since quality is not something in itself, it cannot be quantified; a key figure can be measured. One can also agree to define the attainment of a certain key figure as a quality. But one must always be aware that defining a given quality based on key figures is arbitrary and never to be interpreted as representative of "truth." So, quality assurance involves in the first instance an overview of key figures, which the inexplicable practice of medicine renders "explicable" by making the subjective "objective." Typical key figures in a medical database are, for example, the number of ambulant interventions, mesh implantations yes/no, OP time (elapsed time from incision to suture), perioperative antibiotic treatment yes/no, complications at discharge, or duration of hospitalization. Such key figures defined as quality indicators do not say for individual patients whether guidelines have been followed, whether ambulant follow-up was necessary, how long the patient was unfit for work, and also not what the 30-day morbidity was, to name just a few examples. The renowned economist Mathias Binswanger (St. Gallen, Switzerland) sees three basic problems with today's "quality assurance culture":(1) it creates a data cemetery, bureaucracy grows, flexibility is lost, and mere numbers generate interest at the expense of long term strategies. In this regard, the renowned social critic Simon Sinek has coined the phrase "infinite vs. finite perspectives," where the attainment of pre-established goals corresponds to a "finite" perspective. (2) This problem is easily derived from the first: "finite" goals open the floodgates to lining one's own pockets, because key figures can be arbitrarily defined to "artificially improve" performance (resulting, e.g., in large bonus payments to managers and CEOs), which paradoxically can lead to purportedly "positive" key figures that are ultimately damaging to a hospital or private clinic. The third problem with quality assurance based on "artifi-

cial" key figures according to Binswanger is that (3) they function as conceptual blinders that limit the ability to make real-world judgements. To quote Binswanger, "Actions based on key figures do not make an enterprise successful, only the flexible managing of problems confers a competitive advantage" [2]. The concept of quality assurance must be abandoned in favor of a transparency of results that is value-neutral and opened to continuous questioning and ever new analyses.

The primary goal of a database is to facilitate research aimed at improving treatment. Erik Nilsson sets a high standard; the goal speaks for itself.

A further goal of databases is "post-market surveillance" of medical products, of surgical meshes, for example. Databases play a major role here since only after extensive prospective collection of given product's results in the entire patient population can conclusions be drawn regarding its safety and performance. This requires that all patients have a patient identification number (PIN) to facilitate the comprehensive collection of data. If, for example, a patient in Modena, undergoes hernia surgery and 1 year later is treated for a mesh complication in Milan, this information would be lost if the patient did not have a single PIN. Here a European-wide health policy is needed. Frederik Helgstrand (Copenhagen, Denmark) succinctly but comprehensively summarizes the goal of a surveillance registry as "to observe changes over time, including adjustment of several confounders; impact on clinical practice in addition or opposition to guidelines" [3].

Another type of database is used by health insurance billing systems: for insurance settlements information on patient treatment is gathered and remuneration is calculated. In many European countries, this is practiced in the form of Disease-Related Groups (DRGs); it is also a common practice in the USA. Patient data from billing systems can be used to a limited extent for epidemiological assessments but not to answer medical questions. Strategies for "optimization of billing" in hospitals and the active involvement of health insurance companies in the codification of treatment procedures—with the goal of minimizing the amount patients are billed—are a powerful bias and produce a completely distorted picture with regard to individual patients. It is not surprising, then, that there is little agreement between medical data from "medical registries" and from "billing registries," with a kappa value of <0.4, about equal to chance (compare ACSNSQIP and Medicare data on 110,000 patients) [4]. In the same category can be included databanks for certification or specialty accreditation (e.g., the Center of Excellence or Surgeon of Excellence): upon closer examination, they are of no use for medical questions because the input of data—to cite Sinek—only follows a "finite" goal.

Surgeons must know, therefore, for what purpose they want to gather data, so they can determine which database best suits that purpose.

9.3 How Much Data Makes a Successful Databank?

Regarding how much information should be gathered, a wide gap exists between the aspiration to gather "all the data that can be collected" and the real-world expenditure in time and money that is needed to accomplish this.

How complex can a set of data be and still be of use in task-based clinical routine? The complexity of medical knowledge is best conveyed by breaking it down into smaller components. How this can be done in a systematic way is examined in "A Theory of Granular Partitions" [5]. Granularity is the systematized level of detail contained in a body of information. The higher the granulation level, the more general the information (e.g., as in an organogram) (Fig. 9.1); the lower the granulation level, the more specific the information. Each level is distinct from adjacent levels. The findings on patients with, e.g., an umbilical hernia can be broken down into different granulation levels, which allows access to the data on this topic from various perspectives and for diverse purposes (Fig. 9.1). In a registry or databank, the criteria must be terminologically

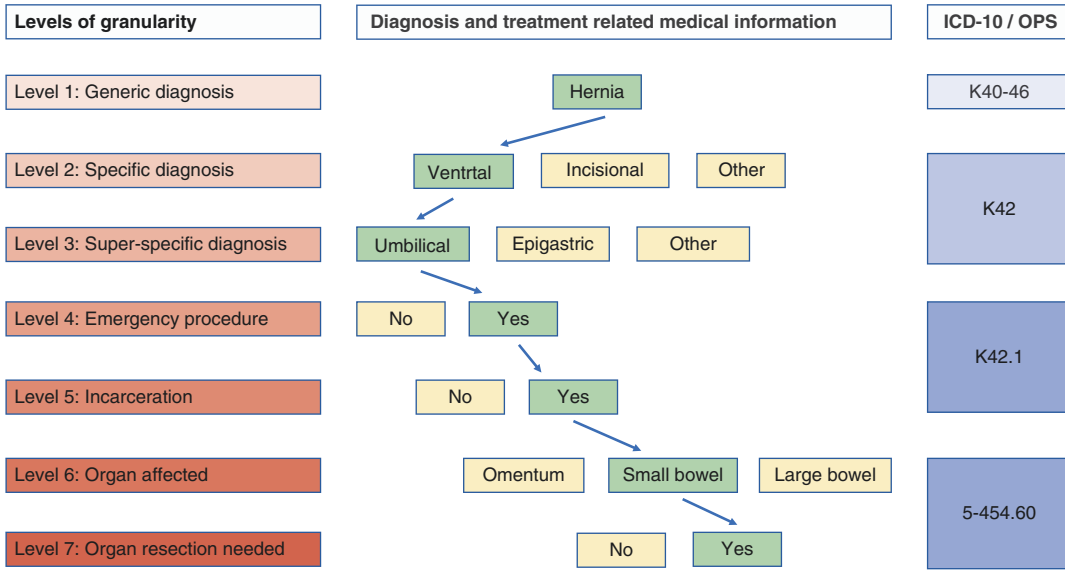

Fig. 9.1 The granulation of information in a database using the example of an incarcerated umbilical hernia. The green path describes the information relevant for diagnosis and therapy from the physician's point of view as itemized in the European Registry of Abdominal Wall Hernias (EuraHS) [6]. The ICD-10/OPS column shows the corresponding information for billing purposes. Depending on the granulation level, information can be summarized in boxes, as done in the ICD-10/OPS path (blue boxes). Once the information has been compressed (or summarized in higher granulation levels), the compressed data can no longer be unpacked to regain the information for more detailed lower granulation levels. In the example above, the seven granulation levels for medically relevant information are compressed into only four granulation levels for the ICD-10/OP coding system. In the ICD-10, recurrent umbilical hernia is coded as K42 (the same as primary ventral umbilical hernia), whereas the EuraHS classification categorizes recurrent umbilical hernias as incisional hernias (which appear as K43 in ICD-10). This shows how much a databank depends for its ability to provide clinically relevant information on how it answers the question "what is its purpose" (see above). The green information path above would end in a "no"; "no" is not coded in the ICD-10 and would have to be "accepted as an interpretation," which is anything but scientific. If a novel scientific question is posed prospectively, additional information levels may have to be inserted, which requires an ability to learn (flexibility) on the part of the computer platform or database. If a dedicated "certification" registry is needed, several of the granulation levels shown above would be unnecessary

unequivocal and strike a balance between a minimum of information for a maximum of clinical relevance.

An invaluable instrument for collection of our own results is the EuraHS registry. In this scientific platform, every participant is the owner of their own data and has 24/7 access to it. The platform is anonymous, which allows formation of research groups across borders. The registry allows both simple collection of data to assess their significance and to improve treatment and prospective research in the field of hernia surgery (www.eurahs.eu). Participation in the registry is free of charge and only requires formal online registration [6].

9.4 Which Algorithms and Mechanisms Are Needed to Maintain a Databank?

As in every scientific study, the accuracy of the information in a databank is directly proportional to the accuracy of the data gathered and the accuracy with which patient-related data is entered into the databank.

To standardize the input of data into the EuraHS registry, the registry can be accessed in several languages. It is important that the individual bits of information can be formulated as clearly as possible. If there is the least chance of

confusion in the data, clarity is provided by means of "pop-up" information. In clinical routine, collecting data is not a trivial task. Scant time is available to harvest patient data from files and OP reports and transfer it to the registry. Entering the data of a single patient into a robust database will take between 15 and 30 min depending on its complexity, with a similar investment of time for every subsequent follow-up. The Swedish Hernia Registry has addressed this problem by reducing the number of questions to a minimum. Moreover, a large proportion of the questions can be gathered perioperatively by the nursing staff in the OP room and in postoperative consultation with the surgeon. In theory, regarding the collection of follow-up data, patients do not need to be scheduled for ambulant questioning but can be contacted by post, by telephone, or by apps. It is imperative, though, that the ethical, insurance, and legal parameters for follow-ups are clarified in advance.

It is important that data are entered into the database as soon as possible after they are generated and collected. Ideally, surgeons should not enter the data themselves but use someone who is solely responsible for this task. Data from the USA show that data is more reliable if it is collected and entered by an independent person. This guarantees that data of purported little importance, data on complications, and results the surgeon may not like are all collected. In other words, the person entering the data should not stand to profit from or be adversely affected by it. One study shows, for example, that 27% of researchers report they would be tempted to present data in such a manner that it benefits or does not harm them personally when compared with others [7], so much for benchmarks.

The problem of data entry has been examined by various researchers. The psychologist Uri Simonsohn (University of Pennsylvania, Philadelphia) has even demanded that every scientific research article includes the following disclosure: "We report how we determined our sample, all data exclusions, all manipulations and all measures in the study." With regard to the use of statistics in scientific papers, he speaks of data that is "p-certified, not p-hacked" [8]. For the statistician Richard Royall (Johns Hopkins, Baltimore), three questions must be answered after completion of every study: (a) What evidence is presented? (b) Should I believe it? And (c) what can I do with it? Certainly a single method (not even a single registry) cannot answer these questions. Results from registries and databanks can be taken as an incentive to reflect and try new approaches to research. Steven Goodman (Stanford University) says: "The numbers (i.e., the statistical findings, comment of the author) are where the scientific discussion should start, not end" [9].

9.5 The Databank as a Diagnostic Tool for Improving Treatment

Anyone can make their results transparent with the help of a database or registry and can ask themselves whether they need to make further improvements or can be satisfied with their status quo. This critical pursuit of excellence is part of the Hippocratic oath. In addition to the evaluation of individual data, the gathering of grouped data offers an excellent chance to create transparency of results and improve treatment. To improve treatment, the data must be reliable (see above on data input), the statistical analysis of each finding must be balanced and appropriate (to validate the applicability of the results = draw broad inferences), missing data must be discussed transparently, the data must be risk-adjusted for interregional comparison, and the benchmark must set a "high bar."

Data must be reliable, as discussed above. Statistical analysis does not deal with the "truth" but with results that stimulate critical thought. As in science in general, findings are validated or falsified. This involves the formulation of precise hypotheses and asking the right questions of the registry. Results from databanks are not a goal in themselves, but dynamic indicators pointing the way to continuous improvement. For such analyses qualified statisticians are

needed to work with clinicians and to formulate and test novel statistical algorithms. This, together with risk adjustment, is one of the preconditions for the application of the data to other populations. To produce results that are readily applicable to multiple populations, the statistical handling of missing individual data in the registry must be transparent and published; some registries practice the exclusion of incomplete data sets from their analyses, which can represent a clear bias. Thus, for example, follow-up compliance declines sharply after only 6 months. Further, statistical analysis of registry data is not trivial if many patients and many variables lead to many subgroup analyses. It must be pointed out, however, that a registry analysis does not involve a comparison between procedures, but rather investigation of the results obtained with the procedures in a given population.

Without adequate risk adjustment, there can be no benchmarking and no comparison between two clinics. This is of special importance in a time when benchmarking is overrated. And finally, the general applicability of results from registries must be reassessed. Above all statements regarding the superiority of one or another, surgical technique must be examined closely in light of all the available data and the risk adjustment, for the experience of the surgeon also plays a role. Every act of benchmarking that compares the "surgeon with the mean value of his peers" is nonsense. For benchmarks as they pertain to patients must always aim at the best, never at the mediocrity of a majority!

Conclusion

Perhaps the most important advantage of a database is the awareness they raise regarding the findings they contain. This is the starting point for lifelong learning and continuous improvement of personal results. Surveillance of medical products, benchmarking, and public health policy interests should not be allowed to overburden and misuse the potential of databases.

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10 Ventral Hernia Surgery in Europe: Trends and Actual Situation

S. G. Parker and A. C. J. Windsor

10.1 Background

European surgeons have been at the centre of hernia research for the past 150 years. In the mid-1800s, Billroth predicted the development of prosthetic mesh by writing, "if we could artificially produce tissues of the density and toughness of fascia and tendon, the secret of the 'radical cure' for hernia would be discovered" [1]. Since then the search for the perfect mesh implant has been one of the main aims of hernia research.

Hernia research has also focused on improving the surgical technique for both inguinal hernia and ventral hernia surgery. Nuttall, from the UK, described his technique of "rectus transplantation in the treatment of ventral hernias" in 1926, and although this has not been adopted as a commonly used technique, this paved the way for reconstructive surgeons to use more imaginative and complex techniques to try and improve outcomes. In the same publication, Nuttall acknowledges that "the difficulties of obtaining a 'radical cure' in large ventral hernias are well known" [2]. Over the last century, despite the discovery of numerous innovative surgical techniques and the synthesis of many complex surgical meshes, the complication rates and hernia recurrence rates after ventral hernia repair remain high, and the "difficulties" in finding a "radical cure" for ventral hernia disease still remain.

We will first discuss the trends in ventral hernia surgery in Europe, focusing particularly on the contributions made by European surgeons. We will outline the trends in ventral hernia prevalence; we will discuss the risk factors involved in ventral hernia recurrence, the methods used to prevent ventral hernia occurrence, the evolution of the mesh implant in ventral hernia repair, the development of ventral hernia grading scales and the emergence of day surgery and laparoscopic surgery along with the associated reduction in length of hospital stay. After this, we will discuss the actual situation of European ventral hernia surgery focusing on the innovative surgical techniques being used, ventral hernia sub-specialisation, multidisciplinary abdominal wall reconstruction, surgical site infection prophylaxis and finally the emergence of national ventral hernia databases. Ventral hernia repair has now become so complex that the term "abdominal wall reconstruction" is now commonly used.

10.2 Trends

10.2.1 Prevalence of Ventral Hernia

Worldwide, studies have shown an increasing prevalence of ventral hernia over the last 20 years [3, 4]. In Europe, smaller studies have also reported an increasing prevalence in the ventral

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hernia repair [5, 6]. This increasing prevalence is due to the increasing number of intra-abdominal operations being performed and the high incisional hernia [7] and hernia recurrence rates, which are reported at between 10 and 30% [8, 9]. A systematic review performed by Bosanquet et al. from Cardiff University reported an overall primary incisional hernia rate after midline laparotomy at 12.8% at 2 years follow-up [10]. This review also reported an increase in prevalence of midline incisional hernia, with reported rates averaging 8% in 1980 to 16% in 2012 [10] showing that incisional hernia rates have doubled in the past 30 years. There is, however, some doubt as to whether the true ventral and incisional hernia recurrence rates (and therefore prevalence rates) are ever reported. Results from the Danish Ventral Hernia Database have demonstrated that reoperation rates (frequently used to estimate ventral hernia recurrence rates) underestimate hernia recurrence by four- to fivefold, [11] and a publication from Spain in 2014 reported the true umbilical trocar incisional hernia rate at 26% after laparoscopic cholecystectomy at 47 months of follow-up. Previous estimates of umbilical trocar incisional hernia rates had been reported at between 1 and 2% [12]. Consequently, it seems that ventral hernia recurrence rates are likely to be grossly underestimated due to loss to follow-up.

10.2.2 Prevention of Ventral Hernia

European surgeons have led the research in incisional hernia prevention. In 1976, Jenkins published his landmark paper "The burst abdominal wound: a mechanical approach" demonstrating that a suture length to wound length ratio of 4:1 or greater significantly reduced the rate of burst abdomen when compared to a ratio of 2:1 [13]. Jenkins later published his results for incisional hernia repair showing that his new technique for mass closure reduced the rates of incisional hernia recurrence [14]. Consequently, the "Jenkins Rule" which advised a suture length to wound length ratio of 4:1 became common practice amongst general surgeons. European academic surgeons continued to analyse laparotomy closure technique and its associated wound complications and incisional hernia occurrence. Mayer et al. showed that with high tension on a suture line, there is a higher incidence of surgical site infection (SSI) compared to low tension [15]; this is probably due to compressed and devitalised tissue. Suture closure with large bites was shown to be associated with SSI, and again this is thought to be because large bites compress and cut through more tissues when compared to small bites [16]. The Israelsson group, from Sweden, published the first level one evidence, in 2009, which showed the "small bites" technique for midline laparotomy closure significantly reduced the incidence of post laparotomy SSIs and incisional hernia. In the following year, the INLINE systematic review, written in Germany, was published [17]. This confirmed that laparotomy closure should be performed using a continuous (vs. interrupted), slowly absorbable (vs. rapidly absorbable) suture to significantly lower incisional hernia rates. To finally address the topic of whether laparotomy closure should be with either the continuous "small bites" (Israelsson technique) or the continuous "large bites" (Jenkin's rule) technique, a multicentre randomised controlled trial (RCT), the STITCH trial, was carried out in the Netherlands between 2009 and 2012, and the results were published in 2015. This RCT, containing 560 patients, showed a significant reduction in the rate of incisional hernia using the "small bites" closure technique therefore recommending it's standard use for laparotomy closure [18].

There are two other much-debated topics in incisional hernia prevention. Firstly, whether or not a midline or transverse incision should be used, and secondly, whether or not a prosthetic mesh (synthetic or biologic) should be inserted at the time of laparotomy closure. Brown et al., from the UK, published a Cochrane review supporting the use of transverse abdominal incisions as this significantly reduces post-operative pain, the risk of wound rupture and incisional hernia and may quicken recovery. The review does recognise the limitations of transverse incisions in terms of access to the abdominal cavity and

recognises that the choice of incision remains the preference of the surgeon [19]. Timmerlans et al., from the Netherlands, published a meta-analysis of five RCTs and showed a significant reduction in the rate of incisional hernia after using polypropylene mesh at primary laparotomy closure when compared to suture closure. There was no difference in wound infection or seroma rate [20]. Currently, general surgeons do not use the addition of synthetic mesh as a standard method of laparotomy closure despite this supportive evidence to do so. This is because of the added expense, the risk of mesh-related complications and the difficulties in access if a sequential intra-abdominal operation is required. There is currently insufficient evidence to support the use of biological mesh for incisional hernia prophylaxis [21].

This research into laparotomy closure resulted in the publication of European Hernia Society guidelines on the closure of abdominal incisions in 2015 [22]. These guidelines include the use of a non-midline incision where possible, a continuous slowly absorbable suture, the "small bites" technique, the mesh augmentation in high-risk patients and the closure of laparoscopic port sites with a diameter of 10 mm or greater.

10.2.3 Risk Factors for Ventral Hernia Recurrence

The prevalence of ventral hernia disease remains high, and there is no evidence that recurrence rates after repair are improving. To reduce recurrence rates, researchers have been working to identify and control the risk factors associated with recurrence. Observational studies and large case series of ventral hernia repairs have been published to analyse the variables that predispose to wound complications and recurrence. In the literature, high BMI [23], smoking [24], diabetes [25], advanced age [26], steroid use [27], previous hernia repair [28], previous and post-operative wound infections [29], size of hernia defect [26] and onlay mesh [30] have all been shown to be associated with surgical site occurrences and hernia recurrence. In Europe, Rios et al. published a series of 261 open ventral hernia repairs showing that age greater than 60, previously attempted ventral hernia repair, hernia width greater than 10 cm, and post-operative wound infection all predisposed to hernia recurrence [9]. Bencini et al. published a series of 146 laparoscopic ventral hernia repairs in 2009 and showed that smoking and previously failed ventral hernia repair were significant factors for recurrence [31]. In 2013, the Danish Ventral Hernia Database published its outcomes for 3258 incisional hernia repairs and showed poor early outcomes for patients with advanced age, open repair, a hernia defect greater 7 cm in diameter, and a vertical incision at the time of primary laparotomy. Higher late complication rates were associated with younger age, open repair, wider hernia defects greater than 7 cm, and onlay or intraperitoneal mesh [26]. Advanced age was an inverse risk factor for long-term reoperation due to more comorbidity, fewer cosmetic objections and shorter life expectancy. Recently, Hauters et al., from Belgium, have shown that in laparoscopic ventral hernia repairs with a bridging technique, recurrence is associated with incisional ventral hernia, BMI >35, defect width >4 cm, defect area >20 cm^2, mesh overlap <5 cm and ratio of mesh area to defect area of ≤12 [32]. This demonstrates a worldwide emerging trend in ventral hernia research that surgeons are increasingly looking at preoperative CT scan dimensions as risk factors for recurrence.

10.3 The Mesh Implant

The first prosthetic mesh was made from silver filigree and used by Goepel in Germany [33], and during the first half of the nineteenth century, other metallic meshes were trialled, but their use was not popularised due to their propensity to cause sinus tracts and chronic pain. The first use of polypropylene mesh was in 1956 when Sir Francis Usher used a flat sheet of polypropylene mesh (Marlex) to bridge a hernia defect [34]. Since then polypropylene has become the most widely utilised material for ventral hernia repair. Polyester and expanded polytetrafluoroethylene

(ePTFE) are two other plastics that have been used to make synthetic mesh. In the 1980s, Rives and Stoppa helped to popularised the mesh repair with their independent publications describing the placement of mesh in the retro-rectus plane [35, 36]. During the 1990s, Luijendkil et al. conducted the first multicentre randomised trial comparing suture and mesh repair in 181 elective ventral hernias [37]. The 3-year hernia recurrence rates were 46% for suture repair and 23% for mesh repair. At 10 years of follow-up, the authors found a recurrence rate of 63% for suture repair and 32% for mesh repair with no significant difference in other complications [38]. This level one evidence has led to surgeons abandoning primary suture repair and adopting mesh repair as the technique of choice. As a result, researchers have since focused on the properties of the mesh prosthesis aiming to discover which mesh produces the best surgical outcomes.

Multiple mesh products have been developed. For small ventral hernias, patch or plug systems have been developed and are widely used across Europe [39, 40]. The advent of laparoscopic ventral hernia repair has led to the invention of composite meshes, as synthetic polypropylene and polyester meshes cause bowel adhesions when in contact with the abdominal viscera [41]. Composite meshes have a biodegradable coating that provides a barrier between the viscera and the synthetic mesh allowing for the formation of neoperitoneum before absorption. Many composite mesh products have emerged on the market (Parietex, Proceed, DualMesh, etc.). The fear of mesh infection and subsequent mesh explantation after ventral hernia repair has led to the development of both biologic and biosynthetic mesh. Published guidelines recommend the use of biologic mesh in a contaminated operative field due to the theoretical benefits of tissue ingrowth, revascularisation and infection resistance [42]. However, level one evidence comparing synthetic vs. biologic mesh in contaminated ventral hernia repair is still lacking, and recent retrospective trials give conflicting results as the real benefits of a biologic mesh [43, 44]. Similar to composite mesh, there are multiple biologic (Strattice, Cellis, XenMatrix, Surgimend, etc.) and biosynthetic (Gore Bio-A, Phasix, Tiger, etc.) mesh products available.

Many other mesh products exist but to go into all the available products, and their theoretical advantages, disadvantages and indications is beyond the scope of this chapter. Mesh products differ in their pore size, weight, strength, absorption half-life, method of fixation and cost. Today, there is a highly competitive market in Europe, and worldwide companies compete to produce the best synthetic mesh.

10.4 Ventral Hernia Grading Scales

At the second international meeting of herniologists in Suvretta, Austria, in 1998, Volker Schumpelick called for a classification of incisional hernias, which would enable "multicentre trials" and "comparison of the literature". Consequently, at the turn of the century, incisional hernia classification systems began to be described by European surgeons. In the following year, Schumpelick published his own grading scale [45], and at a similar time, Chevrel and Rath published their, better known, classification scale [46]. A modification of the Chevrel classification was published shortly afterwards, after a meeting of ten international hernia experts [47]. In 2005, Ammaturo and Bassi argued for the addition of the "anterior abdominal wall to the hernia defect ratio" to the Chevrel classification [48]. Later, Dietz et al. described a highly complex incisional hernia classification system [49]. However, none of these grading systems have been validated or adopted for clinical use. At the 29th Congress of the European Hernia Society (EHS) in May 2007, Andrew Kingsnorth, the society's president, stressed that a classification of ventral and incisional hernia was important as the literature was comparing "apples and oranges". This led to the development of the EHS classification systems for primary and incisional abdominal wall hernias [50]. Both the primary and incisional classifications categorise the hernias according to their location and size, allowing for the comparison of ventral hernias according to their morphology.

These two EHS classification systems have been widely adopted in the literature as they are simple to use but detailed enough to describe a ventral hernia's physical characteristics. They are currently being used by both the European ventral hernia database (EuraHS) and the American Hernia Society Quality Collaborative (AHSQC) database. To date, there is only one publication that externally validates the EHS classification system. This shows a significant dependence of surgical site occurrences according to the EHS classification [51].

Worldwide, several other classification systems have been described, which stratify patients according to their risk of either surgical site infection or recurrence. Some have been externally validated showing differing degrees of accuracy. Perhaps the most well-known of these is the Ventral Hernia Working Group (VHWG) grading scale [42], which uses comorbidity and risk of wound contamination to stratify patients into four tiers. Many European surgeons use this scale whilst carrying out their own research and when describing ventral hernias.

10.5 Reduction in Hospital Length of Stay

During the end of the twentieth century, the length of hospital stay for the post-operative ventral hernia patient has reduced significantly. This came about because of the development of day surgery and the invention of laparoscopic surgery.

10.5.1 Day Surgery

Day surgery for hernia repair was a concept principally developed in the UK by Brendan Devlin. His landmark paper, published in the Lancet in 1977, showed no difference in complication rates after inguinal hernia repair for patients who were discharged 8 h after surgery compared to patients who stayed in hospital for 5 or 6 days after surgery [52]. In this paper, he also demonstrated that day surgery resulted in significant cost savings. Over time day surgery units were developed throughout Europe, with many hernia centres reporting large case series of day-case ventral hernia repairs by the early 2000s [53, 54].

10.5.2 Laparoscopic Ventral Hernia Surgery

Ever since the first laparoscopic cholecystectomy in 1985, laparoscopic surgery has been utilised for a vast number of general surgery procedures. The first laparoscopic ventral hernia repair is accredited to Leblanc in 1993 [55]. Soon afterwards case series of laparoscopic ventral hernia repairs started to be published by European surgeons [56]. The first RCT comparing laparoscopic and open ventral hernia repairs was published in 1999 by a Spanish surgical group [57]. This RCT demonstrated that laparoscopic repair significantly reduced not only post-operative complication rates but also length of hospital stay, reoperation rate, hernia recurrence and operation time. Since this publication other RCTs haven't shown such complimentary result for the laparoscopic technique; however, there is little doubt that laparoscopic repair does significantly reduce the length of hospital stay and the local wound infection rates [58].

During the early twenty-first century, laparoscopic ventral hernia repair has become a widely accepted technique. Large case series have been published from European hospitals, most notably from Spain [59, 60]. To improve outcomes, researchers have been trying to adjust and improve the finer details of laparoscopic repair. In Europe, Muysoms et al. carried out an RCT comparing the "double crown", "tackers only" mesh fixation technique with the "tackers and sutures" mesh fixation technique. This trial found that the "double crown" fixation was quicker and less painful post-operatively and at 3 months after hernia repair. There was no associated increase in recurrence rate [61]. However, a published systematic review, also from Belgium, reports "none of the currently available mesh fixation techniques used for LVHR is found to be superior in preventing hernia recurrence as well

as in reducing abdominal wall pain", and the literature, in general, remains inconclusive about the best mesh fixation technique. Indeed, much of the literature on laparoscopic ventral hernia repair has been contradictory, and this led to the publication of the evidence-based guidelines from Italy in 2013 [62]. Of note, they recommend a mesh to hernia defect overlap of 3 cm for smaller defects (3–4 cm) and a 5 cm mesh overlap for larger defects (>4 cm). Currently research in laparoscopic ventral hernia repair in Europe is focusing on mesh type, defect closure and mesh fixation with glue. Further studies are required to evaluate the long-term outcomes of these many different methods and techniques.

10.6 Actual Situation

10.6.1 Innovative Surgical Techniques

In recent years, there has been much pioneering work investigating new ventral hernia repair techniques. This innovation was, in part, led by French surgeons, Rives and Stoppa, who both published their case series of retro-rectus incisional hernia repairs in the 1980s [35, 36]. This technique placed the synthetic mesh posterior to the rectus abdominis muscles and anterior to the posterior sheath and has reduced the local wound complication rates and hernia recurrence in patients receiving open surgery [26]. Shortly afterwards, Ramirez published the anterior component separation technique, which is used by most hernia surgeons to achieve primary abdominal closure with large ventral defects [63]. Preoperative pneumoperitoneum and botulinum injections into the abdominal strap muscles are two other techniques that have been invented by surgeons to stretch the abdominal muscles before ventral hernia repair. Several European surgeons have published their series of ventral hernia repairs with preoperative pneumoperitoneum [64–68], over the last 30 years. However, despite these series show promising results, preoperative pneumoperitoneum has not become a routine practice in specialist hernia centres.

Today, innovative ventral hernia repair techniques are being investigated by many European surgeons. Whilst the Rives-Stoppa repair and the anterior component separation technique remain standard techniques for open midline hernia repair, many European institutions are now using the open transversus abdominis release (TAR) approach for the larger, more complex midline hernias [69, 70] with one cohort study reporting a lower wound infection rate with TAR when compared to anterior component separation [71]. This is thought to be due to the use of subcutaneous skin flaps during anterior component separation, which predispose to local wound complications. Laparoscopic ventral hernia repair with intraperitoneal onlay mesh (IPOM) is also a commonly used technique throughout Europe. To improve this technique, specialist centres are now using the "laparoscopic augmentation" repair, or the "IPOM plus" repair, which combines closure of the defect with intraperitoneal mesh placement. Defect closure is achieved either via an intra-corporeal continuous suture or by extracorporeal interrupted transfascial sutures. A recent large case series of 1326 patients from Belgium using the "IPOM plus" technique shows promising results with a wound infection rate, a seroma formation rate and a recurrence rate of <1%, 2.6% and 4.7%, respectively, at 78 months follow-up [72]. In Denmark, Lars Jorgensen is performing open ventral hernia repairs with assisted endoscopic component separation [73]. This technique preserves the blood supply to the midline subcutaneous tissue, therefore aiming to reduce local wound complication rates. At present, larger studies are required to see if endoscopic component separation adds any significant clinical benefit. The use of preoperative pneumoperitoneum may become "in vogue" again after a recent case series published by Renard et al., from Reims, which showed an 8% recurrence rate [74]. In addition, another recent case series from Spain used both preoperative pneumoperitoneum and botulinum injections for preoperative abdominal wall relaxation [75]. By using both techniques simultaneously, they have reported an excellent recurrence rate of 4.4% with a median follow-up of 40.5 months. Other innovative techniques

currently being investigated in Europe include both robotic and laparoscopic retro-rectus ventral hernia repair. The results of these two new techniques are yet to be reported in the literature.[1]

10.6.2 Sub-Specialisation

Ventral hernia repair is becoming increasingly complex. This is partly due to the rising prevalence of obesity, advancing age and the high recurrence rate of ventral hernia (as each subsequent hernia repair becomes increasingly challenging). The presentation of obese, elderly patients with multiple previous ventral hernia repairs and a history of significant abdominal surgery (either for cancer or not) are now not unusual. These patients with multiple comorbidities and large, complex recurrent ventral hernias are difficult to repair. As a result, most European countries have started to introduce national centres for hernia surgery with varying degrees of formality. In Germany, a three-tier system for ventral hernia surgery, with formal surgeon training and certification, has been implemented [76], and Denmark has five nationally approved hernia surgery centres [77]. In the UK, complex ventral hernia patients have traditionally been referred to our national intestinal failure units; however, we plan to create hernia centres [78] and introduce a national triage system for ventral hernia patients.

Specialist hernia centres must have the appropriate resources if they are to treat these complex patients affectively. Multidisciplinary teams including both general and plastic surgeons, bariatric surgeons, intensivists and radiologists are required. If the centre also treats intestinal failure with contaminated ventral hernias containing entero-cutaneous fistulas, medical nutritionists are also required. This multidisciplinary approach to complex ventral hernia repair is being performed in many centres across Europe [69–80].

[1]Robotic ventral hernia repair is being carried out by Filip Muysoms, Gent University Hospital, Belgium. Laparoscopic retro-rectus ventral hernia repair is being performed by Salvador Morales-Conde, Ave Maria Surgical Centre, Seville, Spain.

10.6.3 Prevention of Surgical Site Infections

As previously stated in this chapter, studies have reported an association between surgical site infections (SSIs) and ventral hernia recurrence [29, 81]. Consequently, in recent years there has been much research into the prevention of postoperative wound infections. One technique that has been instrumental in lowering SSIs is the design of the negative wound pressure dressing. Retrospective comparative studies [82, 83] of post abdominal wall reconstruction have shown negative pressure dressings to significantly reduce wound infections rates. These negative pressure dressings are now being used in clinical practice for SSI prophylaxis, particularly for high-risk or contaminated patients.

10.6.4 National and International Ventral Hernia Databases

Throughout surgery there has been an emergence of multicentre databases. Pooled data from large population samples can be used by academic surgeons to determine complications rates, discover preoperative risk factors for operative failure and improve our knowledge about the consequences of variations in surgical technique. In Europe, so far, three national and one international databases have been implemented in recent years: the Danish Ventral Hernia Database (DVHD) [84], the German Ventral Hernia Database, “HerniaMed”, the Spanish incisional hernia database (EVEREG) [85] and the European registry for abdominal wall hernias (EuraHS) [86]. The Danish database was the first to be founded in 2007 and has already produced many informative publications. These databases will contribute much to the future literature and to our understanding about ventral hernia disease. In particular, they should be used to externally validate the previously mentioned ventral hernia grading scales as accurate grading scales which predict ventral hernia repair success and would be extremely useful in the clinical setting.

Conclusion

As ventral hernia recurrence rates and postoperative wound complications rates remain high, the challenges involved in improving ventral hernia repair outcomes are at the forefront of surgical science. As a result, there has been a significant increase in academic interest in this area of surgery. In Europe and worldwide, this subspecialty is now rapidly evolving with much innovation, which requires accurate investigation and publication to further our understanding and to improve operative outcomes.

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Hernia Repair in the United States: Current Situation and Trends

11

James G. Bittner IV and Natasha L. Clingempeel

11.1 Hernia Epidemiology

In the USA, the incidence and prevalence of hernia are multifactorial and complex. Various medical conditions prevalent in the USA impact the formation and recurrence of hernias. Similarly, many operations on the abdomen and groin are performed using an open approach, though there is a trend toward more widespread adoption of minimally invasive techniques, especially for inguinal and ventral/incisional hernia (VIH) repair. Some aspects of hernia diagnosis remain unchanged over the last 50 years, while some management options, such as robot-assisted hernia repair, are dramatically changing the paradigm.

According to a US National Health Survey, the prevalence of hernia in the USA between 1957 and 1959 was 14.9 cases per 1000 people. The population of the USA in 1959 was approximately 177.8 million people [1]. Given these data were culled from a survey and that respondents may have had a hernia without knowing it, this figure likely underestimates the prevalence of hernias in the population at the time. More recent data (2001–2010) supports abdominal wall hernia prevalence of 1.7% for all ages and 4% for people over age 45 years. Inguinal hernia accounts for 75% of abdominal wall hernias, with a lifetime risk of 27% in men and 3% in women [2]. Incisional hernia incidence is on the rise in the USA due to increased access to surgical care, increased rates of laparotomy, and availability of minimally invasive techniques.

The current prevalence of groin hernias is estimated at 10% of the total US population (326.4 million) or approximately 32 million people. However, these data are speculative because the actual prevalence of hernia is difficult to determine. Confirming an accurate prevalence of hernia in the USA is challenging because of inconsistency in data sources and collection methodology, lack of standardization in hernia definitions, and subjectivity of physical examination even when performed by experienced surgeons.

According to data from the US National Center for Health Statistics, which represents inpatient hospitalizations, over two million inpatient abdominal wall hernia repairs were performed from 2001 to 2010. It is estimated that over 550,000 repairs were performed emergently, and the annual (age-adjusted and sex-adjusted) rate of incidence of emergent hernia repair per 100,000 people increased over the data collection period. Most patients (50–60%) who underwent inpatient emergent hernia repair during this period were insured by the US Centers for Medicare & Medicaid Services, a federal agency that administers public health-care plans [2]. This

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increase in incidence of emergent hernia repairs parallels the increase in hernia risk factors among the US population. Specific risks factors are highlighted in the subsections that follow.

11.1.1 Groin Hernia

In the USA, the lifetime risk of developing a groin hernia is about 25–27% in men and 3–5% in women [2–4]. Around 800,000 people in the USA undergo groin hernia repair annually. Most groin hernias are inguinal (indirect hernias occur twice as often as direct inguinal hernia), while a smaller proportion are femoral (<10% of all groin hernias). Groin hernias are eight times more common in men compared to women and in Caucasian people compared to other races/ethnicities. Up to 30% of patients with groin hernia are asymptomatic, and 50% may not even be aware they have a groin hernia. The incidence of groin hernia repair rises with patient age, with a peak incidence around age 70–80 years. The highest prevalence of groin hernia occurs in men age 75 years or more (45%). Men are 20 times more likely than women to present for groin hernia repair. Women who present with groin hernia more often come to repair at an older age than men [4].

Factors shown to impact the incidence of groin hernia include a positive family history of groin hernia, occupation, obesity, and certain comorbidities. While not entirely understood, studies show that a positive family history of groin hernia can increase the incidence of groin hernia, reflected by adjusted odds ratios of 4:8 compared to people with no significant family history of groin hernia. Occupations requiring high physical demand may increase the incidence of groin hernia as demonstrated by a cross-sectional study of US sanitation workers. Little additional data are available on occupations that predispose to groin hernia [4]. Obesity contributes to increased intra-abdominal pressure and has been associated with increased incidence of hernia [2]. These data may not be applicable to the whole US population. Comorbidities besides obesity can impact the incidence of groin hernia as well. These include but are not limited to Ehlers-Danlos syndrome, prostate hypertrophy, prostatectomy, chronic obstructive pulmonary disease (COPD), chronic constipation, and possibly peritoneal dialysis [4].

11.1.2 Ventral Incisional Hernia

Many people (two million) undergo primary laparotomy each year in the USA for benign conditions. Among these patients, VIH may occur in up to 28% (over 500,000 people) [5]. At least 300,000 to 500,000 patients undergo VIH repair every year in the USA [5, 6]. According to a 1996 study by Rutkow and colleagues [6], in which they reviewed inpatient data obtained from the National Hospital Discharge Survey and National Survey of Ambulatory Surgery, the estimated number of VIH repairs performed in the USA that year was 339,000. One decade later that number had increased by over 25,000 VIH repairs. Poulose and colleagues [7] determined that 365,400 VIH repairs were performed in the USA during 2006 and that number increases by a conservative 3% per year. If the data-driven calculation proposed by Poulse et al. [7] is used to extrapolate current-day prevalence, approximately 475,000 VIH repairs were performed in the USA during 2016. The total estimated procedural cost to care for patients with VIH approached $3.2 billion (US dollars) in 2006 [7]. Of course, these costs do not account for treatment of complications that may arise because of VIH repair.

A major risk factor that predisposes to formation of VIH includes laparotomy for any reason, particularly midline laparotomy. The odds of developing a VIH may be increased further in the setting of perioperative wound issues, obesity, active smoking, uncontrolled diabetes mellitus, and malnutrition [8]. In the USA, the most significant risk factor for development of VIH besides laparotomy is the widespread prevalence of obesity. The significant obesity rate in the USA represents a major health crisis. Data from a 2015 Centers for Disease Control National Center for Health Statistics highlight the

prevalence and regionalization of obesity in the USA. In that year, approximately one-third (36.5%) of the US population was considered obese and no state had prevalence of obesity less than 20% [9]. Obesity rates are increasing across all states, and certain regions of the country have a much higher rate of obesity than other areas, suggesting further studies are warranted to define the role of obesity and VIH among regionalized populations. While obesity may or may not be protective against groin hernia, multiple studies demonstrate the negative impact of obesity on the development and recurrence of VIH [8, 10]. Active smoking is a major risk factor for VIH occurrence and remains the leading cause of preventable death in the USA, with too little spent on tobacco prevention and control according to the Centers for Disease Control and Prevention [11, 12]. Approximately 36.5 million people in the USA were active smokers in 2015 [12]. Other modifiable factors include malnutrition and poorly controlled diabetes mellitus, both of which can increase the risk of perioperative wound complications. Approximately 29 million people in the USA have diabetes with management costing an estimated $245 billion in medical care and lost wages [13].

11.2 Pre-Habilitation

Increasingly in the USA, surgeons are educating patients about modifiable risk factors that impact the success of hernia repair. Multiple risk stratification tools are available for use in educating patients about their individual risk, defining the impact of modifiable risk factors, and helping select operative technique. Some of the commonly used tools in the USA include the modified ventral hernia working group grading system, American College of Surgeons Risk Calculator, Ventral Hernia Risk Index, and HERNIAscore [14–17].

Due to the prevalence of these modifiable risk factors in the USA, many surgeons institute a pre-habilitation approach to VIH management. Strategies to prepare a patient for VIH vary, but a growing number of hernia experts and hernia centers in the USA now discuss (often require) medically supervised or surgical weight loss with appropriate patients, mandate smoking cessation, ensure glycemic control, supplement nutrition, and modify immunotherapy. Other modifiable comorbidities that pose perioperative risk are cardiopulmonary and hematologic disease, specifically cardiopulmonary function and history of venous thromboembolism, coagulopathy, or bleeding diathesis. These evidence-based pre-habilitation strategies can be used in conjunction with a postoperative enhanced recovery pathway and other adjuncts to improve patient outcomes.

11.3 Operative Techniques

The USA continues to see a change in the types of operative techniques used for hernia repair. Some of what is transpiring in the USA has occurred in other countries at a more expeditious fashion for various reasons. One example is the slow but increasing adoption of minimally invasive groin hernia repair by surgeons in the USA compared to the current, widespread use of minimally invasive groin hernia repair by surgeons in the European Union. Recent data suggest that surgeons in the USA select a laparoscopic approach to hernia repair only 15–20% of the time, with no variability by geographic region [18]. On the other hand, adoption of robot-assisted hernia repair is growing rapidly in the USA but much more slowly in the European Union and other parts of the world. The consulting firm, Deloitte, recently estimated that in 2016 robot-assisted hernia repair comprised 19% of all hernia repairs in the USA [unpublished data, Intuitive Surgical, Sunnyvale, CA]. This increased use of a robot-assisted approach to hernia repair came at the expense of fewer open hernia repairs.

The frequency of open anterior and posterior component separation for VIH repair seems to be on the rise in the USA as evidenced by a growing body of data from USA centers supporting the safety and long-term efficacy of both techniques [19, 20]. However, the trend is to adopt an approach that minimizes postoperative

complications and hernia recurrence. This has led an increasing number of surgeons to learn and adopt open posterior component separation, specifically transversus abdominis release (TAR). When performed by experienced surgeons, open TAR yields lower wound morbidity compared with open anterior component separation, though the risk for wound-related events remains an issue [21]. Novitsky and colleagues [21] reported on 428 consecutive open TAR patients and found surgical site events in 18.7%, surgical site infections in 9.1%, hernia recurrence in 3.7%, and mesh debridement in 0.7% at a mean follow-up of 31.5 months. Teaching institutions, surgical organizations, and industry partners throughout the USA offer training in open TAR at surgical meetings, workshops, and hands-on courses, speaking to the evidence-based popularity of the technique.

Given the proven benefits of both a minimally invasive approach to hernia repair and TAR, some expert surgeons in the USA, including the author, are capitalizing on those benefits by offering laparoscopic and/or robot-assisted TAR for VIH repair. A retrospective, multi-institutional propensity-matched cohort study of patients from the Americas Hernia Society Quality Collaborative demonstrated the benefits of robot-assisted retromuscular VIH repair regarding hospital length of stay, surgical site occurrence, surgical site infection, and surgical site infection requiring procedural intervention [22]. The study propensity matched 222 patients who underwent open retromuscular VIH repair to 111 patients who had robot-assisted retromuscular VIH repair. A similar proportion of patients in each cohort underwent TAR (83% open vs. 85% robotic, $P = 0.7$). Ultimately, the authors showed that patients who underwent a robot-assisted retromuscular VIH repair experienced a significantly shorter hospital length of stay (1 day) with no difference in 30-day surgical site infection rates (4% vs. 2%, $P = 0.5$). Out to 30 days postoperatively, few patients in the open and robot-assisted retromuscular VIH repair groups suffered surgical site occurrence requiring procedural intervention (5% vs. 4%, $P = 0.8$) [22].

While still in its infancy, there are a growing number of mentorships and postgraduate courses throughout the USA dedicated to teaching minimally invasive TAR to experienced surgeons. One such example is a program of the International Hernia Collaboration (International Hernia Collaboration, Inc., New York, NY) that pairs expert faculty with experienced (vetted) surgeons interested in TAR and provides didactics, video review, hands-on training, proctoring, and longitudinal mentorship.

11.4 Mesh Type and Location

Another paradigm shift occurring in the USA is the way surgeons think about mesh type and location for hernia reinforcement. Recent studies show that mesh placed in a retromuscular/preperitoneal location yields lower morbidity and hernia recurrence rate compared to other positions [23, 24]. Surgeons who already offer a minimally invasive approach to VIH repair are increasingly placing mesh in the retromuscular/preperitoneal space trying to minimize adhesions to foreign body and potentially improve outcomes. Other surgeons who once offered only open VIH repair are now adopting a robot-assisted approach at an increasing rate. These surgeons feel the robotic surgical platform allows them the ability to offer benefits of a minimally invasive approach and mesh placement in a retromuscular/preperitoneal location.

Another changing aspect in the USA is the increasing use of permanent synthetic, hybrid, and absorbable synthetic meshes in lieu of biologic grafts for reinforcement of VIH repair particularly in clean-contaminated wounds [25, 26]. While correct choice of technique is paramount to minimize complications and hernia recurrence, a growing number of novel meshes and mesh types currently available in the USA are designed to aid in those goals.

According to independent market analysis (QuintilesIMS™ Inc., Danbury, CT) from 2016, the total hernia market for mesh in the USA exceeds $550 million. Much of the total sales come from the inguinal ($90 million) and ventral

($450 million) hernia mesh markets. Within the inguinal hernia market, which is harder to quantify due to reporting inadequacies, the amount of money spent in the USA for inguinal hernia mesh increased by 5%, but the number of units sold remained stable in 2016 compared to 2015. Various shifts in the way surgeons approach inguinal hernia repair impacted the tack fixation market, which decreased by 7% in dollars and 6% in units sold over the same period. This change is due in part to the increasing market penetrance of robot-assisted inguinal hernia repair, surgeon's efforts to avoid tacks and minimize postoperative chronic groin pain, and cost constraints.

Independent market analysis (QuintilesIMS™ Inc., Danbury, CT) of the ventral hernia market in 2016 shows hernia biomaterials such as biologic graft ($250 million) followed by permanent synthetic mesh ($205 million) and absorbable synthetic mesh ($130 million) comprise most of the mesh used. The total hernia market saw a 2% increase in the ventral mesh segment in 2016 compared to 2015. Within the ventral mesh segment, sales of synthetic mesh products increased by 3%, absorbable barrier products increased by 7%, and permanent barrier products decreased by 10% over the same period. Changes in the management of ventral hernia impacted the tack fixation segment as well. The decrease in tacker use may be due in part to an increase in robot-assisted ventral hernia repair, mesh type and location, as well as a concerted effort by surgeons to minimize postoperative pain and shorten hospital length of stay in a patient-centered, value-driven health-care system. Instead of using tackers, more surgeons are seeking alternative methods to fixate mesh including barbed sutures, fibrin sealant (with or without sutures), self-fixating mesh, or a combination thereof [27].

The biomaterial segment of the total hernia market is made up of biologic grafts and absorbable synthetic mesh. This is the segment of the total hernia market that saw the most interesting change. Independent market analysis (QuintilesIMS™ Inc., Danbury, CT) shows that dollars spent on biomaterials decreased by 11%, while units sold increased by 3% from 2016 to 2106. These effects on the biomaterial segment may be due to multiple factors. Certainly, pricing pressures on a macroeconomic scale play a role as does the recent introduction of novel, lower cost absorbable synthetic mesh products to the biomaterials segment of the market. A growing body of literature supports the clinical effectiveness of lower cost absorbable synthetic meshes compared to higher cost biologic grafts regarding surgical site events and hernia recurrence [26, 28, 29]. Additionally, data from several centers show the potential safety of permanent synthetic mesh in high-risk wounds, which contributed to a movement by many US surgeons away from biologic grafts for hernia repair. These studies and mounting surgeon experience contribute to the trend of selecting clinically effective but less expensive biomaterials whenever possible.

Analyzing the total hernia market is a good way to evaluate trends in mesh sales and extrapolate mesh selection among US surgeons. However, market data do not provide sufficient information to assess operative technique or extrapolate the location of mesh placement, which are known to impact outcomes, particularly after VIH repair. Before adopting novel techniques, implanting new mesh types, or choosing different fixation methods to follow current trends, carefully consider all available data as well as local experience.

Various patient factors including comorbidities, surgical history, and hernia type and location can impact the choice of mesh location. Potentially modifiable risk factors such as body mass index [30], smoking status [11], wound class [31], and hernia-specific risk score [14–16] impact the choice of mesh location as well. Operative approach, based on patient acuity, surgeon skill set and experience, and availability of equipment for minimally invasive procedures, may alter options for mesh location. A recent meta-analysis, which analyzed 21 published articles (3 randomized controlled trials, 5 prospective cohort studies, and 13 case series), found that the pooled hernia recurrence rates between 5 and 60 months postoperatively varied by mesh location (16.5% onlay, 30.2% inlay, 7% sublay, and 14.7% underlay). Similarly, mesh location

impacted the rates of surgical site infection, with the sublay position conferring the lowest risk (16.9% onlay, 31.3% inlay, 3.7% sublay, 16.7% underlay) [24]. Other clinical trials and meta-analysis suggest that mesh in the sublay position offers the best outcomes [32], allows for anterior fascial coverage [33], minimizes exposure to intraperitoneal viscera [23], decreases the needs for fasciocutaneous flaps (depending on operative technique), provides for optimum load-bearing against tension generated by the abdominal wall [34, 35], allows for wide mesh overlap of the hernia defect, and permits use of inexpensive mesh. Based on these data and concepts, an international expert consensus concluded that sublay is the optimal location for mesh in open, elective ventral hernia repair, but there is a role for other mesh positions [36]. Dissemination of this information in the form of publications, guidelines, expert consensus, national surgical meetings, and other educational events is creating a slow but steady shift among US surgeons toward placing mesh as a sublay (retromuscular/preperitoneal) position whenever possible.

11.5 Robot-Assisted Hernia Repair

Robot-assisted hernia repair is on the rise in the USA. Using a national database, it was projected that 19% of primary inguinal and ventral hernia repairs would be done using a robotic surgical platform by the end of 2016. This speculation is supported on a smaller scale using city-wide data (Richmond, Virginia, USA) that confirm the high penetrance of robot-assisted inguinal hernia repair (20%) and VIH repair (30%) during 2016. That same year, approximately 26% of primary inguinal and ventral hernias underwent repair laparoscopically. The US data show a slow but noticeable downtrend in open inguinal and VIH repairs over the last 10 years, with the steepest decline in the last 2–3 years, and a concomitant uptrend in robot-assisted hernia repair.

Speculation for the growing interest in robot-assisted hernia repair among US surgeons is quickly being replaced by evidence of its adoption in the form of national presentations and published reports demonstrating better surgeon ergonomics compared to traditional laparoscopy [37], greater ability to perform more complex cases [38], improved short-term outcomes and shorter convalescence compared to an open approach [22, 39], and increasing availability of the robotic surgical platform.

11.6 Outcomes Assessment and Mentorship

Outcomes assessment remains a critical topic of discussion and ongoing research among US surgeons. With the recent adoption of a national, hernia-specific database – Americas Hernia Society Quality Collaborative (AHSQC)—patients can now benefit from real-world clinical outcomes assessment potentially improving value-based hernia care in the USA. The AHSQC contains data on almost 18,000 patients submitted by over 200 surgeons as of May 2017 [40]. While this represents a small fraction of patients with inguinal and ventral hernia in the USA, the AHSQC is gaining in popularity and utility, so the number of patients represented in the database should continue to grow. Perioperative hernia management, hernia characteristics, operative details, and short-term outcomes reporting are not standardized in the USA; however, the AHSQC characterizes these aspects of hernia care using predetermined, standard definitions. AHSQC also assures quality data and delivers it to end users in real time for quality improvement purposes.

Scientific studies using AHSQC data are helping shape the landscape of hernia repair in the USA. Investigators used the AHSQC to study the clinical effectiveness of epidural analgesia in elective VIH repair, question the utility of preoperative bowel preparation prior to VIH repair, compare the outcome of onlay vs. sublay mesh location, and assess the potential value of robot-assisted retromuscular VIH repair to highlight a few. Adoption of the AHSQC is growing among US surgeons and hospitals, as it allows for real-time analysis of diverse patient outcomes to

facilitate patient-centered and value-based hernia management. Nationwide, outcomes-based reporting is a trend that will continue for years to come.

It is challenging for surgeons, in the USA and elsewhere, to learn, adapt, and adopt new information and techniques in a safe, effective, and timely manner to benefit patients. Traditionally, practicing surgeons sought education and training through surgical organizations and/or industry partners in the form of national meetings, workshops, or short courses. With the rapid growth of so many new strategies for hernia management, surgeons in the USA are increasingly adopting web-based platforms to disseminate, discuss, and detail novel data and techniques. These real-time, web-based platforms expose US surgeons to hernia experts, entice cutting-edge management strategies, and provide networking among a multidisciplinary group of colleagues worldwide. The trend in the USA is rapid growth of social media to facilitate the practice of surgery and improve the outcomes and lives of the patients suffering with groin and/or VIH hernia. In summary, a growing number of US surgeons seek to expand their understanding of hernia, dialog with surgeon colleagues, offer new value-based operative techniques, assess longitudinal outcomes, and establish mentorship by expert hernia surgeons.

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Hernia Surgery in Asia

12

Davide Lomanto

12.1 Introduction

It is important to understand how the hernia disease may influence any healthcare system due to its prevalence and clinical outcome because it represent one or if not the most common surgical procedures performed annually in millions of patients worldwide. And for these reasons, it is naive to think that the surgical treatment and its related outcome will not have any impact on our society and that the healthcare policy maker from government to insurance companies would not be interested to the outcome and in decreasing the affected cost.

This is nothing new, Sir Cecil PG Wakeley, President of the Royal College of Surgeons of England in 1948, in one of his lecture to the college was saying that "A surgeon can do more for the Society by operating on hernia cases and seeing that his recurrence rate is low than he can by operating on cases of malignant diseases". A visionary, that is merely actual in today's world; in fact if we consider that the hernia disease has a prevalence that is age-related and raises from 12% at group age of 25–34 to 30–34% above 65 years old with a lifetime prevalence of 24.3% [1–3], we can easily calculate the entity of the problem. Moreover, the improvement of the socio-economics, the development of medical care, the affordability and availability of healthcare resources improved significantly the average life expectancy of individuals worldwide reaching 71.5 in 2015 from 61 in 1970 and today countries like Japan (83.7), Switzerland (83.4), and Italy (82.6) and above 80 years in other several countries.

The data from the hernia prevalence, the improved life expectancy and the rising population worldwide is an alarming news for healthcare services and providers.

Not surprisingly the incidence of hernia repair is lower than the incidence of the disease but this varies widely between developed and developing countries. Prevalence differences across regions are likely to be caused by variations in population age structure, access to surgical care and risk of death from hernia accident. We estimate a global inguinal hernia prevalence of 5.85%, meaning that about 223 million people globally have hernias [4] and that according to marketing strategies analysts, the market value for hernia mesh will reach four billion USD by 2020 with 11 million per year of surgical repairs and five billion by 2024 with 13 million surgical repairs yearly.

If we look at Asia, is the world's largest and most populous continent that covers 8.7% of the Earth with a population of about 3.9 billion in 169. Asia has a huge diversity in race, religions, languages, cultures not only within the continent itself but also within the country. For example, 600 languages are spoken in Indonesia, 800 in India and about 100 in the Philippines.

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Regarding to hernia, there are not many studies on incidence and prevalence of the disease in Asia but seems that prevalence is not different from other countries worldwide. Therefore, we can assume that in Asian countries like China or India, the prevalence may easily reach over two million yearly, about 450,000 in Indonesia, 300,000 in Pakistan and Bangladesh and between 150 and 250,000 in countries like Japan, Vietnam, Thailand and the Philippines. This has a significant impact on healthcare cost in the future of each countries considering that today the healthcare spending is still below the global average ranging from 200 USD per capita in Thailand to 800 USD in India and 2265 USD in China. There is a wide gap in type of hernia repairs among the Asian continent that with the improvement of the socio-economic data, the healthcare infrastructures is going to be minimized to the level of developed countries in 10–20 years.

Considering that Asia has a large population, in 2014, around 62% of total number of hernia repair procedures performed worldwide were in Asia but only less than 50% of hernia repair were performed using mesh, which corresponds to about 20% of the market worldwide. The adoption of mesh repair varies between 10 and 75% in various countries and also within the countries between the big city centre and the rural hospitals. In fact, still a large number of hernia surgeries in countries like India, China, Bangladesh, Myanmar, the Philippines and others are still being performed using the economical suture repairs with a greater risk for recurrence and post-operative sequelae.

That's why in Asia, awareness about "*optimal repair*" is becoming more and more important. An optimal repair that produces a good outcome, comparable to the worldwide standard in terms of recurrence rate, mesh-related infection, post-operative chronic pain, good quality of life after surgery with an acceptable and affordable cost.

At this purpose, it is an important role of the national societies and their experts, the continental Asia Pacific Hernia Society (APHS) and its community to regularly host and update the Asian surgical community. The Hernia Essentials programme developed and organized in several Asian countries by the APHS is focused to make awareness to the surgical community about the most updated guidelines [5–8] on the indications, diagnosis and surgical treatment for inguinal hernia repair, a wide comprehensive educational programme based on the current guidelines and tailored to the different reality of healthcare system, socio-economics and resources available in the different Asian countries. APHS has also produced a standardized template for hernia surgery educational workshops and courses that are organized in the continent.

We hope that, with the combination of several factors like the improvement of the economic status of the nations, the availability of better healthcare resources, the awareness and better knowledge and skills of the Asian surgical community will help to reduce the gap between developing and developed countries for the hernia repair providing ultimately a better treatment for all patients.

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Hernia Surgery in Australasia

13

Andrew Bowker

13.1 A Brief History for Australia and New Zealand (and Probably the World)

The modern era of hernia surgery in Australasia (Australia, New Zealand and the surrounding Pacific Islands) started in the early 1990s, as it did for general surgeons around much of the globe, as a result of the advent of videolaparoscopic surgery. Laparoscopic cholecystectomy was the operation which brought the technology to general surgical attention, and it was immediately apparent to most surgeons in this part of the world that if they could not manage this new technology, then cholecystectomy would no longer be part of their surgical repertoire. There was a scramble to learn the technique, spawning an era of travelling surgical roadshows where surgeons, mostly from the United States and Europe, ran courses in Australia and New Zealand. These were rapidly oversubscribed. Typically they consisted of the visiting experts performing procedures, which were relayed live to auditoriums, after which delegates would proceed to animal laboratories to practise on anaesthetised animals, usually pigs, before returning to their home towns to practise on humans. Unfortunately the process following these courses was often managed in a less than satisfactory manner, which resulted in operations being performed poorly, with a sharp rise in complications, particularly common bile duct injury [1].

In 1991 the author enrolled in a course for "Laser Laparoscopic Cholecystectomy", this particular roadshow starring Leonard Schulz and several other American surgeons. It was run at the Adventist Hospital in Sydney, Australia, with around 200 surgeons attending. Shultz was one of the pioneers of laparoscopic inguinal hernia surgery [2]. While there was no live surgical demonstration of laparoscopic hernia repair, the attendees had the opportunity to try transabdominal preperitoneal (TAPP) laparoscopic herniorrhaphy on the unfortunate pigs, after the gall bladders had been removed. At that time the author was working in Townsville, North Queensland, Australia. The approach in Townsville to gaining experience with laparoscopic cholecystectomy was very well measured and well managed. The author found he had a particular aptitude for the technology and was encouraged to try laparoscopic TAPP inguinal hernia repair, once comfortable with laparoscopic cholecystectomy. The first case was a somewhat daunting venture into the unknown. A session with George Fielding, who was one of the pioneers of laparoscopic surgery in Australia [3], improved the author's confidence, allowing him to build his series. At this time the Townsville surgeons had one of the few prototypical staplers, a reloadable non-disposable device, manufactured by Johnson & Johnson. This was soon superseded by Autosuture's disposable stapler.

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In the early days of laparoscopic inguinal hernia repair, all were done using the TAPP approach. The technique received some bad press as a result of small bowel obstruction secondary to adhesions or internal hernias [3]. Laparoscopic hernia repair itself also had very vocal critics, who considered the procedure an unproven technique, costly in terms of equipment used and costly in terms of the extra time being taken to achieve the repair [4]. The fact that general anaesthesia is required for the laparoscopic approach was not a valid criticism in Australasia, as very few surgeons were performing open hernia repairs under local or regional anaesthesia anyway. A phrase attributed to the American psychologist Abraham Maslow, "When you have a new hammer, everything looks like a nail", was considered by many surgeons an appropriate epithet for those seeking to advance the cause of laparoscopic inguinal hernia repair.

A further driver for being critical of laparoscopic approaches to hernia repair was the anxiety experienced by many surgeons who were struggling to achieve competence with laparoscopic cholecystectomy; they had seen their surgical practices, particularly their private surgical practices, be adversely affected by the arrival of this new technology and were very concerned that the other main component of general surgical private practice, hernia repair, might suffer the same fate. As a generalisation, these tended to be the senior surgeons, whose world was more shaken than most by the paradigm shift caused by the introduction of videolaparoscopic surgery. It had the effect of reversing the traditional power base of senior surgeon over junior surgeon, with the senior surgeons being put in the position of having to ask their juniors for help as they struggled to achieve technical competence with the laparoscope.

13.2 Early Days in New Zealand

It was in this environment that in 1993 the author returned from Australia to the city of Auckland (population 1.5 million), in his home country of New Zealand. He and his surgical partner, John Dunn, set up the private surgical clinic Laparoscopy Auckland in order to further their experience with this technology, which both enjoyed. The author ran an audit of his laparoscopic hernia procedures from the outset. This was used to counter early criticism of the technique, by presenting outcomes at Royal Australasian College of Surgeons meetings in NZ and Australia. In NZ there did not appear to be any surgeons who collected data regarding their (open) hernia practices, particularly better data, to counter these results, which showed a low complication rate, rapid return to full activity and a very low recurrence rate. In the early years, all patients were contacted annually for phone review. When the numbers became too unwieldy, follow-up was restricted to phone review at 3 months by an assistant, with occasional batches of patients being contacted at 12 months, to check the later results. In the early 2000s, attempts were made to contact 1000 consecutive patients at around 5 years post-surgery. Successful contact was made with over 700. There were no unexpected outcomes in this group, i.e. any complications or recurrences which had not already come to attention. The implication from this was that the data regarding recurrences, in particular, was a fair reflection of the author's practice. The author now has an experience of over 7900 laparoscopic inguinal hernia repairs, 7600 of these using the totally extraperitoneal (TEP) approach, with a recurrence rate of two per thousand in the TEP group.

In Australia and New Zealand in the early 1990s, there was an initial burst of enthusiasm for laparoscopic TAPP repair of inguinal hernias, on the back of success with laparoscopic cholecystectomy. However, complications, such as internal hernias causing bowel obstruction and large vessel injuries, together with the increased technical challenges of achieving effective repair with the new technology, resulted in significant tempering of this enthusiasm. These complications were not a feature of open repair nor was the new phenomenon of "retained hernia", which was seen to occur when laparoscopic technique was particularly lacking [5].

13.3 The Current Situation for Australia and New Zealand

With time laparoscopic inguinal hernia repair has gained respectability, resulting in a steady rise in the rate of laparoscopic repair compared to open. In New Zealand this has been largely driven by the private sector of surgical practice, where patient choice is a factor; good outcomes result in word of mouth recommendation, which is particularly effective in relatively compact societies such as New Zealand (4.5 million). There is quite marked regional variation within the private sector in New Zealand. These differences can be influenced by individual surgeon preference/laparoscopic skill, particularly in the smaller communities (Table 13.1). Uptake in the public sector has been slower. Table 13.2 demonstrates this for unilateral and bilateral inguinal hernia repairs respectively. The data in these tables is public sector only for the NZ rates, combined public and private for Australian rates.

13.4 Survey of Surgeon Preferences for Hernia Repair

For purposes of this chapter, the author surveyed Australian and New Zealand surgeons regarding their approaches to hernia surgery. The survey was completed by 209 general surgeons, 100 of whom were New Zealanders, representing more than 50% of those asked, and 105 Australians, a much smaller proportion of the surgical population of that country. Four respondents were from the Pacific Islands.

Questions were asked regarding preferences for laparoscopic or open approaches to inguinal, umbilical/epigastric and incisional hernias, as well as technical aspects when performing these operations. Overall, responses were similar for the two surgical populations.

13.4.1 Inguinal Hernia Repair

While there are many similarities between the two surgical populations, NZ surgeons appear to

Table 13.1 Laparoscopic versus open rates in private practice by region (New Zealand)

Inguinal hernia repair 2016	No of repairs		Technique (%)	
Region of NZ	Laparoscopic	Open	Laparoscopic	Open
Greater Auckland	374	111	77	23
Christchurch	160	41	80	20
Capital and Coast	111	20	85	15
Waikato	75	25	75	25
Southern	45	29	61	39
Nelson Marlborough	13	33	28	72
Bay of Plenty	9	65	12	88
Hawke's Bay	5	41	11	89
Mid Central	9	27	25	75
Northland	9	21	30	70

Source: Southern Cross Healthcare Group, which funds 71% of New Zealand's healthcare claims

Table 13.2 Comparative rates of laparoscopic inguinal hernia repair in New Zealand and Australia; New Zealand data public sector only, Australian data public sector plus most private hospitals

Inguinal hernia repair	2000–2001 (%)	2004–2005 (%)	2009–2010 (%)	2013–2014 (%)
Laparoscopic unilateral NZ	13.2	13.8	24.0	27.8
Laparoscopic unilateral Australia	11.9	16.1	23.4	29.5
Laparoscopic bilateral NZ	27.9	24.5	46.5	60.9
Laparoscopic bilateral Australia	24.2	37.0	52.0	63.5

Sources: Australian Institute of Health and Welfare, Ministry of Health New Zealand

be more embracing of laparoscopic repair for inguinal hernias, with 49% performing more than half of their repairs laparoscopically compared to 25% of the Australian respondents. In both countries, TEP is overwhelmingly favoured at 91% compared to 9% for TAPP. Those preferring TAPP tend to have learnt the technique outside of Australasia. Over 85% of surgeons give prophylactic antibiotics for laparoscopic inguinal hernia repairs, despite there being no good evidence of benefit [6]. Over 70% of surgeons place all operating ports in the midline. Polypropylene is used by 64% of surgeons, polyester by 36%. Penetrative fixation is used by 80% of surgeons to secure the mesh, 67% favouring absorbable tacks over titanium in NZ and 75% in Australia, presumably in the hope that if penetrative fixation causes pain, there is a chance it will diminish as the tacks are absorbed. A minority of surgeons use either self-fixing mesh (ProGrip) or glue (fibrin or cyanoacrylate). If the TAPP technique has been used, two thirds of surgeons use tacks to close the peritoneum rather than suture. Postoperatively, most surgeons advise patients to avoid heavy lifting for variable periods up to a month; only 11% encourage early/immediate return to full activity.

With open repair, the Lichtenstein technique is favoured by 87% of surgeons, with most of the remainder using other mesh-based techniques. Bassini or Shouldice (non-mesh) repairs are favoured by 5%. No one answering the survey has taken up the Desarda (non-mesh) technique as their preferred option. Antibiotic prophylaxis is given by 91%. Nearly 90% use sutures to secure the mesh, the remainder split between tacks and self-adhesive mesh or glue. Postoperative restrictions on heavy lifting are recommended by 95% of surgeons.

13.4.2 Paraumbilical and Epigastric Hernia Repair

Over 90% of surgeons employ an open approach for the majority of repairs. Mesh is used in 80% of repairs, with a similar percentage receiving antibiotic prophylaxis. Of those not giving antibiotics, most are using mesh. A wide variation is seen regarding the need to avoid heavy lifting, up to a month being recommended by 69% of surgeons, longer periods by 25%. 6% do not impose any restrictions.

13.4.3 Incisional Hernia Repair

Overall, responses are similar between the two countries, the only difference being that laparoscopic repair appears more favoured in Australia than NZ, with 25% of Australian survey respondents doing more than half of their incisional hernias using a laparoscopic approach compared to 11% of New Zealand surgeons. Respondents were asked if they had changed their open or laparoscopic preferences of recent times. Thirty-one percent of 191 surgeons answering this question have changed, with a marked trend for fewer laparoscopic (80%) compared to more laparoscopic (20%). A wide array of different meshes is used for laparoscopic repair, all employing some form of barrier. Close to 60% of surgeons doing laparoscopic repair for incisional hernias attempt to close the fascial defect before positioning the mesh. For mesh fixation, tacks are used by 98% of respondents, 75% absorbable, 25% titanium, 62% of surgeons supplementing the tacks with transfascial sutures. Fewer than 5% of surgeons use glue or self-adhesive mesh.

For the positioning of mesh when doing open repair, most surgeons favour sublay, with the majority placing the mesh between the peritoneum and the posterior rectus sheath, rather than in the retro-rectus position, on top of the closed posterior sheath defect. Nearly a quarter of surgeons use an onlay technique, at least some of the time.

Antibiotics are administered as prophylaxis against infection by 98% of respondents. When giving advice regarding activity postoperatively, 80% recommend no heavy lifting for 4–6 weeks.

13.5 Laparoscopic Training

The increased rate of laparoscopic inguinal hernia repair has occurred as a result of increased public awareness of the technique and increased surgical acceptance of the validity of laparoscopic

repair, plus laparoscopic surgical skills becoming a core part of surgical training. Most trainee surgeons learn how to carry out laparoscopic inguinal hernia repairs during their training, but courses in laparoscopic inguinal hernia repair continue to have a role. From the mid-1990s, the author has run courses in New Zealand, mainly for small groups of qualified surgeons who wish to add laparoscopic repair to their open skills. Similar courses are on offer in Australia. The author's courses typically consist of a PowerPoint presentation/discussion, including edited videos highlighting aspects of technique, followed by observation of five or six laparoscopic repairs. There is no option for mentoring in the author's private practice setting. Initially anaesthetised pigs were used to allow some "hands on" experience for the attendees, but the pig is an unsatisfactory model for laparoscopic inguinal hernia repair, especially for the TEP approach. Several mechanical models were tried and discarded. The most successful has been the use of cadavers preserved in a manner which maintains a degree of tissue plasticity, but availability became limited, and it is no longer an option in Auckland. When observing colleagues applying themselves to learning laparoscopic hernia repair, it is readily apparent to the author which surgeons are likely to carry on and succeed in achieving competence rapidly and which surgeons are more likely to struggle and may be best advised to keep to a perfectly satisfactory open approach to hernia repair. Courses of this type have contributed to the gradual but progressive uptake of laparoscopic inguinal hernia repair in the two countries. There have been fellowships specifically for laparoscopic skill development in general surgery in Australia, but these have been superseded as a result of laparoscopic skills becoming increasingly embedded in general surgical practice and fellowship training over the past 20+ years.

13.6 TAPP Versus TEP

The debate about the relative merits of transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP) approaches to laparoscopic inguinal hernia repair has had little airing in Australia and New Zealand; TEP is overwhelmingly preferred, TAPP being practised by for the most parts by surgeons who have learned their skills in other countries.

13.7 Open Inguinal Hernia Repair

As in most parts of the world, preferences for open repair of inguinal hernias have progressed from the Bassini to Shouldice to Lichenstein technique. There is no problem with the supply of surgical mesh in Australasia, so it is now rare for any form of hernia to be repaired without the use of mesh. The Lichenstein approach remains the most favoured of "tension-free" open repairs, though other techniques, such as the Kugel patch, plug and patch, prolene hernia system and ONSTEP, have their enthusiasts.

13.8 Mesh Controversy

Of recent times there has been some interest in the Desarda technique, which avoids completely the use of mesh. Interest in this has been fuelled by the public (in New Zealand), as a result of widespread publicity regarding the problems caused by synthetic mesh placed transvaginally to treat urinary stress incontinence [7]. There has been some crossover of this adverse publicity to hernia repair, particularly with hernia patients who have developed chronic pain issues postoperatively. In this setting there is a natural tendency to assume it must be the mesh which is the problem, rather than neurogenic pain which can be induced by suture, scarring or mesh, but is not as a result of the mesh itself. These chronic pain sufferers also have had exposure in the press, resulting in an assumption that there may be a systemic issue in surgery regarding the use of mesh. In New Zealand, a pressure group acting on behalf of women who have suffered from transvaginal mesh ("Mesh Down Under") has lobbied for a moratorium on the use of all surgical mesh. Education of relevant members of the press, general practioners and the public, through statements made by the surgical profession, has

helped balance the situation, but concerns regarding mesh are still frequently aired.

13.9 The Wider Influence of Videolaparoscopy on Hernia Repair

Hernia surgery prior to the introduction of videolaparoscopic technology had a low profile in day to day surgical life. Inguinal hernia repair was the operation which junior registrars learnt early in training and the one which they were often left to do on their own when still relatively inexperienced. As a senior house officer in England in the 1980s, the author was shown how to do an open inguinal hernia repair by five different surgeons, each only once, before being given his own list of repairs to do. Although this was perhaps an extreme example of attitudes to hernia repair in those times, it is not an unrepresentative one. The challenges and threats (as outlined above) that the new technology has had on surgical practice has had enormous benefits for how hernia repair is managed. Scrutiny has been brought to bear on the actual outcomes of these very common operations, bringing about an era when many surgeons look carefully at how they are doing their repairs and how their patients fare as a result of these repairs. This increased scrutiny has spilled over from inguinal hernia repair to repairs of all types of hernias, as laparoscopic approaches have been applied to them as well. Hernia repair was a subject which previously had minority interest only and was usually buried within surgical conferences dealing with more important matters. The past 25 years has seen a proliferation of conferences around the world which are dedicated solely to discussing hernia repair, generating healthy debate about which techniques work best for surgeons and patients. Important data about complications, recurrence rates and chronic pain postoperatively has been collected and analysed from sources such as the Danish Hernia Registry. Centres and surgeons specialising predominantly in hernia repair have provided an improved standard of care, causing all surgeons to take notice of how and what they are doing.

13.10 The Pacific Island Nations

There are many countries which make up the Pacific Islands. Feedback for the purposes of this chapter was obtained from surgeons working in Fiji, the Cook Islands, Tonga, Vanuatu, Samoa and the Solomon Islands. Most of these nations are characterised by small populations spread over vast distances. For example, Tonga has 169 islands over 800 km north to south, 36 of which are inhabited, supporting a total population of 107,000. Vanuatu has 82 islands over 1300 km north to south, 65 inhabited, population 270,000. This means that health resources are spread very thinly, the quality of service being markedly influenced by relative poverty; the GDP per capita in Tonga is US$4220 and Vanuatu US$3036.

When considering hernias, the surgeons working in these settings favour contemporary techniques for repair, most opting for Lichtenstein mesh repair of inguinal hernias. Surgical mesh is not always available, on account of cost and problems of supply. It tends to be bought in large sheets which are then divided into smaller pieces and resterilised. While surgeons are aware that mosquito mesh has been used in hernia repair [8] where surgical mesh is not available, none of the surgeons contacted by the author had any experience with using it. If mesh is not available, then either Shouldice or Bassini techniques are employed. Laparoscopic equipment is available in a number of the main hospitals, but its use for repair of hernias is a luxury, due to the high cost of the required consumables.

Other factors compound the problems facing hernia repair in these countries. In many areas, the volume of work facing local surgeons is such that the smaller, less complex hernias might not receive priority. Hernias tend to present late anyway, at a time when they are very large or developing complications. Problems of access are an issue for remote communities separated by large tracts of ocean from regional hospitals. In general

there is not a stigma attached to hernias, but in Tonga there is a stigma with hydrocoeles, so inguino-scrotal hernias tend to be included. The use of traditional healers claiming to be able to affect cures can be a delaying factor in some areas. Many of the remote island communities are serviced by a nurse, who is often female, and this can be a cause for (male) hernia patients being reluctant to seek attention.

For incisional hernias, an open sublay approach is generally preferred, most placing the mesh between the peritoneum and posterior rectus sheath. Some of the island nations are periodically serviced by surgical teams, usually from Australia or New Zealand, at which time there are alternative options for repair of more complex hernias.

13.11 Laparoscopic Inguinal Hernia Repair: A Theory for Pain Prevention with Penetrative Fixation

Although the incidence of chronic pain following laparoscopic inguinal hernia repair is significantly less than with open repair techniques, it is still a problem in most series [9]. As a means of trying to reduce pain postoperatively, surgeons have looked to avoid penetrative fixation by using none, using glues (fibrin or cyanoacrylate) and using self-adhesive mesh (ProGrip). The use of lightweight, wide-pore meshes results in reduced mesh contraction and, theoretically, less foreign body sensation, with the expectation that this may reduce pain. In the author's unpublished data, the incidence of pain, or even awareness, at 3 months postoperatively is very low (Table 13.3), as compared to most published series [9], despite routine use of heavyweight mesh and titanium tack fixation. Following a change to using lightweight large-pore mesh, data was again collected by the author, this time at 3 and 12 months (Table 13.4). As anticipated, there was a reduction of awareness of the repairs with the further passage of time. The difference in pain incidence between the period when the author was using heavyweight, narrow-pore mesh and lightweight, wide-pore mesh was small, favouring the heavier mesh slightly. The surgical literature is mixed on the relative values of heavy- and lightweight meshes, with some studies describing no increase of recurrence rates with lightweight mesh and reduced long-term pain [10]. Others detect little difference between the two [11]. However, others have raised concern that longer term pain may be greater with lightweight mesh and recurrence rates higher [12, 13]. This has been the author's impression, the possibility of recurrence following the use of lightweight mesh being related to the handling characteristics of the mesh; some lightweight meshes are very "floppy" and do not sit as well against the posterior wall of the inguinal canal as the stiffer heavyweight meshes. As there appears to be little difference in outcome between the two options, it seems reasonable to use the mesh that best suits the individual surgeon. For those with cost constraints, flat heavyweight meshes tend to be cheaper than the lightweight options. The author currently uses a medium weight, wide-pore mesh, on account of its favourable handling characteristics. The answer to the very low rates of pain post laparoscopic inguinal hernia repair achieved by the author lies in technique, attention to detail, thinking about what is being done operatively and the possible consequences of those actions.

When using penetrative fixation, most surgeons fix the mesh both medially and laterally. Moreover, the medial fixation is often into soft tissues alongside the superior pubic ramus, rather than into the surface of the pubic ramus itself. Many surgeons fear that some form of periostitis may result from bony fixation. Absorbable tacks are used by some surgeons, with the rationale that

Table 13.3 Review of unilateral inguinal hernia repairs in males, groin strain excluded

Restriction	Nil	Mild	Moderate	Severe
At 3 months ($N = 951$)	99.9% ($N = 950$)	0.1% ($N = 1$)	Nil	Nil
Pain/awareness				
At 3 months ($N = 951$)	91.1% ($N = 866$)	8.5% ($N = 81$)	0.4% ($N = 4$)	Nil

Routine titanium tack fixation, heavyweight mesh (1996–2007)
Source: Author's database

Table 13.4 Review of unilateral inguinal hernia repairs in males

Pain/awareness	Nil	Mild	Moderate	Severe
At 3 months ($N = 129$)	85.27% (110)	11.63% (15)	3.10% (4)	Nil
At 12 months ($N = 122$)	93.44% (114)	6.56% (8)	Nil	Nil
Restriction				
At 3 months ($N = 129$)	99.2% (128)	0.78% (1)	Nil	Nil
At 12 months ($N = 122$)	100% (122)	Nil	Nil	Nil

Routine titanium tack fixation, lightweight large-pore mesh (2013–2014)
Source: Author's database

if pain is caused, at least it may be time limited, as the fixations eventually resorb. Fixation to the soft tissues alongside the superior pubic ramus may in itself be a cause of chronic pain, as penetrative fixation here is effectively injuring tissue (ligament, tendon) which has a poor blood supply and therefore poor healing capacity. Furthermore, if there is both medial and lateral fixation, as the mesh contracts, which all meshes do, the penetrative points of fixation are dragged through the tissues towards each other, with potential to cause pain. Wide-pore mesh contracts less than narrow-pore mesh. The author suspects that any pain reduction observed with the use of lightweight mesh relates to the reduced contraction between medial and lateral points of fixation. If there is no lateral fixation, then mesh contraction is not a concern.

The author has employed penetrative titanium tack fixation throughout his entire series. He adheres the postero-medial edge of the mesh to the surface of the superior pubic ramus with multiple tacks, which are driven into the periosteum/bone surface. Initially, like many surgeons, he restricted himself to two cautiously placed tacks, but recurrence of a large direct hernia early in his experience, when the mesh pulled the tacks off the bone into the defect, encouraged him to be more aggressive with tack placement into the bone. Strong fixation is even more important in the current era of using wider-pored mesh, as the wide pores have a tendency to slip off over the tacks. There has not been any periostitis or osteitis pubis as a result of this practice in his series. For 20 years lateral fixation has been avoided completely, instead relying on careful placement of mesh such that, as the gas is released at the end of the operation, the weight of the abdominal contents through the peritoneum pins the mesh against the pelvic wall. Medial contraction of the mesh lateral to the deep ring of the inguinal canal is not a concern, as mesh coverage in this area is generous. Mesh contraction away from the midline, where there is little overlap medial to the posterior wall of the inguinal canal, is prevented by secure fixation to the superior pubic ramus +/− the linea alba further anteriorly. The mesh is able to glide unimpeded across the pelvic wall from lateral to medial as any contraction occurs. The repair is secure, and immediate return to heavy physical activity is encouraged, as the mechanics of laparoscopic hernia repair permits this.

Conclusion

A wide range of hernia repair techniques is employed by surgeons operating in Australasia and the Southern Pacific Ocean nations. The advent of videolaparoscopic technology has had far reaching effects on how hernia surgery is approached and taught. For inguinal hernia repair, laparoscopic techniques are increasingly employed, the public sector lagging behind private practice. For laparoscopic inguinal hernia repair, the totally extraperitoneal approach is favoured over transabdominal preperitoneal. For open inguinal hernia repair, the Lichtenstein technique is still the most commonly performed operation. There has been some disenchantment with laparoscopic repair of incisional hernias, with surgeons tending to prefer open mesh sublay techniques. The Pacific Island surgeons have some restraints regarding the choice of repairs they choose, due to supply and economic factors. As with elsewhere, the surgical profession in this part of the world has to deal with misinformation regarding the use of mesh in hernia repair, secondary to publicity sur-

rounding complications for transvaginal mesh placement for treatment of urinary stress incontinence.

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Hernia Surgery in Africa

14

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14.1 Summary

The AMEHS was founded on September 2009 in Geneva for my will and other African and Middle East colleagues. The reason why we want to join Africa and Middle East is connected to the concept of "Africa as the cradle of humankind." In fact the most ancient finds were found in sub-Saharan Africa. The Sahara was an important element in the historical evolution of the continent as well as the Arabic language. These are the two crucial points on which the idea of the AMEHS (Afro Middle East Hernia Society) was based. From here we can understand how the Middle East, irrespective of the social development over the last 100 years, is linked to Africa for better or for worse. Often the people of Middle East, full of their oil discoveries with the consequent power of evolution, don't like to be considered African brothers, but the root is the same. AMEHS understood it and is following that way.

AMEHS has started to walk in small steps over the years, pointing to the world of "Pathologies of Abdominal Wall" distinguishing itself for its own identity during the various congresses.

It wasn't so easy to present ourselves to the world, as Africa is a continent and Middle East already has its clear identity. But we are working with our well-defined identity over the years to find space into social and scientific society, presenting ourselves with our scientific knowledge about the health status in each country. Moreover, it is difficult to follow a clear and unique line to everyone as Africa and Middle East are agglomerations of completely different situations, economically, politically, socially, and from the point of view of health status. More specifically, North Africa is well-defined and very "westernized," Central Africa is suffering from many serious problems connected to the poverty, but it is full of highly performing and willing colleagues and surgeons, Middle East is clearly evolved for welfare, and South Africa is influenced by the Western countries. Therefore it is not so easy for AMEHS to coordinate and be able to bring our work to one voice. We are trying to do it. Today, 8 years after the foundation, we are preparing to select the best substitute of the General Secretary who will be able to make this flower blossom in a clear way, this flower that is already growing well. A special thanks to the friend of all

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of us, Giampiero Campanelli, our honorary president, who has guided us in the right development that we desire with the Congress of Milan on 2015 and future plans.

According to the Preface of the chapter, AMEHS is a young society with many spirits within itself, so it is more than a continent. Slowly and with many efforts, we are trying to make understand the value of joint nature, democracy, and collaboration to achieve an objective, which is not an individual objective but a shared one including a social value and above all, especially in this case, a scientific value of mutual growth, considering the exchanges among researchers, clinicians, and healthcare professionals on the field and in first line. We are convinced that all these steps are slowly leading to the awareness that the present line is appropriate and correct for everyone. The story of other continents is an example: Europe, America, Asia, and Oceania.

In this sense we wanted to gather the efforts of those who had given courageously their contribution for this fundamental text which will leave a trace in the whole world about the pathology of abdominal hernia.

Prof. Abi, a famous woman surgeon from Morocco, brought us her experience that, even if dated, makes us understand the importance of hernia pathology in her country and the treatment she had performed with a TEP.

From July 1998 to December 2001, 117 patients were admitted for inguinal hernia to the surgery department 2 of the Ibn Rochd University Hospital in Casablanca. Of these, 48 had a totally extraperitoneal (TEP) approach (29.62%), 6 transabdominopreperitoneal (TAPP) approach, 21 (12.96%) had mesh by conventional surgery, 2 Lichtenstein procedures, 83 Shouldice procedures (51.23%), 2 Mac Vay procedures, and 1 Bassini technique. Thirteen of them were not operated for various reasons. We reviewed the outcome of 59 inguinal hernias in 48 patients who underwent laparoscopic totally extraperitoneal (TEP) approach by 4 surgeons between July 1998 and December 2001. Patient demographics, hernia characteristics, operative parameters, and clinical outcomes were evaluated. The selection criteria were age of more than 45 years and the absence of contraindication to general anesthesia and retro-pneumo-peritoneum. Mean age of 47 men and 1 woman undergoing 59 inguinal hernia TEP repairs was 62.9 years (range 45–85). Twenty-seven (56.25%) of our patients were professionally active, and 21 (43.75%) were sedentary. Six had cardiovascular and endocrine disruptions, respiratory risk factors were present in 20 patients (41.66%), and urinary for 19 (39.58%). Strenuous activity was reported by 19 patients (39.58%). Two patients complained of chronic constipation. Inguinal hernias were unilateral (n = 30) 27 right inguinal hernia (RIH) (56.23%)? left inguinal hernia (LIH), 13 (27.08%) and bilateral (BIH) (n = 8) (16.66%), indirect hernia 37 (77.08%), direct hernia 11 (22.91%), 8 defects (16.66%) were recurrent. Surgery was programmed in all patients (100%), and general anesthesia was performed in the 48 patients (100%). Antibiotic prophylaxis has been systematic in all patients (100%). The first patients benefited from an antibiotic prophylaxis (based on Penicillin A + inhibitor of B lactamase) and the latter from a second-generation cephalosporin. Intraoperative diagnosis showed indirect hernia in 38 patients (79.16%), direct hernia in 8 patients (16.66%), and pantaloon hernia in 2 patients (4.16%). Our patients were classified according to the NYHUS classification to type 2, 24 cases (50%) (18 patients (37.5%) classified as stage 2 had associated risk factors); type 3a, 3 cases (25%); type 3b, 13 cases (27.08%); and type 4b, 8 cases (16.66%). The conversion into open surgery was necessary in 26 patients (54.16%). The reasons for conversion were the difficulty of reducing the hernia sac in 7 patients (26.92%), the difficulty of dissecting the hernia sac in 5 patients (16.23%), hypercapnia with subcutaneous emphysema in 5 patients (19.23%), persistence of a large pre-hernia lipoma after reduction of the sac in 4 patients (15.38%), pneumoperitoneum in 2 patients (7.69%), the introduction of the trocar directly intra-abdominal in 1 patient (3.84%), a technical problem in 1 patient (3.84%), and difficulty to unfold the mesh in 1 patient (3.84%). The types of mesh used in patients operated only under laparoscopy were Parietex in 2 patients (9.9%), Mersilene in 5 patients (22.72%),

Prolene in 14 patients (63.63%), and Hi-tec in 1 patient (4.54%). The size of the prostheses is on average 15/14 cm (range 12/10–17/15 for unilateral hernias and 15.5/29 for bilateral hernias). The suture fixation with slow resorbable wire knots for five patients (one Hi-tec and four Mersilene prostheses) and tack fixation for the other three meshes: two Parietex and one Mersilene. One patient out of the 22 completed under laparoscopy had drainage. Of the 26 patients requiring conversion, 15 patients underwent mesh implantation: 13 according to the Stoppa procedure by Pfannenstiel incision, 1 according to the Rives technique, and 1 by the Lichtenstein technique. Eleven patients had a Shouldice operation. The operative complication rate was 0%. Postoperatively the migration of an unattached mesh was seen in one patient. The latter was operated again on a postoperative day 3 by the same approach with replacing the mesh with good outcome. There were no complications in all the other patients, treated entirely by laparoscopy and converts. There was not any postoperative death. The average hospital stay was 3.54 days (range, 2–7 days). At the outpatient surveillance, two patients had scrotal edema (9.09%) that responded perfectly to anti-inflammatory treatment and two others (9.09%) showed an induration of the inguinal region which disappeared at the following control without treatment. One patient had moderate pain at the groin that responded perfectly to anti-inflammatory treatment. The follow-up was nil for 4/22 patients (18.18%); however, the remaining 18 patients (81.81%) had a follow-up average of 5 months and 21 days (range 6 days–38.5 months). No patient in our study showed recurrence. Endoscopic inguinal herniorrhaphy has become an established approach to groin hernia. The use of a totally extraperitoneal (TEP) approach allows a tension-free, preperitoneal approach with potentially less discomfort and morbidity than to classic repairs. Concerns have been raised regarding excessive cost, need for general anesthesia, and an extensive learning curve for the surgeon. The need for a long and difficult learning of this technique is at the origin of a high conversion rate observed during the first ten interventions. Some reports have listed specific indications for laparoscopy over open repair, including recurrent hernias, bilateral hernias, and the need for earlier return to full activities. Although the actual hospital costs of laparoscopic repairs are higher than those of open repairs, the increased cost may be offset by the societal benefits of earlier return to full activities.

Prof. Obama, surgeon from Equatorial Guinea, already a Minister of State for Health in his country, confirms that, according to statistics updated to 2016, upon 7800 operations in Equatorial Guinea, e.g., Spanish colony, with a population of 1,222,442 inhabitants on a surface of 28,051 km, the abdominal wall hernia is one of the first and most common conditions for surgery in Equatorial Guinea; the hernia repair represents more than 45% of all surgery performed at national level. The surgeons observed all varieties of hernia, but the most frequent type is the inguinal.

More than 90% of hernia repair practiced at national level is performed through the open method and approximately 5% of repair they used is mesh. The most frequent technic used is the Lichtenstein.

In 2016 only 57 laparoscopic hernia repairs were performed, and all were done by foreign medical staff.

In Qatar, part of the Middle East and thus participating in AMEHS, Prof. M. El Akkad describes the work on the hernia pathology at the Al Wakra Hospital which is a Hamad Medical Corporation hospital opened in December 2012. Prof. El Akkad describes:

We started during the first year doing routine hernia surgery with repair of inguinal hernia using Lichtenstein repair with prolene mesh and laparoscopic TAPP. For ventral hernia we were doing only anatomical closure and on lay prolene mesh. After one year we decided to develop the hernia service with dedicated team and we started doing laparoscopic TAPP and UHS for open inguinal hernia, where TAPP was standard and open are done due to contraindication to lap or patient preference. For Ventral hernia we shifted mainly to lap repair with high or ultra-light

meshes. Our rate jumped to 250 cases per year. Then it applied for accreditation by SRC as a center of excellence for hernia. As cases increased we started to deal with ventral hernias differently. We started doing anterior and position component separation. We did lot of TAR and Carbonelli repair for large abdominal defects. We were using different kinds of meshes but mainly light weight. In 2015 we were accredited as center of excellence and it was the first and only one in the Middle East. This increased our work load from referrals from other centers and growth of our hospital. We reached 450 that year. In 2016 we had the Davinci Robot and we started our robotic assisted hernia repair. We started with inguinal and then moved to ventral and divarication of recti. Laparoscopic hernias are now done robotic using Davinci. We have done now 110 cases robotic assisted. All through the development we sought help and advice by travelling to hernia centers in Europe or inviting experts to come and work with us on regular intervals. So now we exceeded 750 cases per year. Our practice now includes (1) Robotic assisted repair of all inguinal hernia and ventral hernia with small to moderate defect for which we close the defect and apply mesh with suturing all around with no clipping; (2) Carbonelli on TAR in large abdominal defects with light weight mesh applied; (3) We did a lot of rare hernia that present every now and then like lumbar hernia, Spegillian hernia all by lap or robotic. We did apply biological mesh for 4 cases. One of them was a case presented in the last Tokyo conference. The patient presented to us with recurrent fibrosarcoma in his rectus abdomen muscle. He already did the left one before. So we resected his Rectus muscle, he was left with no recti and big defect which we closed with biological mesh and reinforced by another light weight mesh. We followed him for 3 years now and no recurrence. The meshes we are using are: Prolene, UHS, PVP, Ultrapro, Progrip.

In the end in Iraq, a country tormented by a 27-year-long war, Prof. Moosa explains that hernia is a common surgical disease. It affects both gender and all age groups (even if it is more in third and fourth decades). In a study done by Moosa in 2015, inguinal hernia forms the majority of cases, and it forms about 65% of all hernia patients when it affects male more than female, followed by incisional hernia and then umbilical hernia which affect female more than male in both types. Incisional hernia is more in female following mainly Caesarian section and hysterectomy operations, while it is lower in male in spite of war injuries in Iraq which affect male soldiers because Iraqi surgeons built up great experience in trauma and war surgery. All types of surgery are done according to the type of hernia, the experience of surgeon, and the circumstances of hospital; in spite of that, open surgery is done more than laparoscopic surgery because of short resources.

Humanitarian Hernia Surgery: Lessons Learned

15

Alexander D. Schroeder and Charles J. Filipi

15.1 Introduction

Almost 10 years ago, Dr. Paul Farmer identified surgery as the "neglected stepchild of global health" [1]. This is attributed to communicable diseases dominating global health initiatives. However, approximately two billion people lack access to essential surgical care. The impact of such care in low-income countries (LICs) and low-middle-income countries (LMICs) can be estimated in avertable mortalities and disability-adjusted life years (DALYs). Providing basic surgical care at the district hospital level (50–250 beds) is cost-effective and could prevent up to 1.4 million deaths and 77.2 million DALYs per year [2].

An increasing number of short-term surgical missions have identified specific challenges. These include adequate outcomes, appropriate patient follow-up, a shortage of skilled local staff, and patient access. In high-income countries (HICs), elective inguinal hernia repair is considered a basic surgical procedure with low morbidity (0.02–4.5%) and mortality rates (0–0.1%) [3–5]. However, there have been reports of unacceptable mortality rates in LICs, up to 100 times higher than in HICs [6, 7]. In the following, the authors describe lessons learned from service and training mission trips addressing the inguinal hernia burden of disease and the ability to achieve HIC results in austere environments.

15.2 Service Missions

15.2.1 Surgeon Selection

To obtain HIC surgical results, successful global surgical outreach requires recruitment of competent surgeons. There is no universally accepted definition of surgical competency [8]. Several tools are available to measure technical competency [9, 10], but there is no objective way to measure improvisation, communication, leadership, technical, and teaching skills in the surgical arena. Additionally, surgeons operating in LMICs are often confronted with more complicated inguinal hernias and a higher risk for complication [11]. In order to produce surgical outcomes comparable with those in HICs, expert hernia surgeons were recruited. Our organization has had the good fortune to have access to these experts.

Surgeon leaders of the American Hernia Society (AHS) and European Hernia Society (EHS) came as volunteers to the Institute of Latin American Concern (ILAC) center in Santiago, Dominican Republic. There, they operated upon hernia patients for a week, each performing 30–40 operations, and were directly observed for operative technique, leadership, fund of knowledge, adherence to the organizational mission, and overall results to determine who was qualified to

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train the Lichtenstein repair (our standard operation for training) and lead future hernia teams. Of our nine trainers, four directly and one indirectly mentored under Dr. Parviz Amid, the surgeon that popularized the Lichtenstein repair. It has been demonstrated that deliberate practice and acquisition of expert performance are related to "focused improvement with immediate feedback, time for problem solving and evaluation, and repeated performance to refine behavior" [12]. The opportunity to work with true experts and their willingness to serve the poor plus the catalyzing political and logistic influence of past AHS presidents have been paramount factors for good patient outcomes. Table 15.1 lists many of the surgeons that served patients and trained surgeons. The Hernia Repair for the Underserved training surgeons are shown in Figs. 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8 and 15.9.

Table 15.1 Surgeons participating in HRFU missions

Surgeons	Country	Trainer	No. of trips
Carl Boyd	US		2
Kevin Buckley	US		5
Giampiero Campanelli	Italy	X	13
Marta Cavalli	Italy		12
David Chen	US	X	8
Robert Cusick	US	X	14
Robert Fitzgibbons	US	X	6
Colleen Fitzpatrick	US		1
Jarrod Kaufmann	US		5
Steven Kern	US		1
Oliver Lao	US		1
Tommy Lee	US		2
Antoine Loutfi	Canada		1
Brent Matthews	US	X	1
Dwijen Misra	US	X	4
John Murphy	US		2
David Partrick	US		4
Steve Raynor	US		2
Mark Reiner	US		3
Wolfgang Reinpold	Germany	X	13
Sergio Roll	Brazil	X	4
Michael Schroeder	Germany	X	2
Kelly Shine	US		1
Lutz Steinmueller	Germany		1
Erwin van Geffen	US		2
Rob Weinsheimer	US		4
Marvin Wexler	Canada		4

Fig. 15.1 Dr. Giampiero Campanelli

Fig. 15.2 Dr. David Chen

Fig. 15.3 Dr. Robert Cusick

Fig. 15.4 Dr. Robert Fitzgibbons

Fig. 15.5 Dr. Brent Matthews

Fig. 15.6 Dr. Dwijen Misra

Fig. 15.7 Dr. Wolfgang Reinpold

Fig. 15.8 Dr. Sergio Roll

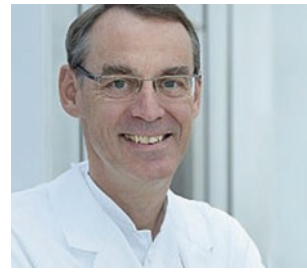

Fig. 15.9 Dr. Michael Schroeder

Fig. 15.10 Barb Elliott RN

15.2.2 Staff Selection

Volunteers want to go on hernia trips some for the adventure and novelty, but it is important to select nurses that are devoted to quality care and have leadership ability. One such nurse is Barb Elliott pictured in Fig. 15.10. After our first service trip, she assumed a leadership role organizing equipment, soliciting in-kind donations, seeking staff volunteers, and arranging matching grants for nurse and surgical technician airfare—she ran the mission. A true charge nurse is invaluable, and for 15 years she has maintained her passion to serve the poor in every way possible including personal and financial sacrifice. Find a Barb Elliott and your team will prosper.

15.3 Surgical Technique and Equipment Used

Numerous suture and mesh techniques for inguinal hernia repair have been described. Tension-free mesh repair as described by Dr. Lichtenstein and Dr. Amid is the widely accepted treatment for inguinal hernia in HICs [3, 13]. Compared to suture repairs, tension-free mesh repair significantly decreases recurrence rates. However, in many LICs and LMICs, surgeons perform only suture repairs due to the high cost of mesh. Hernia Repair for the Undeserved aims to provide surgical care to poor patients without any compromise in outcomes. Therefore, we chose to utilize the Lichtenstein—Amid technique for service and training missions. We have been able to obtain an abundant supply of donated commercial mesh from industry. Ultimately, we expect market evolution to lower the cost of commercial mesh due to competition from in-country manufacturers.

Other surgical outreach initiatives have described the use of mosquito netting for inguinal hernia repair [14]. A recent randomized controlled trial by Loefgren et al. demonstrated similar complication and recurrence rates at 1-year follow-up, when comparing sterilized mosquito mesh to commercial mesh for inguinal hernia repair [15]. However, the authors reported one postoperative death in the low-cost mesh group due to unclear causes, and during further follow-up, there was another death in the low-cost mesh group and three deaths in the commercial mesh group. It remains our contention that proven standardized operative techniques, expert surgeons and anesthesiologists, and uncompromising quality of equipment are essential for good outcomes in developing countries. Polypropylene mesh is easier to sterilize and manufacture than polyethylene mesh and should remain the standard of care until there is more compelling long-term evidence to the contrary. Low-cost innovative solutions to health care remain critical, and therefore, further randomized controlled studies with long-term follow-up are encouraged.

15.3.1 Procedures to Closely Monitor in the Austere Operating Room Environment

Hydrocele is one of the most common comorbidities encountered during preoperative assessment of inguinal hernia patients. Non-communicating hydrocele, due to lymphatic filariasis (*Wuchereria bancrofti*, a mosquito-borne worm), is endemic in

Southeast Asia and Sub-Saharan Africa [11]. It is also one of the most common urologic pathologies encountered in Haiti, comprising up to one third of urologic procedures performed at the district hospital level [16]. The biological predilection of the adult filarial worms to live and reproduce in lymphatic channels of the scrotum means that greater than 50% of infected men will, with age, develop a chronic hydrocele. In untrained hands, large hydroceles should be avoided during inguinal hernia campaigns due to infection rates of up to 60% and overall high recurrence rates [17]. Beard et al. point out that in some cases simple hydrocelectomy is contraindicated, and reconstructive surgery is necessary [11]. Specific procedures for large hydroceles condition are followed by our organization.

15.3.2 HRFU Hydrocele Protocol and Guidelines [11, 18, 19]

Aspiration is generally unsuccessful due to rapid fluid re-accumulation. Indications for surgical management are pain, disturbing size, and sensation of heaviness. Surgical repair should not be performed in infants under age 2, but for older patients a persistent hydrocele suggests a concomitant inguinal hernia, and repair should be considered.

The surgical repair appropriate for most hydroceles is the Lord's technique. An incision is made in the scrotum lateral to the median raphae. The dartos fascia is divided until the hydrocele sac (tunica vaginalis) is identified. The sac is bluntly dissected free of surrounding tissue and delivered through the incision, if possible. A small incision is then made to drain the fluid. The sac is opened proximally, everted around the testicle and spermatic cord, and the cut edges are sutured with a running locking closely spaced for hemostasis, absorbable suture. Care must be taken to ensure that the testicle is not twisted prior to placing it back in the scrotum. A pexy suture should be placed from the testicle to the scrotal wall to maintain its anatomical position. For hydroceles with large dissection beds, a drain may be left in place. A variation on this procedure involves subtotal excision of the sac. This technique is gaining favor in treating filarial hydrocele due to its associated lower recurrence rate.

Complication rates after hydrocelectomy are as high as 20%, even in HICs. The complications include hydrocele recurrence, hematoma, infection, and testicular infarction. Repair of filarial hydrocele may have complication rates up to 30%, because the scrotal skin and lymphatics are damaged by the parasitic infection, leading to increased inflammation in the operative field and poor wound healing.

Guidelines

- All patients are examined by the operating surgeon prior to entering the operating room.
- A presumptive diagnosis of hydrocele mandates transillumination during the preoperative assessment.
- The groin and scrotum must be prepped thoroughly—i.e., all folds should be flattened when prepped, and the prep should include the contralateral scrotal side and the penis. A sterile towel is placed under the scrotum/over both thighs, and the operative site is carefully draped with towel clips used to secure them, as the towels often move and expose the unprepared skin.
- Extra consideration is warranted for any massive hydrocele, hematocele, acute hydrocele, or suspected lymphatic filariasis hydrocele. If hospital admission or significant postoperative care is expected, the patient should be referred to a tertiary care center.
- The decision to operate on a larger complicated hydrocele should depend on surgeon experience and the local surgeons' postoperative availability and ability to manage complications.
- Preoperative intravenous antibiotics are administered for large hydrocele patients.
- Postoperative care
  - A sterile dressing should be maintained over the external portion of the drain if used. If the patient is unlikely to be compliant or lives in a very disadvantaged circumstance, they should be kept in the hospital overnight.

– Oral antibiotics for routine hydroceles may be initiated at the discretion of the surgeon, and if filariasis is suspected, treatment should be initiated.
– If a drain is left, the surgeon should change the dressing on the first postoperative day and decide about removing it. If the drain is not removed, the patient should be followed daily until it is. After drain removal the patient should be seen by an in-country surgeon.

15.3.3 Adult Giant Scrotal Hernias and Large Inguinal Scrotal Hernias

Giant inguinal scrotal hernias are highly morbid and are defined as hernias extending below the midpoint of the inner thigh with the patient standing [20] and an anteroposterior diameter of at least 30 cm and a laterolateral diameter of 50 cm or more [21] (Fig. 15.11). They are more common in developing countries because pediatric hernia repair is dangerous or unavailable, and a safe adult repair is almost impossible without an effective intensive care unit. Campanelli et al. describe a successful but sophisticated operative approach that necessitates HIC resources [20]. A large lower pararectus incision extending into the groin is made; full reduction of the hernia sac contents into the abdominal cavity using the "hug technique" is used; resection of bowel may be necessary; and a 30×30 cm piece of retroperitoneal mesh is fixed with fibrin glue. The patient is ventilated for 1 day and then extubated and supported by intensive respiratory therapy. Giant scrotal hernias are highly morbid and are currently out of the HRFU purview.

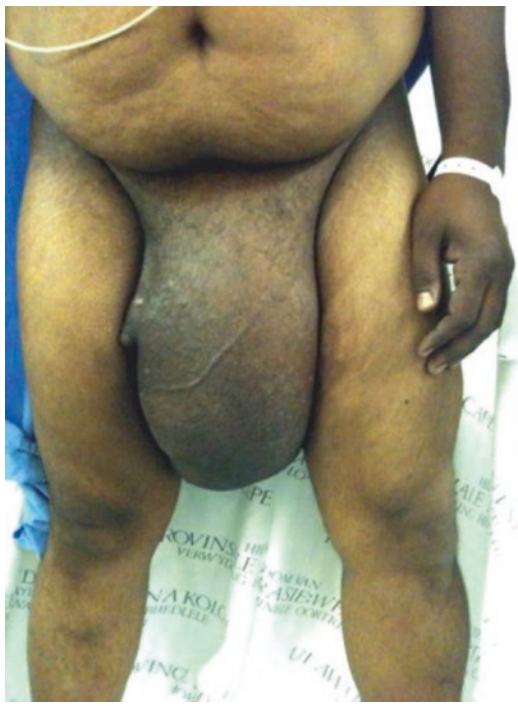

Fig. 15.11 Giant scrotal hernia

Large inguinal scrotal hernias also are morbid and cause sexual dysfunction, chronic pain and present a higher risk of incarceration and strangulation. These hernias can be repaired in an austere environment, but a thorough preoperative medical evaluation, an experienced anesthesiologist, and careful dissection and hemostasis are necessary. An overnight stay may be appropriate, and surgeon postoperative follow-up is necessary. A scrotal support during the first postoperative week is advisable.

15.3.4 Pediatric Hernia Repair and Undescended Testicle

Dr. Robert Cusick, an Omaha-based pediatric surgeon (Fig. 15.12), established a level of excellence within our organization, and other pediatric surgeons including Dr. David Partrick (Fig. 15.13) have sustained that expectation. Dr. Cusick is an officer in the American Pediatric Surgical Association, and through his network of colleagues, we have been able to reliably recruit excellent pediatric surgeons. We have had to avoid hernia repair on children under the age of 6 months because hospitalization is not possible in most of our sites. All hernia repairs are done on an outpatient basis, and therefore, one child with a large omphalocele-related fascial defect and hernia was referred to an in-country pediatric surgeon. Patients with congenital undescended testicles that are intracanalicular or supra-scrotal are operated

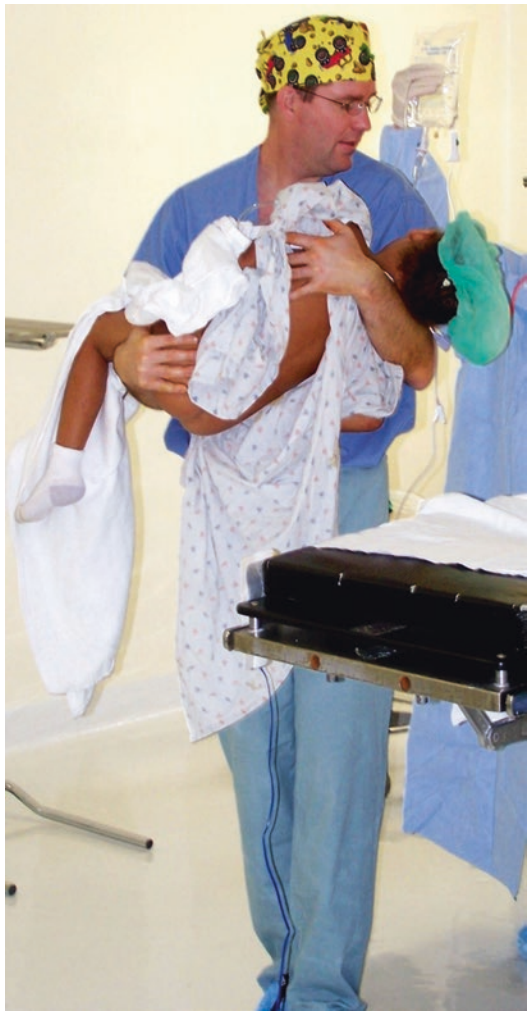

Fig. 15.12 A Dominican Republic patient with Dr. Cusick

upon, and there have been no related complications. A pediatrician's preoperative examination and early postoperative support and a pediatric anesthesiologist are other important elements to a successful children's program, and in most circumstances, we were able to provide that support.

15.3.5 Incisional Hernias

Incisional hernias are a common complication after abdominal surgery with the incidence after laparotomy estimated at 10–15% [22]. In LMICs, gynecologic procedures are frequently performed

Fig. 15.13 An Ecuadorian patient with Dr. Partrick

[23], and large incisional hernias will result. Surgical repair can be complex with prolonged postoperative in-hospital care, and complications can be catastrophic requiring multiple operations, mechanical ventilation, and a prolonged ICU stay. Even in HIC hernia centers of excellence, postoperative complications range from 10 to 48% [24]. In a retrospective analysis from Nigeria, large ventral hernia repair was associated with 25.6% morbidity rate and a 4.9% mortality rate [25]. Another report from Nigeria recorded a wound infection rate of 31.6%, wound dehiscence rate of 21.1%, and overall mortality of 4.8% [23]. Even clinically small incisional hernias can intraoperatively reveal multiple fascial defects [26], necessitating a large incision, significant surgical expertise, and extended postoperative care. Previously at all facilities partnering with HRFU, high-quality postoperative care was not available. A new hospital in Port-au-Prince, Haiti, is now, however, making it possible

to safely perform incisional herniorrhaphy on select patients.

15.3.6 Anesthesia Care

There is a dramatic disparity in anesthesia-related complications and deaths when comparing outcomes in HICs with those in LMICs. Anesthesia care has significantly improved in HICs since 1970 with an estimated 40-fold decrease in overall mortality to approximately one death in 200,000 anesthetics [27]. Similarly, the rate of anesthesia-related cardiac arrests decreased threefold within the last 30 years [28]. Data from LMICs is limited, but anesthesia-related mortality rates are estimated to be fivefold higher [29] and in individual reports up to 60-fold higher than in HICs [27]. High anesthesia-related mortality rates in LMICs are especially prevalent in the pediatric population. A recent systematic review by Gonzalez et al. found significantly lower anesthesia-related mortality rates in HICs (0.0–0.69 per 10,000) than in low-income countries (2.4–3.3 per 10,000) [30]. However, there is considerable variability in quality of anesthesia at different LIC sites. One report from West Africa reported a pediatric anesthesia-related mortality rate of 97 per 10,000 anesthetics [31]. It is apparent that surgical outreach missions have to pay special attention to the availability of well-trained anesthesia staff, adequate equipment, medications/anesthetic agents, hemodynamic monitoring, and pulse oximetry. An experienced pediatric anesthesiologist is vital to the success of any mission that operates upon children.

15.3.7 Patient Follow-Up

A common pitfall of surgical outreach missions is lack of systematic follow-up. Shrime et al. identified temporary short-term platforms as being prone to inconsistent follow-up [32]. Other reasons for low follow-up rates include lack of local medical staff involvement, patient transportation costs, local staff and patient misunderstanding about the value of follow-up, unreliable documentation methods, and costs associated with cell phones and absence of internet service.

Torchia et al. report a follow-up concept for orthopedic surgery missions which involves a Peruvian physician, who performs four follow-up consultations within 12 months postoperatively [33]. An incentive structure with a graduated payment plan was created for the physician. With this method, consistent follow-up was achieved in 82% of patients. Latifi et al. described utilization of an online database for preoperative assessments prior to surgical mission trips to the Philippines [34]. Preoperative consultations can be documented by a mission team member or local physician and uploaded to an online server allowing for remote clinical decision-making. This concept could also be applied to postoperative evaluations.

Hernia Repair for the Underserved trained 120 health-care promoters to provide hernia patient follow-up in the Dominican Republic. Health-care promoters are volunteers that are elected by their local community and are educated on basic health-care issues at the ILAC center. The program is 35 years old and highly respected by patients and the Ministry of Health. The volunteers see patients independently, consult with their coordinator who may take a cell phone picture of the incision and send it to Dr. Filipi. If necessary a local surgeon, trained by HRFU, then sees the patient. In other countries pictures are sent to Dr. Filipi, and a referral is arranged with a pre-identified local surgeon. Our organization has not had sufficient funding to pay local providers for systematic follow-up as mentioned above, although it is one of HRFU's goals.

15.4 Training Missions

15.4.1 Capacity Building

Capacity building is defined by the United Nations as developing a "country's human, scientific, technological, organizational, institutional and resource capabilities … based on an understanding of environmental potentials, limits and of needs perceived by the people of the

country concerned" [35, 36]. For global surgery, education is a recognized priority for capacity building. Beard et al. mention that a systematic teaching program for mesh hernia repair techniques would add greater sustainability to surgical outreach programs [11]. Hernia Repair for the Underserved developed a surgical training program for tension-free mesh repair with the goal of local community self-sustainability within 5 years.

15.4.2 Training Method

Fully trained surgeons are chosen for training, on condition that they use donated mesh for poor patients only and that a mesh patient spreadsheet is sent to the HRFU education coordinator before more mesh is provided. Six to seven nonrecurrent, non-scrotal inguinal hernias are chosen for training purposes during the 1-day course. The trainer uses a validated surgical technique rating form (the Operative Performance Rating Scale (OPRS)) designed by the University of Southern Illinois surgical department education division with the help of Dr. John Mellinger and input from Dr. Parviz Amid, Dr. David Chen of the UCLA department of surgery, and Dr. Filipi of Creighton University. The OPRS basic method is approved by the American Board of Surgeons for resident training.

Before the first operation, the rating form is reviewed with the trainee, and then the trainer performs the first operation, and the trainee first assists. The trainee (Fig. 15.14) and trainer reverse their roles with the following 4–6 operations. After each operation the trainer fills out the rating form in privacy (Fig. 15.15) and then immediately reviews it with the trainee giving him a numerical score and explanation for all of the operative step ratings (Fig. 15.16). All training operations are performed the same day, and the OPRS feedback is completed after each operation. If the trainee achieves satisfactory scores, they are given a certificate of participation and 20 pieces of donated mesh. Photographs 15.14, 15.15, 15.16 show the process.

Fig. 15.14 The trainee giving local anesthesia

Fig. 15.15 The trainer filling out the form

15.4.3 Hernia Mesh in Developing Countries

Since HRFU started hernia trips in 2004, we have always had an abundance of high-quality polypropylene mesh. C. R. Bard, Ethicon, Covidien, and Winer from Columbia have been most generous. There is now more red tape with some manufacturers, but the supply continues. We have always

Fig. 15.16 Discussing the OPRS form after an operation

been able to supply mesh when the surgeon requests it. Unexpired mesh is used, although at the beginning we did on occasion use mesh that was within 2 years of expiration if the packaging was intact. Now we have more mesh, and companies are beginning to locate manufacturing sites in HMICs with the intent to provide more affordable mesh. As the companies see the market expand due to surgeon and hospital request, and increased competition occurs from in-country companies using well-regulated manufacturing and sterilization standards, the Lichtenstein repair and other mesh operations, including ventral hernia operations, will eventually become commonplace. Well-conceived training is necessary, however, for tissue repair surgeons to make the transition to mesh.

15.4.4 Surgeon Trainee Selection

Trainee selection is critical to the success of any educational program. A trusted in-country coordinator that understands the requirements for effective education and cultural barriers is essential, but even with that, there is the unexpected. The trained surgeon has to continue performing elective hernia surgery, but doctor strikes, natural disasters, government dysfunction, and many other barriers abound. The trained surgeon has to be motivated to keep learning, but in austere circumstances, their family may not have enough food, so despite a passion for learning, economic necessities pervade, and rather than perform charity hernia operations, the surgeon has to promote a private pay practice and take emergency room call. The list of barriers is endless, but most important are the trainees ability, their previous training, and their loyalty to the in-country coordinator. Good trainee support and selection can with time allow trainees to become a trainer—which provides overall sustainability of the education initiative.

15.4.5 Additional Barriers to Education Assessment and Sustainability

In our experience surgeon trainee follow-up has been plagued by communication difficulties and cultural/economic disparities. Although most trainee surgeons have cell phones and an e-mail address, many do not have affordable internet, consistent internet, and or a working computer. Surgeon annual incomes are such that computer repair or a new purchase is often not possible. Cell phone communication may be difficult because there can be a more pronounced language barrier on the phone. Some surgeons do not fully understand the reason for follow-up and the information we are seeking. Additionally, the problem is conceptual. In Haiti, for instance, it is extremely difficult to obtain reports especially from the public sector. Surgeons follow this trend and do not feel compelled by education or instinct to fill out a spreadsheet, especially if it is for a foreign program. The other developing country vagaries of life notwithstanding, postgraduate education, and the added responsibilities are a professional luxury that is rarely experienced and

unfamiliar, plus the program is relatively new, and some surgeons do not feel adherent. We are trying to better understand the individual follow-up issues and improve trainee follow-up by reminders and in person visits. To do so, we now have a multilingual United States-based surgeon education coordinator.

Trainee follow-up is more likely but there are still issues; the language barrier is lower but not always conquered, and the culture of accountability is often foreign in LICs and LMICs. Corruption and the spoils system is alive and well in many developing countries, and honest interchanges, especially when money is involved, are only possible if the in-country organizational infrastructure is reliable. We provide mesh to the trainee surgeon for use in poor patients only, but follow-up communication and mesh use has occurred with only 50% of our trainees. This is not because the trainees are disingenuous but because we, as an organization, after 5 years of training, need to understand how best to select, monitor, and help our trainees to perform elective hernia operations on a regular basis.

Therefore, periodic coordinator assessments of the surgeons' ability to perform elective surgery are necessary. An in-person visit is, however, expensive. Nonprofits often live on the ragged edge of solvency, and balancing financial priorities is always a challenge. If there is to be dedication to in-country training and capacity building, the best method appears to be that implemented by Torchia et al. [34]. In addition to paying the United States coordinator expenses, improving the surgeon's capacity to perform elective surgery by paying for or obtaining needed new equipment, and possibly supplementing the surgeon's salary, with accountability systems in place may help the surgeon, his prospective patients, and the country at large. It is our organizational goal to mature this approach and learn further lessons to enable our trainee surgeon partners.

Conclusion

Lessons learned for service missions:

1. Without compromise adhere to the preferential option for the poor.
2. Have an organizational zero tolerance for patient mortality.
3. Recruit and screen true expert hernia surgeons.
4. Use pediatric surgeons for children under 16.
5. Recruit expert anesthesiologists.
6. Use pediatric anesthesiologists for children.
7. Recruit experienced dedicated nurses and sterilization staff.
8. Team leaders should be experienced hernia surgeons with leadership skills.
9. Utilize proven surgical techniques and high-quality equipment.
10. Operate selectively on large hydroceles and giant scrotal hernias.
11. Avoid incisional hernias when starting.
12. Avoid large or complicated incisional hernias.
13. Utilize well-trained local staff for follow-up.

Lessons learned for training missions:

1. Recruit a multilingual surgeon education coordinator.
2. Determine if potential surgeon trainees perform >20 elective operations a month.
3. Train surgeons utilizing OPRS and lectures for 2 days rather than 1.
4. Establish systematized patient and surgeon follow-up.
5. Train candidates to train other local surgeons.

The HRFU elective morbidity and mortality rates are consistent with outcomes from HICs and confirm the feasibility of a public health initiative based on the principles of the preferential option for the poor. The model is reproducible and can benefit many.

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16 The Most Important Clinical Trial in the Last 10 Years in Inguinal and Incisional Hernia Surgery

Lars Nannestad Jorgensen and Thue Bisgaard

Accumulation of scientific evidence is fast, and the number of publications within hernia-related topics increases exponentially. A simple search on PubMed reveals that the number of publications applying the search time *hernia* increased by 100% comparing two 4-year periods (2000–2003, $n = 1590$, and 2013–2016, $n = 3228$). In addition, there is an explosion of alternative non-indexed publications appearing in electronic journals, congress abstracts, search machines, and social media. Therefore, it is challenging for the scientifically active surgeons to keep up with the rapid stream of new data and to implement evidence-based changes into surgical practice. Apart from a long time lap between initiation of a randomized controlled trial and final publication, considerable time is associated with implementation of the study results into clinical practice. While some promising study conclusions based on firm methodology may remain clinically unnoticed, others are simply ignored due to conservatism. Therefore, only a minority of studies lead to significant breakthroughs and change of clinical practice.

Given these conditions, it is challenging—if not impossible—to identify the most important clinical studies on inguinal and incisional hernia repair. We were assigned to point out two of the most important clinical trials in groin and incisional hernia surgery during the recent 10 years. In our search, we aimed to identify papers of exceptional originality and creativity. The study results should have outstanding clinical implications for a large group of patients and the potential to significantly improve surgical practice. Finally, adoption of the study conclusions should significantly impact positively on cost-effectiveness. Our selection criteria were not restricted to papers, which were published in high-impact scientific journals or had an optimal scientific study design. Each of us independently selected five potential papers from each of the two categories. Selection of the final two papers was obtained after consensus.

Groin Hernia Surgery: Löfgren J, Nordin P, Ibingira C, Matovu A, Galiwango E, Wladis A. A randomized trial of low-cost mesh in groin hernia repair. N Engl J Med 2016;374:146–53.

There is an annual number of approximately 20 million groin hernia repairs. Even though they are considered safe and cost-effective in the industrialized world, there are limiting factors for groin hernia surgery in the third world including restricted health economy, relatively high procedural costs, limited access to hospital facilities, and low availability of surgeons. Moreover, patients are often expected to pay for their own medical care. These resource constraints result in a considerable rate of nonoperated patients with

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irreducible large inguinoscrotal hernias and ultimately fatal cases due to hernia strangulation. In this setting, there is a great need to define and evaluate a safe low-cost procedure for groin hernia repair.

The use of inexpensive mosquito net made of high-porosity polyethylene as an alternative to commercially available mesh materials has reduced costs associated with groin hernia repair in some places outside the industrialized world [1, 2]. However, no randomized comparison against conventional mesh products had been undertaken until a group consisting of surgeons from Sweden and Uganda recently published the results from a double-blind randomized controlled trial conducted in Uganda [3]. Patients with a primary unilateral inguinal groin were recruited in several villages. Following informed consent, 302 patients underwent Lichtenstein repair under local infiltration analgesia by one of four surgeons. Patients were evenly randomly allocated under surgery to receive either a mosquito mesh made of polyethylene (38 g/m^2, pore size 1.5 mm, prize US$ 1) or a commercial polypropylene mesh (Parietene Light, Covidien, 53.7 g/m^2, pore size 1.9 mm, price US$ 125). Scrub nurses performed the preparation and sterilization of the mosquito mesh material following a simple guideline.

Astonishing high rates of clinical follow-up were achieved at 14 days (97%) and 1 year (94%). The 14-day incidence of all postoperative complications was 30% with no significant differences between the allocation arms. Most common were wound complications, none of which required removal of the mesh. There was only one patient (0.7%) with a hernia recurrence at 1 year postoperative in the low-cost mesh group. All patients reported significant improvement of groin symptoms (Inguinal Pain Questionnaire), self-assessed health and satisfaction at 1 year compared to the preoperative assessment, whereas these parameters did not significantly depend on the mesh randomization.

The authors are to be congratulated for performing this extremely relevant study and obtain high follow-up rates under relatively challenging East African rural conditions. This study has high potential impact on health services in areas where the cost of a commercially available mesh is prohibitive for groin hernia repair. The RCT demonstrated the safety of implanting mosquito net as a synthetic prosthesis in Lichtenstein repair given that skilled staff is present to conduct the preparation, packing, and sterilization of the material.

Incisional Hernia Surgery: Millbourn D, Cengiz Y, Israelsson LA. Effect of stitch length on wound complications after closure of midline incisions: a randomized controlled trial. Arch Surg 2009;144:1056–9.

Incisional hernia develops in up to 29% of patients undergoing a laparotomy [4]. Surgical site infection (SSI) occurs in nearly one of five laparotomies and increases the risk of incisional hernia formation [5, 6]. The annual number of incisional hernia repairs is 300,000 in Europe [7], and the associated cost per patient is between 9000 and 12,000 € [8] leading to an approximate three billion € in total costs. Incisional hernias are associated with discomfort, pain, risk of strangulation, increased sick leave, and reduced quality of life including impaired cosmesis. Moreover, incisional hernia repair is often complex with a considerable risk of postoperative complications and repetitive surgery because of hernia recurrence. There is thus a great need for effective and easily applied preventive measures to reduce the hernia rate, as even minor rate reductions are accompanied by health-care cost benefits [8]. Lately, prophylactic meshes for abdominal wound closure have proven effective for the prevention of incisional hernia in high-risk patients [9]. However, there are more simple measures to reduce the risk of hernia formation such as adopting a ratio of at least 4 to 1 for the length of used suture relative to the length of the wound [10]. Importantly, a 4 to 1 ratio could be obtained in different ways: large suture bites and gaps between each stich or small suture bites in combination with small inter-stich gaps.

Dr. Israelsson's group from Sweden that originally proposed the 4 to 1 ratio for abdominal wound closure sets out to investigate how to obtain this ratio in the most efficient manner. Impressively, they conducted such a study in their own center during a 5-year period randomizing 737 patients

for continuous midline abdominal closure into two allocation arms: standard long stitch closure with a half-circle needle with a 41 mm diameter and a 1-0 PDS suture versus short stitch closure with a 20 mm diameter and a 2-0 PDS suture. The study was patient- and assessor-blinded with follow-up at 1 and 12 months [11].

The study outcomes were more beneficial in the short stitch group, as both SSI (10.2% vs. 5.2%) and incisional hernia at 1 year (18.0% vs. 5.6%) were significantly higher in the long stitch group. The authors suggested that closure with the large stitch promotes ischemia and SSI, as the suture embraces more remote tissue than just the aponeurosis. There are several reasons to explain the preventive effect of the small stitch closure on the rate of incisional hernia. SSI and early slackening of the suture due to a cutting effect on soft tissues are prevented, when the stitches are placed close to the edge of the aponeurosis. Moreover, a higher number of applied stitches causes less tension on each suture and hence a reduced tendency toward tearing of the aponeurosis. Due to the large study, other risk factors for SSI (contamination and diabetes) and incisional hernia formation (male sex, BMI, operative time, SSI and suture-wound ratio < 4) could be identified in multivariable models. Interestingly, these beneficial effects were not offset by a longer operative time in the short stitch allocation arm.

The study by Israelsson and coworkers has several merits. It is a prominent example of extremely relevant clinical research for a large group of patients introducing a relatively simple and inexpensive surgical technique. The study group was able to monitor the study closely, as it exclusively took place in their own department through years of dedicated inclusion of patients to obtain sufficient study power. Opponents of the small stitch – small bites technique have claimed that the results had not proven reproducible in a general surgical setting. However, a recent large randomized Dutch multicentre study (the STITCH trial) came to a similar conclusion as reported in the Swedish study 6 years earlier as concerns the preventive effect on the development of incisional hernia. The Dutch study elegantly demonstrated the external validity of Israelsson and coworkers' main finding [12].

Development of incisional hernia is associated with morbidity, prolonged hospitalization, repeated surgery, and increased costs. The simple and inexpensive abdominal closure technique for midline laparotomies as originally proposed by Dr. Israelsson should now be considered gold standard with enormous significance for the operating results of the surgical patients in general.

The studies from the groups of Löfgren and Israelsson pose a unique potential to inspire the surgical community to work together and conduct multicentre evaluation of relevant research questions in a randomized manner. Sadly, the abundance of such questions is presently not answered by high-level evidence.

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Part II

Inguinal

Anatomy of the Inguinal Region

17

J. Loriau

As Fruchaud proposed in 1956 [1] (cf. anatomy of the femoral region), we should consider both femoral and inguinal regions as a unique entity: the Myopectineal orifice.

In his conception, widely shared since his description, there are in the area between: the pelvic bone and its surrounding ligaments, the superficial and the deep layer of the abdominal wall muscles forming the conjoint tendon, the psoas muscle and the rectus muscle two zones of potential weakness. The lower one is the femoral region. The upper one is the inguinal region. Those two zones are separated by the inguinal ligament. This approach by Fruchaud is based on the fact that physiopathology of hernia formation in those areas is commonly based on the weakness of the fascia transversalis (Fig. 17.1).

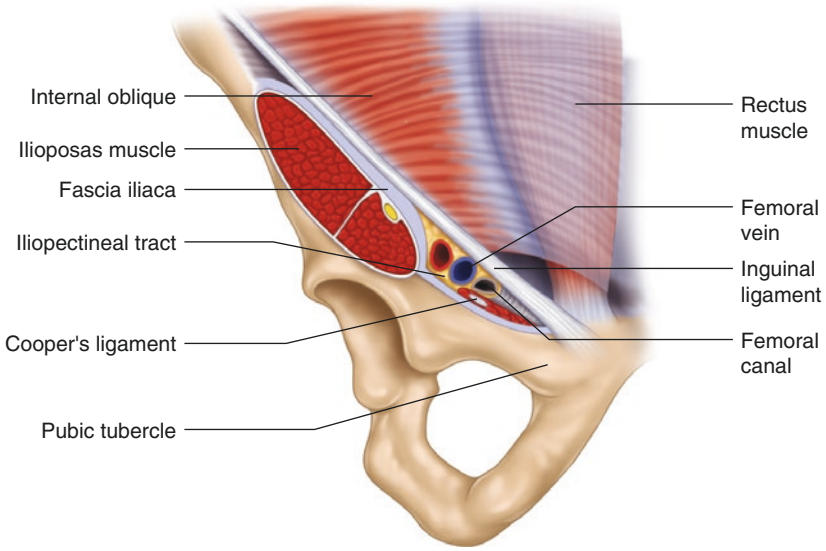

Fig. 17.1 Myopectineal orifice with femoral vessels

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Books of anatomy looks sometimes difficult to appropriate as they display many informations, historical names or nicknames. Their drawings can be beloved for their artistic appearance or hated because of looking old-fashioned.

Nevertheless it is totally impossible to forget anatomic considerations in a textbook about abdominal wall surgery. If we should give only one reason for that I would say that knowing anatomy is one of the best ways to avoid dramatic complications!

Therefore, our purpose will be to highlight the "surgical anatomy" of the inguinal region and give cartography of the points of wreck!

17.1 The Myopectineal Orifice of Fruchaud and the Inguinal Region: Three Muscular Layers Concurring to Weakness (Fig. 17.2)

Although present in the inguinal region, the large muscles of the abdominal wall fail in building a strength rampart to hernia formation.

The external oblique is the most superficial and present just under the skin, fat tissues and superficial fascia.

Indeed the superficial fascia is the first layer the surgeon will cross approaching the inguinal region. This superficial fascia has been described as comporting itself two layers. One more areolar is called Scamper's fascia and one more fibrous and deep called Scarpa's fascia. Both are continued down into the genital organs (penis or labia major). Superficial fascia is easily identified during surgery but it's more uncommon to distinguish its two layers.

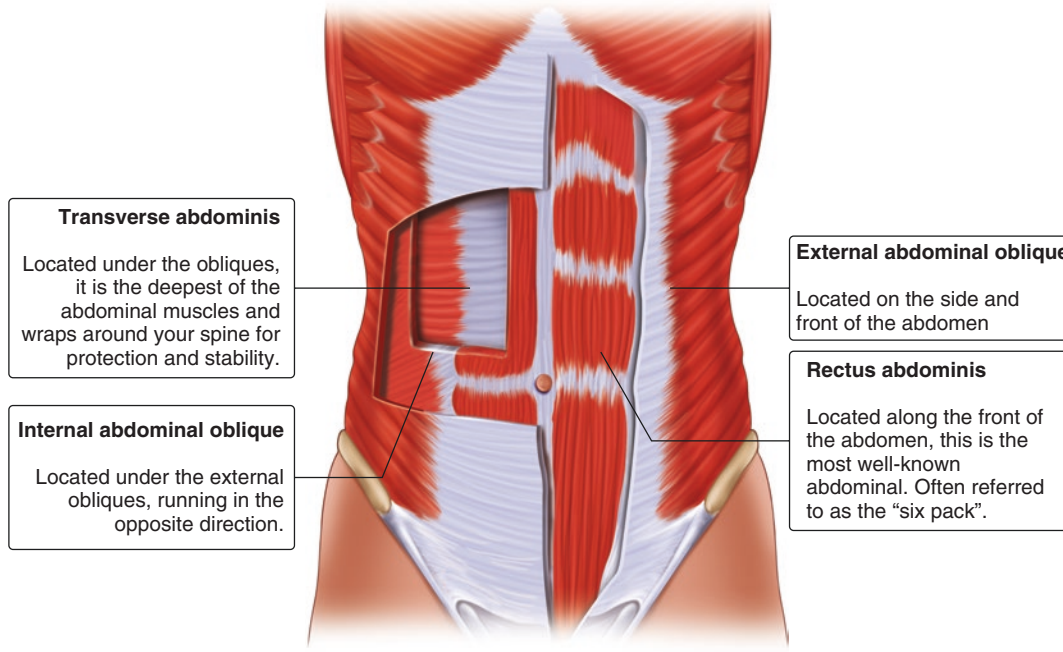

Fig. 17.2 Muscles of the core

The external oblique of the abdomen consists only in an aponeurosis at that level. Its fibers, directed downward and medially towards the midline constitute a strong membrane. Despite this strength, it cannot contribute to avoid hernia formation. First because it is too superficial and contains a whole as a result of its fibers split from each other: the superficial inguinal ring; the exit of the inguinal canal. In case of oblique hernias the superficial inguinal ring, as a whole, cannot play any role in stopping the hernia sac during its outward movement. Second because in case of direct hernias it is also too superficial and can only overhang the hernia. Third because the external oblique fascia ends caudally constituting the inguinal ligament which is the "ground" of the inguinal canal. Inguinal ligament divides in two parts (inguinal and femoral) the myopectineal orifice of Fruchaud but doesn't confer any additional opposition to inguinal hernia formation (Fig. 17.3).

The internal oblique is the second layer. Its fibers run opposite to the one from the external oblique upward and medially. It is a muscle of importance because its fibers joined with the ones from the transverse will constitute the "conjoint tendon". The "tendon conjoint" is the ceiling of the inguinal canal. The role of the "conjoint tendon" in hernia occurrence is discussed under but the internal oblique cannot be considered as an efficient rampart to hernia formation (Fig. 17.4).

The internal oblique also contains fibers that will downward with ones from the transverse muscle constitute the lateral cremaster muscle (see under). When present the medial fibers from the cremaster muscle come from the inguinal ligament.

Deeper lays the **transverse muscle**. In its lower part , its fibers runs horizontally from the iliac fascia, anterior-superior iliac spine and the lateral third or the inguinal ligament almost parallel to the ones from the internal oblique and contributes to the formation of the conjoint tendon. Some fibers also distribute fibers to the cremaster (Fig. 17.5).

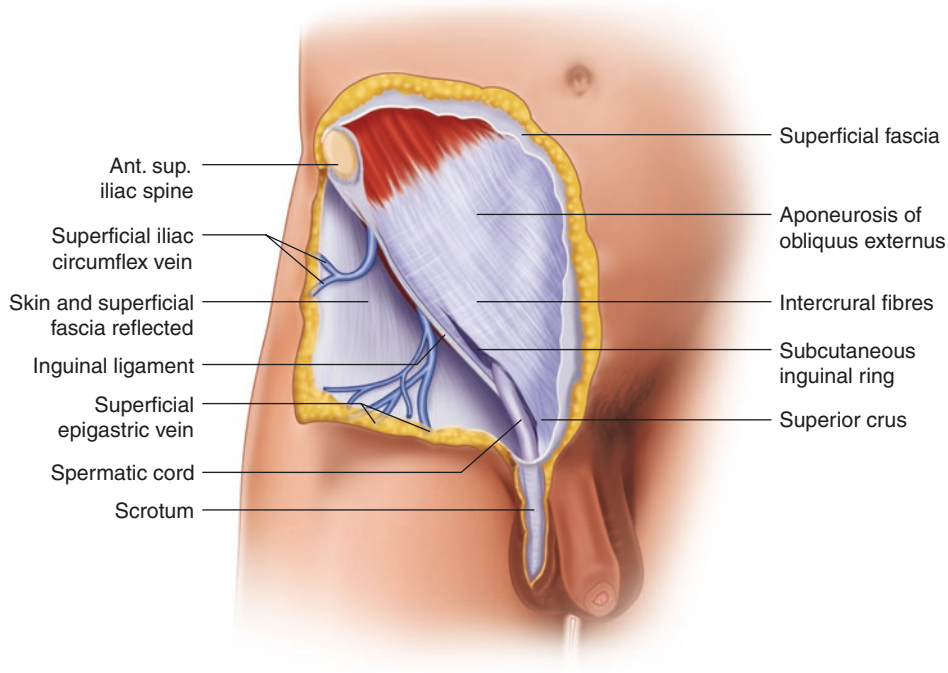

Fig. 17.3 Superficial layers of the inguinal region

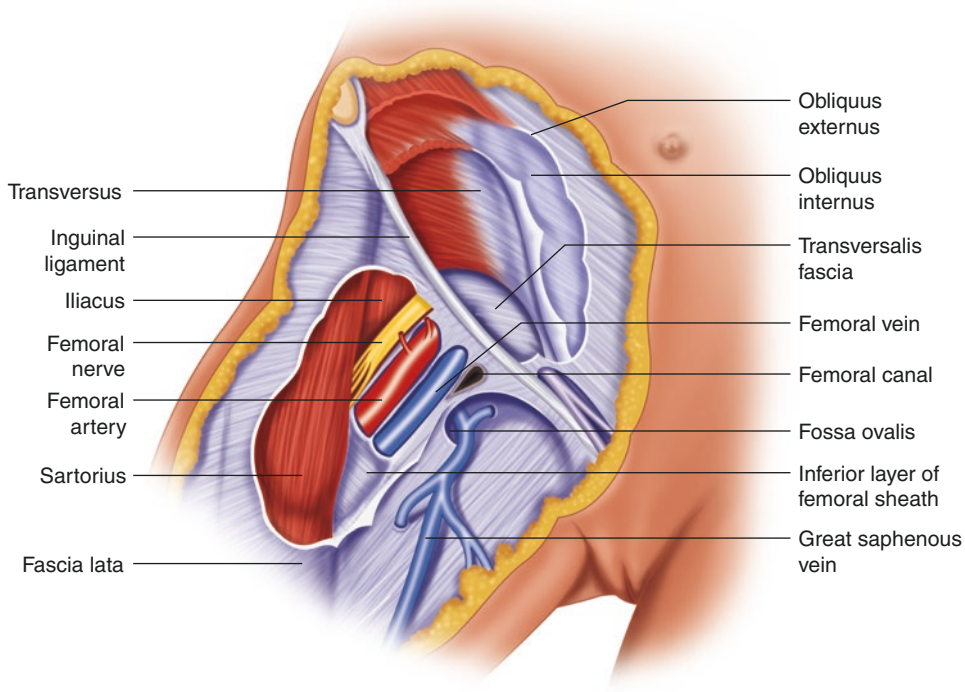

Fig. 17.4 Deep layers of the inguinal region

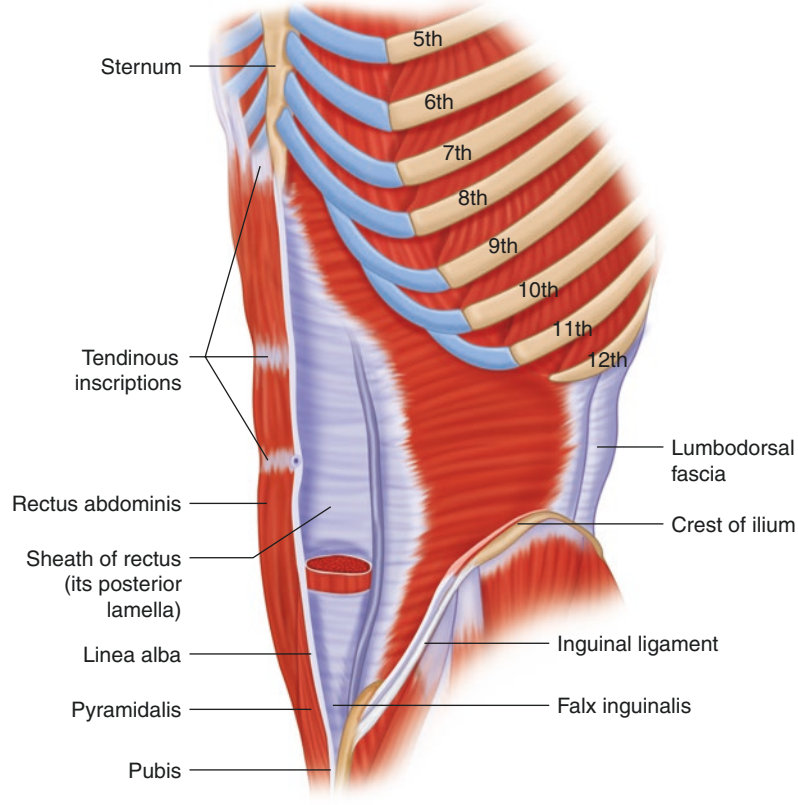

Fig. 17.5 Oblique and rectus muscle insertions

Role of the conjoint tendon in hernia constitution

Born from the horizontal running fibers of both internal oblique and transverse muscle, the conjoint tendon runs horizontally and then vertically to the crest of the pubis and pectineal line. Therefore it was also called inguinal aponeurotic falx. The medial insertion of the conjoint tendon is variable and the variations have been described as possibly playing a role in hernia formation.

Since the tendon is the lowest musculo aponevrotic structure of the myopectineal orifice, all the space between itself and the pectineal ligament represents a weakness space only closed by the transversalis fascia. The more this space (including medially the "inguinal triangle" also called Hesselbach's triangle and laterally the deep inguinal ring) is large due to high lying conjoint tendon, the more the surface receiving abdominal pressure without musculoaponevrotic reinforcement is large and subject to hernia formation.

Physiologic shutter mechanisms exist to deal with this anatomic weakness. In standing position the conjoint tendon is pulled up with the abdominal wall muscles and the potential orifice is open.

During coughing or straining, contraction of the fibers of the conjoint tendon pulls it downward in order to "close" the orifice and contain increased abdominal pressure. The same movement is also observed during squatting where the tendon covers the weak area. The Hesselbach's ligament has also been described to play a role in the movement of closing the inguinal diaphragm.

But in case of an excessive surface due to a high or too external insertion of the conjoint tendon all these movements can be too limited to provide an efficient coverage of the area. Therefore these anatomical predispositions (among others) can play a role in hernia formation (Fig. 17.6)

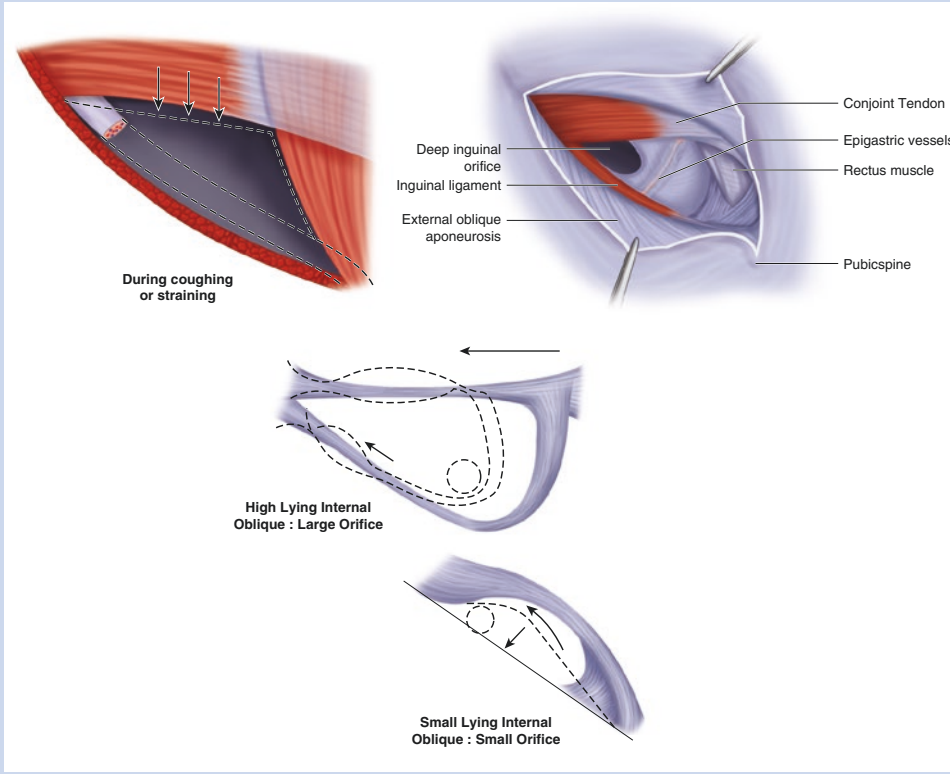

Fig. 17.6 Different modalities of insertions of the components of the ring

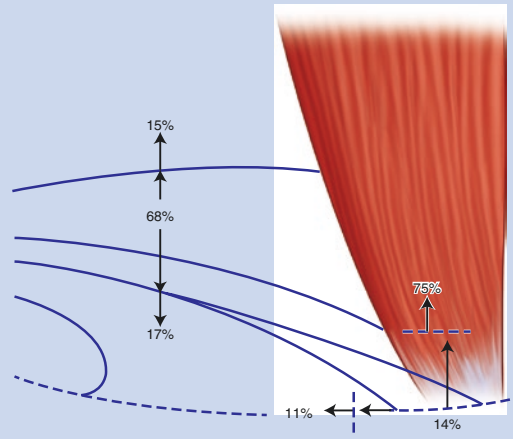

Fig. 17.6 (Continued)

In summary the three different musculo aponevrotic layers doesn't confer any solidity to the inguinal region of the Myopectineal orifice due to their respective positions. A high position of the conjoint tendon could enlarge the myopectineal orifice and facilitate hernia occurrence.

17.2 The Inguinal Canal (Fig. 17.7)

As it has to be understood as a 3D structure, the inguinal canal and its anatomy might be difficult to understand and/or teach to residents. We used to say that one thinks he understands its anatomy as medical students, he (she) believes at last he (she) understands as resident but nobody has really caught the reality before being a certified surgeon!

The easier approach is to consider it as a rectangular block (parallelepiped) which is a geometric structure known to anybody.

Describing such a way the canal 6 sides have to be defined: one on each extremity which are the entrance and the exit of the channel, one ceiling and one bottom; one superficial and one deep face and the content represented by the spermatic cord (Fig. 17.8).

17.3 Entrance to the Channel: the Deep Inguinal Ring

Deep anal ring is a whole inside the transversalis fascia allowing entrance to the spermatic cord into the channel. If we describe it as a square, its 4 for sides are anticlockwise from the top (looking the right side in front of a patient): the conjoint tendon on top and anterior sides constituted by fibers from the internal oblique and transverse muscle, the inguinal ligament in the inferior side, the epigastric vessels medially. Along the epigastric vessels, the transversalis fascia is reinforced and called Hesselbach's ligament or interfoveolar ligament. Keeping in mind that the internal limit of the internal ring is composed by the Hesselbach's ligament but must of all by epigastric vessels might be useful for safe surgery… (Fig. 17.9)!

17.4 Exit to the Channel: the Superficial Inguinal Ring

Located above the pubic tubercle, the superficial ring is, as we described before, a near triangular whole within the lower part of the external oblique aponeurosis. It is made of its fibers split. Medial crura is inserted on the public crest, lateral crura runs to the public tubercle. The inferior side of the surficial ring triangle is made of the lowest fibers of the external oblique aponeurosis constituting the inguinal ligament (Fig. 17.10).

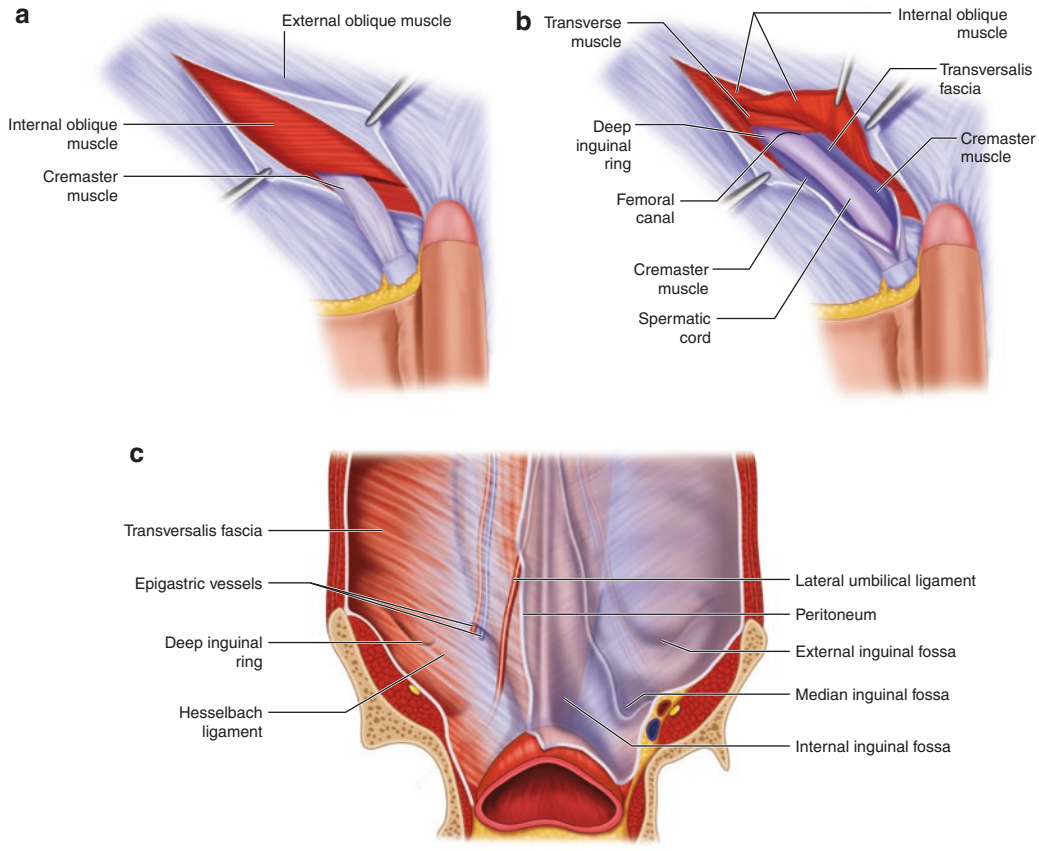

Fig. 17.7 (**a**) Superficial layers of the inguinal canal. (**b**) deep layers of the inguinal canal. (**c**) internal "laparoscopic" view of the inguinal region

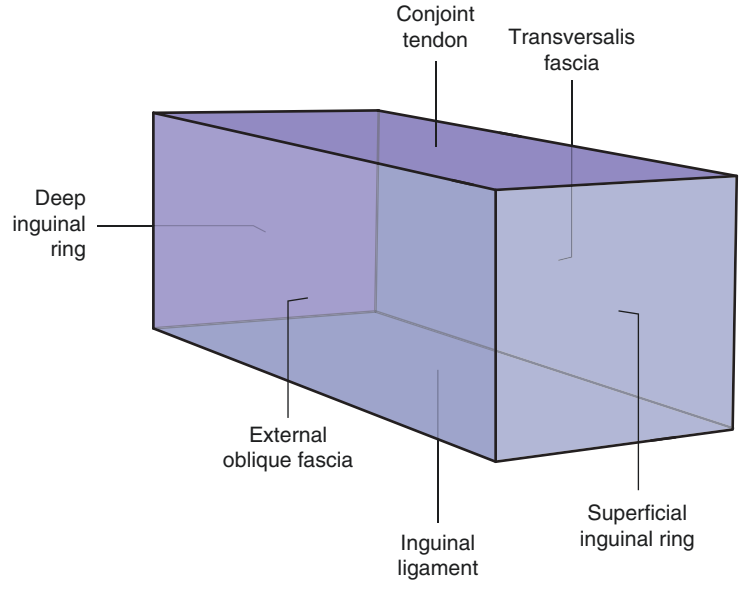

Fig. 17.8 The inguinal "3D Channel"

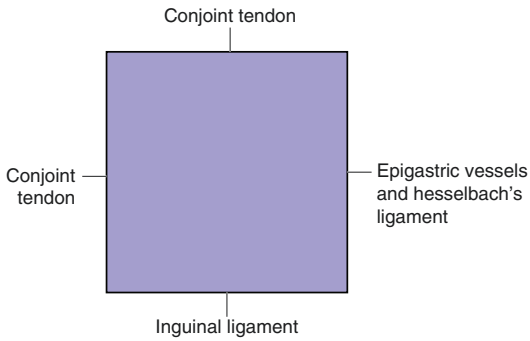

Fig. 17.9 The deep inguinal ring

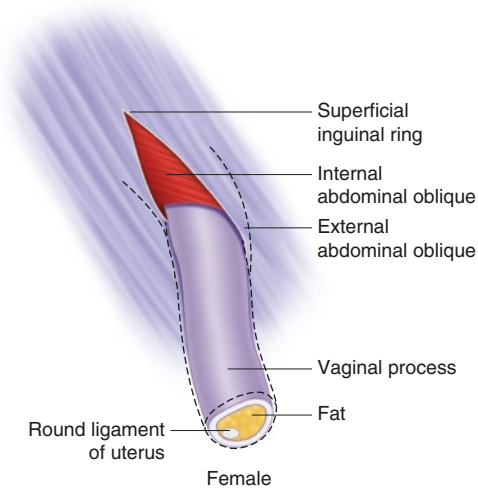

Fig. 17.10 The external inguinal ring

17.5 Floor of the Channel: the Inguinal Ligament

The inguinal ligament is one of the key elements from the myopectineal orifice of Fruchaud. As a strong structure, it divides the orifice in two parts of frailty: the inguinal region and the femoral region. Made of the reinforcement of the inferior edge of the external oblique aponeurosis, it also represents the floor of the inguinal channel.

For anatomists, the "independance"& "constitution" of the inguinal ligament is for a long time a subject of debate. In a paper from a decade, Aclad R. [2] summarized all the conceptions about that ligament that have been proposed by anatomists (Table 17.1).

Streched between the anterior superior iliac spine and public tubercle, its inferior part is generally considered neither totally free nor alone but stretched in connection with the transversalis fascia and also to the femoral sheath by Thomson's band. The existence of Thomson's band or iliopubic tract is another subject of debate but it can be described as a fibrous structure running from the pubic tubercle to the iliac fascia and in connection both with conjoint tendon and femoral sheath. Thomson's band is seen as transversalis fascia reinforcement [10].

Table 17.1 Anatomical terms for the inguinal ligament used by noted anatomists of the late eighteenth and early nineteenth centuries, and the structures to which each author applied the anatomical term(s)

Author	Anatomical term(s) used	Structure(s) described or understood to be included under the anatomical term
Winslow [8]	Ligament de Falloppe	A structure distinct from the external oblique aponeurosis, to which the lower edge of the external oblique aponeurosis is attached.
Gimbernat [9]	Arcade crurale	Superficial part: the in-turned lower border of the external oblique aponeurosis. Deep part: the structure now recognized as the medial part of the iliopubic tract.
Bichât [10]	Ligament de Falloppe	The folded lower border of the external oblique aponeurosis.
Bell [11]	Ligament of the thigh[a] Ligament of Poupart[a] Inguinal ligament[a] Crural arch[a] Ligament of Falloppius[a]	A distinct ligament, independent of the external oblique aponeurosis. Description corresponds largely to the structure now known as the iliopectineal arch.
Hesselbach [12]	Aussere leistenband Innere leistenband	(1) "External inguinal ligament" formed by the lower edge of the external oblique aponeurosis. (2) "Internal inguinal ligament" formed by structures now known as iliopectineal arch and transversalis fascia.
Cloquet [13]	Ligament de Falloppe[a] Ligament de Poupart[a] Arcade crurale[a]	The folded lower border of the external oblique aponeurosis.
Cooper [14]	Poupart's ligament[a] Crural arch	(Description indistinct) Understood the structure now known as the iliopectineal arch to be part of the ligament.

[a]These terms were used synonymously by the named author

Those anatomical debates might be considered useless by surgeons in practice but one anatomical point has to be known about vascular proximal elements of the inguinal ligament. About 4 to 5 cm lateral to the pubic tubercle and just beneath the inguinal ligament (& Thomson's band) lays the external iliac vein. It can be very easily injury by an "unfair" stitching like in many groin hernia procedures were the roof of the inguinal canal is used as an inferior point of anchor.

17.6 Front Wall of the Inguinal Canal: External Oblique Aponeurosis

As we described before the aponeurosis of the external oblique muscle is the most superficial structure (after the superficial fascia) of the abdominal wall at the myopectineal orifice. As the lid of Fruchaud's myopectineal orifice, the external oblique aponeurosis also covers the inguinal canal. This layers contains the superficial inguinal ring (see before) which is the exit of the inguinal canal.

17.7 Back wall of the Inguinal Canal: Transversalis Fascia

However transversalis fascia is known due to its presence and role of shutter of the myopectinral orifice, it's a structure extended from the lumbar region to the spermatic cord (or round ligament of the uterus).

Outside the inguinal region it's only a thin membrane but reaching this area it is much more thicker and reinforced by some ligaments.

Medially the transversalis fascia ends as lining the posterior surface of the rectus muscle. In about half cases the fibers of the rectus muscle extends laterally to the pubic tubercle in a reinforcement known as Henle's ligament.

At its lower part it is connected to the Thomson's band that has been described before.

Anteriorly to the fascia lays the epigastric vessels and behind them, dividing the transversalis fascia in a medial reinforcement stands the Hesselbach's ligament. Please note that the ligament also delimitates the Hesselbach's triangle which other limits are lateral border and sheath of the rectus muscle and inguinal ligament. It is the place of direct inguinal hernias.

Laterally the fascia is inserted at the iliac fascia.

From the inferior margin of the transverse muscle to the pectineal ligament the transversalis fascia is the only structure supporting abdominal pressure and supposed to contain it. The larger is this area, due to the anatomic variations previously described, and the weaker the transversalis fascia is; the more easily a hernia can occur in those regions. For this reason, reinforcement of the transversalis is the CenterPoint of many hernia repair techniques either using sutures or meshes.

The Peritoneum and the 3 inguinal depressions

Even if the peritoneum is not a topic of anatomic specific interest in the inguinal region; since the development of the TAP laparoscopic repair the peritoneum has become of surgical anatomy interest.

Looking from inside the abdomen, the peritoneum is subtended by fibro vascular structures forming 3 depressions: supra vesical, medial inguinal fossa and lateral inguinal fossa.

Lateral to the epigastric vessels stands lateral inguinal fossa. It is the place for indirect hernia outlet.

Between the epigastric vessels and the medial umbilical fold (umbilical artery) the area is named **middle inguinal fossa**. It is the place for direct hernia outlet.

Medial to the medial umbilical fold and lateral to the median umbilical fold (remnant of the urachus) stands the **supra vesical fossa**. Even if hernia sliding at this point is possible this occurrence is very poor? Nevertheless several cases reports of bowel obstruction related to this type of hernia have been published (Fig. 17.11) [11].

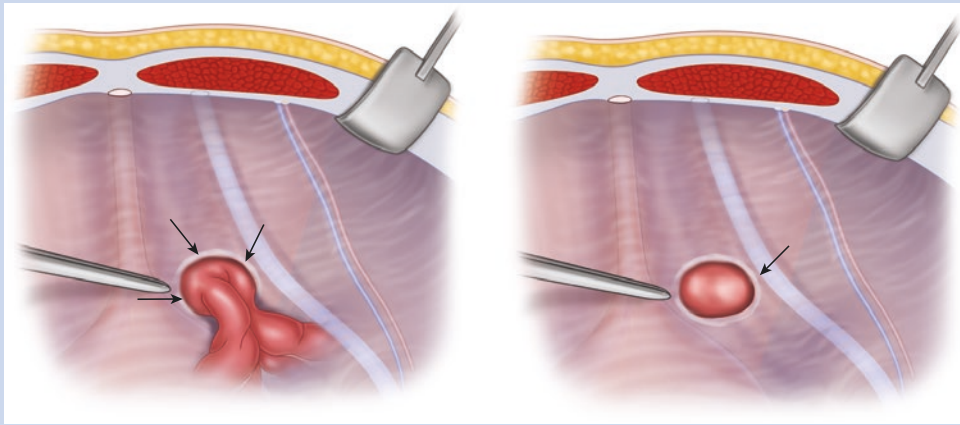

Fig. 17.11 Supravesical hernia

17.8 Spermatic Cord and Vascular Issues

Looking at the cord it is difficult to imagine how complex is its constitution as it looks like a simple and single structure.

Indeed, the components of the cord are wrapped in three different layers. The superficial one is the external spermatic fascia which comes from the external oblique muscle aponeurosis. The second layer is the spermatic fascia formed by fibers and aponeurosis of the internal oblique and transverse muscle. Deeper lays the internal spermatic fascia considered as an extension of the transversalis fascia.

The cord contains itself two nerves: the genital branch of the genito femoral nerve (L1,L2) innerving the cremaster muscle and testicular nerves owning to the sympathetic system (T10-L2). But the cord shares the inguinal canal with another nerve running on it: the ilio-inguinal nerve (L1). The "hot topic" of inguinal nerves and their surgical "implication is treated below.

But the cord is also composed of vascular structures; three arteries and three veins.

Testicular artery as a branch of the aorta arising just below the renal arteries supplies blood to the epidydimis, tunica albuginea and testis.

The artery of the ductus deferens as a branch of the superior of inferior vesical artery supplies blood to the testis and epididymis

The cremasteric artery coming from the inferior epigastric artery, supplies the cremaster.

Fortunately (for the surgeon) anastomosis exists between those arteries allowing blood supply even in case of their respective division. It is estimated that ischemic testicular atrophy occurs in only about 1% of cases. But due to the variability of those artery anastomoses caution must be taken during dissection in order to avoid useless arterial division that in case of unknown anatomic variation could lead to ischemia.

As some blood supply to the testis is also coming from the scrotal artery, inferior vesical artery branches and prostatic artery it is advisable not to pull out the testis in incidental cord division In order to let a chance to avoid testis atrophy thanks to those collateral arteries that could be pulled off.

The venous system included in the cord is a complex network composed by numerous veins of the testis and epididymis. Ascending in front of the cord, the multiple veins composing the Pampiniform venous plexus join themselves in three or four veins along the inguinal canal. Then going on these anastomotic process they stay

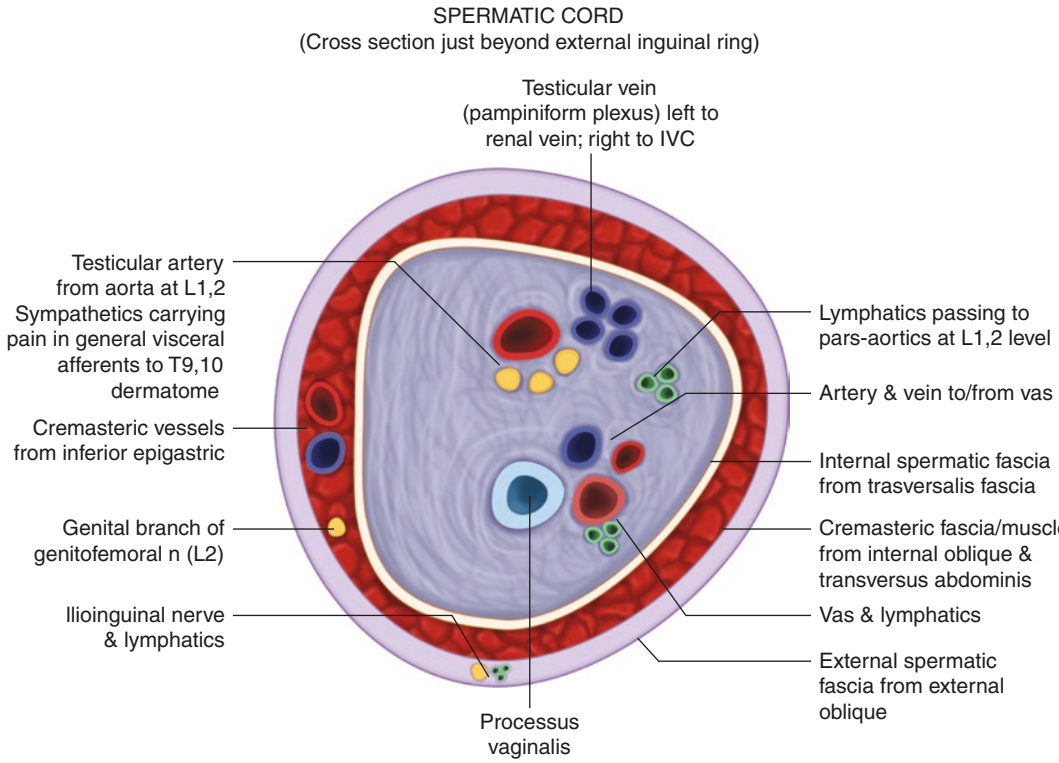

Fig. 17.12 Components of the spermatic cord

only as two veins after deep inguinal ring and and upper converge to give the genital vein (Fig. 17.12).

In women, the round ligament attached to the side of the uterus lays in the inguinal canal in place of the cord. Vascular issues are of course not the same and it can be divided without consequences.

17.9 The Nerves of the Inguinal Region: Turning Enemies to Friends

10 to 54% (!!) of patients operated on for inguinal hernia present chronic inguinal pain [12–13]. The median accepted rate is around 10%.

This high rate, reported in the literature even if unbelievable for each surgeon must lead to develop every prevention measure. Even if the cause of chronic pain is not unique nerve injury is well recognized as one of the major and preventable cause.

In order to prevent chronic pain hernia surgery guidelines [14] recommend to systematically identify the 3 nerves running the inguinal area during groin hernia surgery. Therefore knowing where to find them makes surgery easier (and safer).

The llio hypogastric nerve (T12-L1) crosses the transverse muscle and after divides in two branches. Its lateral cutaneous branch pierces the external oblique aponeurosis close to the anterior superior iliac spine. It innervates the skin of the abdominal wall around the pubis. This branch is more in danger in orthopedic surgery in case of bone from the iliac crest retrieval than in hernia surgery.

Its anterior cutaneous branch goes anteriorly after division and the crosses internal oblique and external oblique aponeurosis above the superficial inguinal ring to innerve hypogastric region.

It is one of the three nerves involved during groin hernia surgery.

Ilio inguinal nerve (L1) innervates the internal oblique muscle, crosses it and then lays on the inguinal canal on the side of the cord. It is not an element of the cord as it is not included inside its different fascia layers but stands outside. As it emerges from the internal oblique muscle it can enter at a variable place the inguinal canal. That is to say that it can't be normally found at the internal inguinal ring. It ends at the superficial inguinal ring and distributes fibers to innervate root of the penis, scrotum, skin of the upper and medial part of the thigh

These two first nerves do have connections

Genital branch of genito femoral nerve (L1-L2) can be found all along the inguinal canal as it pierces the transversalis fascia to enter the deep anal ring and follow to the cord in the canal to the scrotum supplying fibers to the skin of the scrotum, the cremaster and dartos muscle. He is responsible for the cremasteric reflex.

Subcostal nerve (T12) emerges through the transversus abdominis passing between it and the internal oblique. It then enters the rectus sheath and becomes superficial halfway between the pubic symphysis and the umbilicus.

The lateral cutaneous branch of the subcostal nerve courses runs between the internal oblique and the external oblique muscles , and emergies superficial superior to the iliac crest. It innervates the skin and the subcutaneous tissue of the gluteal region and also the lateral side of the thigh, only as far as the greater trochanter of the femur though.

The subcostal nerve supplies the transversus abdominis, rectus abdominis, and the pyramidalis, along with some fibers to the peritoneum. It can be damaged during orthopedic surgery involving the iliac crest but also in case of trocart placement close to the superior anterior iliac crest.

Knowing these anatomical considerations is mandatory for every surgeon who'd like to experience hernia surgery whatever an open or a laparoscopic one. As written before, systematically identifying the three main nerves is recommended in open hernia surgery. But as there is a high variability of the nerves situation it is difficult and might be impossible to delimitate a "safe area" where nerve damage can be avoided for stapling a mesh during laparoscopic approach. The classical and historical "triangle of doom" delimitated by the vas deferens and the spermatic vessels even defining a zone of high vascular injury risk is not large enough to include the other potential nerve damage zones.

The only place where fixation could avoid nerve damage is the Cooper ligament but one must keep in mind that small anastomotic arteries like the anastomotic pubic branch might take place in this area (Fig. 17.13).

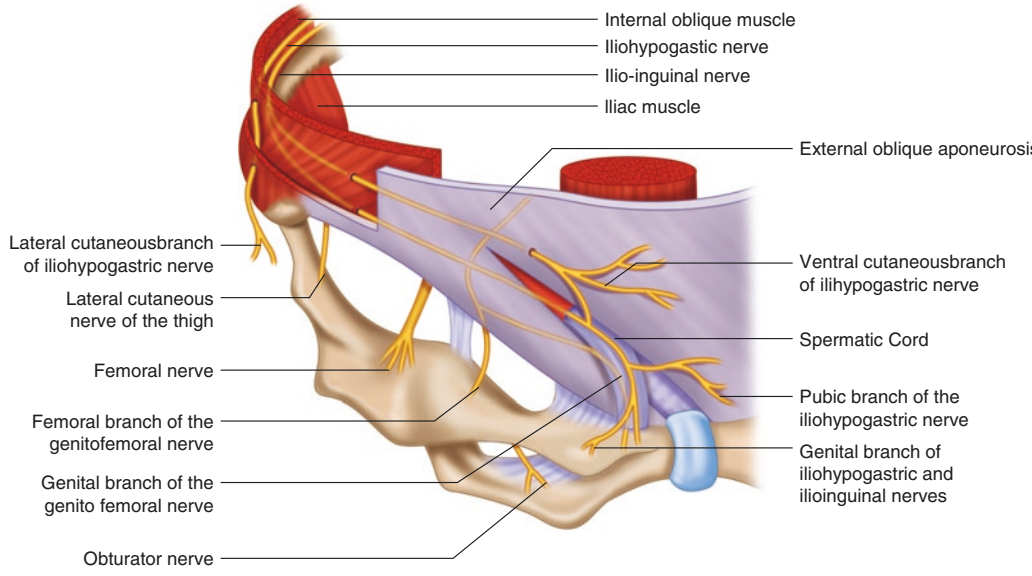

Fig. 17.13 Anatomy of the inguinal region

Surgical Take home message about the anatomy of Inguinal Region

- It is the upper part of the myopectineal orifice of Fruchaud
- The wider is the myopectineal orifice, the more the fascia transversalis is left "alone" to contain abdominal pressure
- Considering the inguinal canal; its borders entry and exit in a 3D approach and as a volume in space is the key for understanding both physiopathology and surgery principles
- In open surgery it is recommended to know and systematically identify the 3 nerves of the inguinal region during the procedures that are: illio hypogastric, illio inguinal, genital branch of genito femoral nerve.
- In laparoscopic approach high variability of nerve situation leads to recommend minimal mesh fixation and maybe, if needed, limited to the Cooper ligament.
- The Retropubic area
- Any hernia surgeon,wether he (she) is or not a laparoscopist couldn't ignore what's beyond the transversalis fascia!
- Once that fascia is opened from an anterior approach or the peritoneum reclined from a laparoscopic approach, we enter a space of fatty tissues in connection with the retropubic Retzius space.
- Let's remember that in its description of the space he gave his name AJ. Bosgros mentioned the existence of an important venous system involving inferior epigastric vein, iliopubic vein, rectusial vein, retropubic vein, communicating rectusio epigastric vein.
- Due to that venous network avoiding hazardous digital exploration or blind mesh stiching in that area might be wise… (Fig. 17.14)

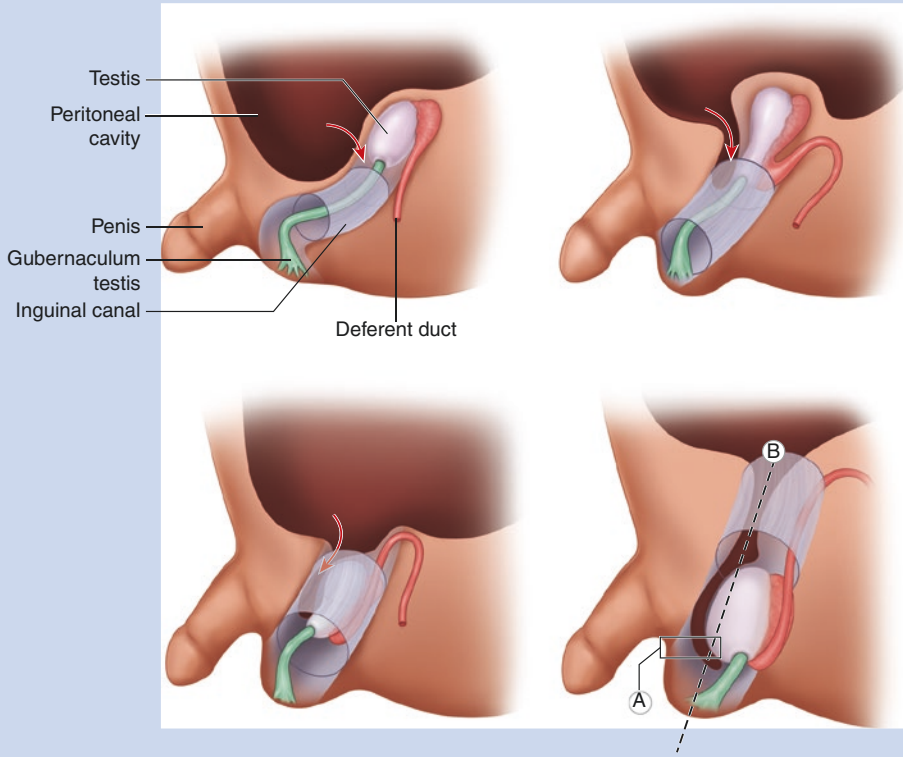

Fig. 17.14 The deep inguinal venous vasculature with in the space

17.10 Inguinal Canal: Some Notions of Embryology (Fig. 17.15)

The migration of the testis from the lumbar area to the future scrotum begins around the 12th week of gestation.

This migration is a result of the action of gumernaculum testis and hormonal influences. Gimbernaculum testis raise up from the low gimbernaculum (future scrotum) after the involution of the mesonephros abouth the 7th week and cranialy is inserted at the testis itself.

During that time (from the 7th to the 12th week), peritoneum evaginates downward laterally to the gimbernaculum creating the vaginal process and accompanying the testis migration through the inguinal canal.

Fibers from the different layers of muscles from the inguinal region are also involved in that process and this will lead to the formation of the different layers wrapping the cord. (see upper.). Vas deferens and vessels are also pulled through the canal during the same process.

At the 8th month the testis is located around the superficial inguinal ring and moves to the scrotum at our close to the birth.

After birth the vaginal process closes progressively from its medial part to the extremities forming rings (Ramonede's rings) and dilatations that will involve. At the top the peritoneal extremity will close and give the lateral inguinal fossa. If not it is one of the way of hernia constitution. At the lower extremity the canal wrappes the testis and becomes the tunica vaginalis testis.

In female there is also a peritoneal migration forming the canal of Nuck that ends in the major labia. After birth like in male the canal closes with the same process. Persistence of the canal leads to inguinal hernia but as unattended ovarian migration in the canal can occur division of it specially in young women must be done with caution.

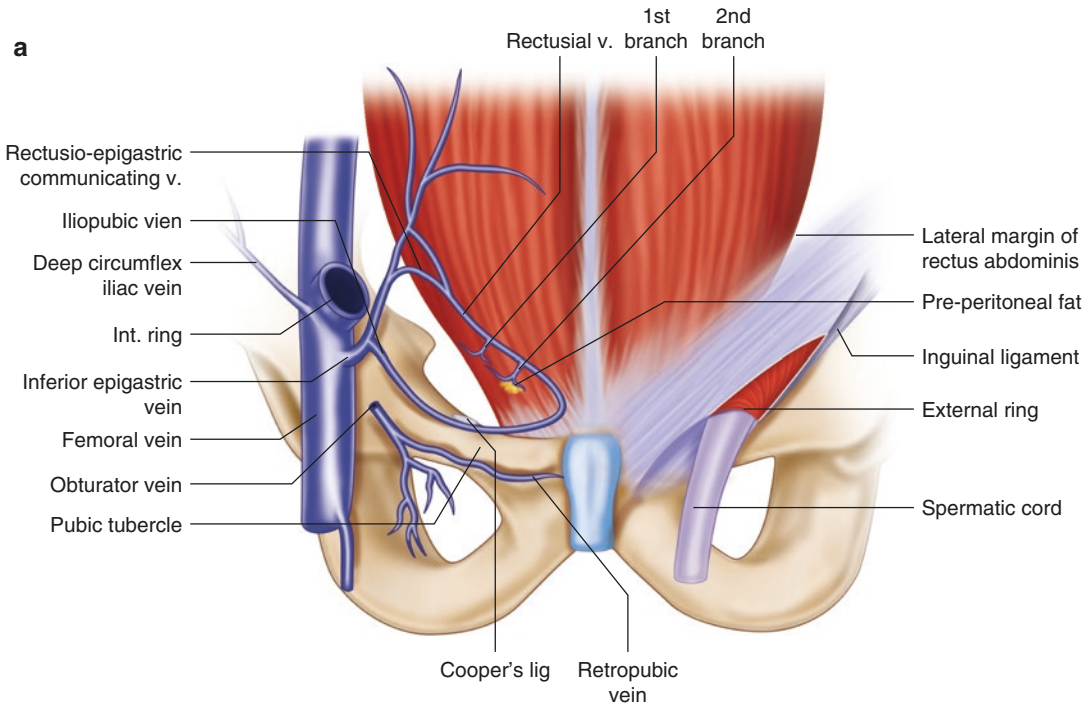

Fig. 17.15 (**a**) Venous network in the inguinal region. (**b**) venous network variations

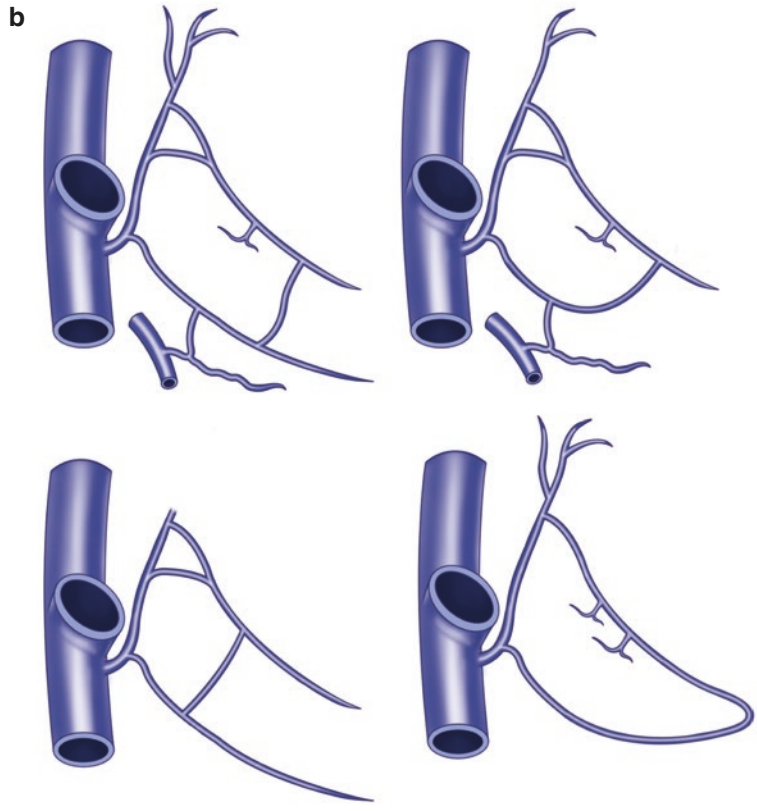

Fig. 17.15 (Continued)

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Ambulatory Hernia Surgery

18

R. Lorenz

18.1 Definition

Even the ambulatory surgery terminology shows some differences internationally. In many countries, the term ambulatory surgery means the following:

> The patient spends the night before and after the operation at home.

In the English-speaking world, the term usually has a broader meaning and often comprises postoperative care for up to 24 h. The following terms and synonyms are used (Table 18.1):

Table 18.1 Ambulatory surgery terminology [1]

Terminology	Synonym and definition
Day surgery	Ambulatory surgery, same-day surgery, day case surgery, outpatient surgery
Extended recovery	23 h, overnight stay, single night
Short-stay surgery	24–72 h in hospital
Outpatient	<24 h in hospital
Inpatient	>24 h in hospital

18.2 History

Ambulatory surgery is much older than surgery performed in hospitals. As far back as antiquity, there were numerous accounts of operations performed on outpatients. In the Middle Ages, the so-called rupture cutters always plied their trade on an ambulant basis, often in the marketplace. Since the late nineteenth century, operations have also been performed in hospitals because of improved asepsis and the development of anaesthesia [2]. The first outpatient surgery centre was founded in Phoenix, Arizona in 1970 [2]. In 2011, the number of outpatient surgery centres in the USA was 5174, nearly attaining the number of hospitals [3].

The first publication about the advantages of outpatient inguinal hernia surgery with faster mobilisation, high patient satisfaction and lower costs appeared in 1955 [4].

18.3 Ambulatory Hernia Surgery Evidence

Thanks to medical progress, most hernia operations today can be performed as outpatient procedures. This is due especially to:

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- New and less traumatic surgical procedures
- Better anaesthesia methods
- Better pain medications for intra- and postoperative treatment
- Fast-track surgery with faster convalescence and earlier increased loading

Outpatient inguinal hernia operations are regarded as safe today. There were no deaths after outpatient inguinal hernia operations, and the rate of readmission to hospital after outpatient operations is also very low [5–7].

There are numerous studies that recommend outpatient inguinal hernia operations without restriction even over the age of 65 years [8–13]. Obesity too is not an obstacle to outpatient surgery [14]. Ambulatory inguinal hernia operations can be performed even in the presence of comorbidities [8].

The advantages of performing inguinal hernia surgery under local anaesthesia are reported repeatedly [10, 14, 15]. The use of local anaesthesia has the advantage of the fastest recovery postoperatively. Lack of urinary retention was probably related to the small IV infusion volumes [15].

Numerous studies confirm that endoscopic inguinal hernia operations can be performed as outpatient surgery in most unselected cases [16–18]. Logistic regression analyses show that "age", "bilateral procedures" and "comorbidities" affect the complication rate. "Age" and "recurrent inguinal hernia" are risk factors for an increased need for analgesic medication. Furthermore, we present an actual distribution of day case vs. inpatient surgeries in inguinal hernia repair based on data from the Herniamed registry [19].

The European Hernia Society guidelines, first published in 2009, recommend outpatient inguinal hernia surgery, regardless of method, in all patients with ASA classification I and II [20]. In the update of the European guidelines published in 2014, this even applies for many patients with ASA class III [21]. In the more recent HerniaSurge guidelines, too, this is recommended for the majority of inguinal hernias if appropriate home care is ensured (Fig. 18.1).

Key Question 9.a: Which inguinal hernias can be safely repaired in day surgery?

More recent studies point to further possibilities for additionally improving the outcome of outpatient surgery. These include, for example, intraoperative noise reduction to reduce surgical site infections (SSI) [23] and the use of a TAP block with local anaesthesia to reduce postoperative pain [24].

18.4 International Comparison

Outpatient inguinal hernia surgery has become increasingly popular internationally in recent decades [25, 26]. In many European countries, there has been a steady rise in the proportion of outpatient inguinal surgery operations [27]. The cost savings are regarded as a crucial advantage of day surgery [28].

In a global comparison, however, there are still considerable differences in the proportion of inguinal hernia operations performed as day surgery (Fig. 18.2).

Key Question 9.a: Which inguinal hernias can be safely repaired in day surgery?

Recommendation	Day surgery is recommended for the majority of groin hernia patients provided adequate aftercare is organized.	X X X ☐	Strong

Fig. 18.1 HerniaSurge recommendations for outpatient surgery [22]

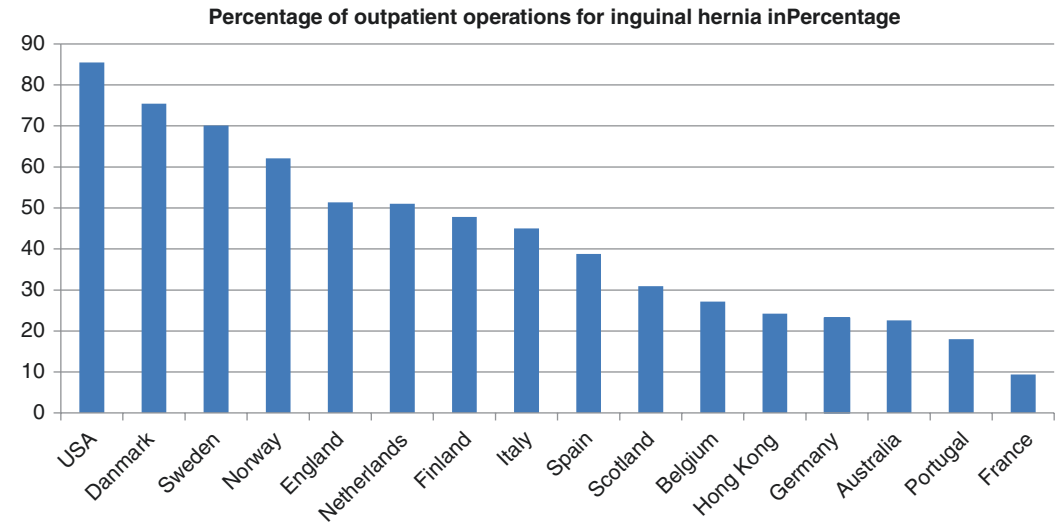

Fig. 18.2 Percentage of outpatient operations for inguinal hernia in selected countries in 2005 [29]

Table 18.2 Percentage of outpatient operations in European countries (EHS survey 2016)

Country	Proportion in %
Sweden	80
Netherlands	75
Portugal	70
Spain	60
England	60
Belgium	40
France	40
Germany	15
Poland	10
Russia	10
Turkey	10
Czech Republic	5
Serbia	5
Ukraine	2
Greece	0
Romania	0

More precise systematic statistics regarding outpatient surgery from the individual countries are lacking. There are usually only studies that consider a short timeframe in individual countries. The European Hernia Society then conducted a survey among the national chapters in 2015. This resulted in the following estimates for outpatient inguinal hernia surgery in percent in the respective countries (Table 18.2).

The proportion of outpatient hernia operations thus varies between 0% and 80%. In most countries, however, there is no systematic recording of the operations. In Sweden (Fig. 18.3, Table 18.3) and Denmark, there are national registries, which record nearly all operations statistically because of state funding. In most other countries, there are only estimates.

Healthcare financing and reimbursement appear to have a decisive influence on outpatient surgery. It can be assumed that endoscopic operations cause higher perioperative costs a priori [31]. In Germany, the extremely low proportion of endoscopic procedures in the ambulatory area is due to the fact that outpatient endoscopic inguinal hernia surgery is linked to a roughly 20 per cent shortfall in funding [32]. At present, there appears still to be a health policy disincentive in Germany [33].

In an international comparison, the reimbursement situation for hernia surgery appears to differ substantially (Table 18.4): in numerous countries, there are ambulatory DRGs, which enable outpatient payments to be similar to those in the inpatient area.

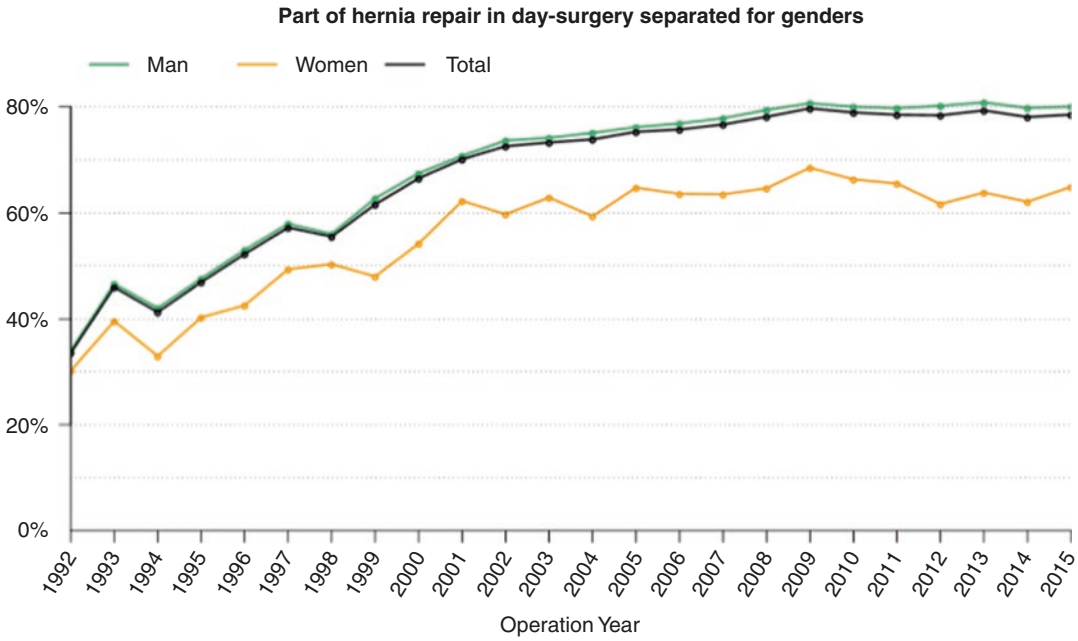

Fig. 18.3 Proportion of outpatient inguinal hernia operations in Sweden compared by year [30]

Table 18.3 Proportion of outpatient inguinal hernia operations in Sweden compared by year 2006–2015 [30]

Year	2006 (%)	2007 (%)	2008 (%)	2009 (%)	2010 (%)	2011 (%)	2012 (%)	2013 (%)	2014 (%)	2015 (%)
Outpatient	75.7	76.7	78.1	79.7	78.9	78.5	78.4	79.3	78.1	78.5
Inpatient	24.3	23.3	21.9	20.3	21.1	21.5	21.6	20.7	21.9	21.5

Table 18.4 International comparison of the reimbursement situation [34]

Country	aDRG[1] /APC[2]	% of inpatient payment
Australia	Yes	<100%
Hungary	Yes	100%
Portugal	Yes	72–100%
USA	Yes = APC	65–85%
Sweden	Yes	100%
Italy	Yes	80–100%
Denmark	Yes	100%
Finland	Yes	50–67%
Norway	Yes	65–100%
Germany	No	25% (14–38%)

[1] Ambulatory diagnosis relatet groups
[2] Ambulatory payment classifications

18.5 Practical Requirements and Current Data

For outpatient surgery, the same structural and staffing provisions should apply as in a hospital.

Successful performance of outpatient surgery requires the following:

- Correct indication
- Precise preoperative diagnosis
- Definition of standardised postoperative care
- Definition of an operation standard
- Management of complications
- Postoperative pain management with use of local anaesthetics
- Emergency contact

A checklist and handout for patients (What happens before and after the operation?) can greatly facilitate the practical implementation of outpatient surgery.

From today's perspective, the following hernia types can usually be repaired by day surgery:

- Primary inguinal hernias with and without mesh, open and endoscopic
- Recurrent inguinal hernias
- Umbilical and epigastric hernias
- Small incisional hernias

Inpatient hernia surgery is beneficial in the majority of the following patients:

1. Based on the hernia

- Incarcerated and possibly non-reducible inguinal hernias
- Extensive scrotal hernias
- Bilateral hernias or multiple operations
- Complex hernia operations, reoperations with mesh explantation
- Primary ventral hernias with planned complex procedures
- Secondary ventral hernias = incisional hernias

2. Because of comorbidities

- Comorbidities with serious secondary conditions such as stroke, diabetes mellitus, CHD, cardiac arrhythmias, renal failure, severe COPD, anticoagulation

3. Because of the patient's social situation

- Lack of patient compliance
- Lack of aftercare in the night after the operation

Moreover, supporting quality assurance is useful.

Based on an initiative by a group of surgeons working in outpatient surgery, the *Netzwerk Leistenbruch [Inguinal hernia network]* was set up in Germany in 2009, an additional quality assurance study of inguinal hernia operations, www.netzwerk-leistenbruch.de, which is linked with *Herniamed*, the German hernia registry. The *Netzwerk Leistenbruch* records in particular the early postoperative course 1 and 3 months after an inguinal hernia operation and evaluates quality of life independent of the surgeon using the *Carolinas Comfort Scale*, with a hernia-specific quality of life questionnaire for patients. This showed that very good quality with low recurrence and chronic pain rates can be achieved in the ambulatory sector [35].

In addition, a univariate analysis of Herniamed data was performed in 2016 to compare outpatient and inpatient inguinal hernia operations: in the period from 01.09.2009 to 31.10.2016, a total of 353,271 hernias in 577 centres were recorded in Herniamed, the German hernia registry. A total of 71,751 male, primary, fully documented inguinal hernias with complete 1-year follow-up were evaluated for this analysis. There were no significant differences between outpatient and inpatient operations. The intra- and postoperative complications, postoperative pain and recurrences showed no essential differences despite different operation techniques and different patient selection (Table 18.5).

Overall, this analysis permits the conclusion that outpatient inguinal hernia surgery can be performed without significant detriment for the patients. Further analyses, possibly matched pair

Table 18.5 Distribution of intra- and postoperative complications and follow-up data—outpatient and inpatient [36]

	Outpatient %	Inpatient %
Intraoperative complications	0.61	1.01
Postoperative complications	2.21	2.40
Recurrence on follow-up	0.77	0.90
Rest pain on follow-up	4.01	4.59
Pain with movement on follow-up	9.66	8.86
Pain requiring treatment on follow-up	2.23	2.52

or multivariate, are necessary for comparing outpatient and inpatient operations in detail.

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Obscure Groin Pain in Women

19

Shirin Towfigh

19.1 History of the Hidden Hernia

The concept of hidden hernias was first introduced in the 1970s by two separately interested surgeons from the United States: William Webb from Alabama and Jack Herrington from Wisconsin. They each noticed that women were presenting with symptoms suggestive of inguinal hernia; however, the surgeons had a hard time diagnosing hernia on physical examination. Their patients reported intermittent pain along the inguinal canal that was related to physical activity. However, the physical examination was essentially normal and "without detectable impulse."

Webb reported his experience with 12 women who had symptomatic inguinal hernias without diagnostic examination findings. Physical examination was mostly normal. He offered them an exploration based on their history alone. They presented similar to most other symptomatic inguinal hernias: groin pain radiating along the inguinal canal. He found that these women typically had small indirect inguinal hernias with preperitoneal fat content only. There was no hernia sac. Repair was successful in all the patients, with resolution of their preoperative pain.

Over a 5-year period of time, Herrington operated on 13 such patients (8% of his practice), all of whom were also women. They suffered with groin pain of undiagnosed etiology. Mean age was 20 years (15–45). Most had undergone a wide range of gastrointestinal, urologic, and gynecologic workups. Operative findings were of the typical indirect inguinal hernia, and most had a peritoneal sac. At 10 months follow-up, ten (77%) patients had a cure of their symptoms after open inguinal hernia repair, and three patients had significant improvement. He referred to these as "female occult inguinal hernias" and urged their early diagnosis, as hernia repair was curative.

The concept of the non-palpable, symptomatic, occult, or hidden hernia did not become popular despite these groundbreaking reports. Textbooks continued to report 25% lifetime risk of inguinal hernias among males and only 2% risk among females. It wasn't until Bendavid's textbook of *Abdominal Wall Hernias* that this topic was readdressed in the twenty-first century.

Similar to their predecessors, Spangen and Smedberg reported on 180 women in an 18-year span with 192 occult hernias. Most were found to have typical inguinal hernias with peritoneal sac. However, 57 (30%) had inguinal hernias with preperitoneal fat content only and no peritoneal extension within the inguinal canal. They had successful outcomes after hernia repair, with relief of preoperative symptoms in 89% of patients, with mean 20 (1–60) months follow-up.

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19.2 Anatomical Explanation for the Hidden Hernia

Women naturally have a narrower inguinal canal than men. Essentially, it contains a thin round ligament and perhaps the genital branch of the genitofemoral nerve. Conversely, males begin with a naturally wider inguinal canal that houses the spermatic cord. Meanwhile, the female pelvis is broader and shallower. As a result, the insertion of the internal oblique and transversus abdominis muscles is broader along Cooper's ligament and further onto the rectus muscle. Also, the round ligament pierces the abdominal wall more laterally and follows a more oblique path within the inguinal canal. Lastly, the natural forces from gravity and from internal abdominal pressure are distributed more evenly along the pelvic floor, as compared to that in the narrow pelvis of men.

As a result, women tend not to present with wide palpable defects or significant bulging from their hernia. Instead, they present with groin pain, sometimes with the very smallest amount of preperitoneal fat entering the narrow inguinal canal.

On physical examination, men typically have a palpable if not visible bulge. When standing, an impulse may be generated by Valsalva or cough. Using the redundancy of the scrotal skin, the spermatic cord can be followed toward the external ring, and the rest of the pelvic floor in this region can be directly palpated. In women, there is no direct access to the external ring and the inguinal canal contents. Palpation is made directly over the inguinal canal at the level of the skin. Any hernia must be noted through the layers of skin, soft tissue, and external oblique aponeurosis. If a vaginal examination is performed, the examiner can sometimes detect a mass via the vaginal sidewall. This is another reason for the occult non-palpable hernia.

19.3 Symptoms in Women

Hernias among women tend to present with a wide variety of symptoms. As many of these symptoms are not similar to those typical of men, it can delay their diagnosis. In my practice, I have shown that the typical hernia was diagnosed by me after 20 weeks of presentation. Those with hidden hernias averaged 96 weeks of symptoms. Typically, the dominant symptoms for hernias among women are activity-related, such as pain with lifting heavy objects. Normal daily routines that cause increased pressure onto the inguinal canal may also cause pain, such as prolonged sitting, prolonged standing, and bending. The pain is often worse at the end of the day. Pain may also be distributed along the distribution of the ilioinguinal and genital nerves, and this can be misinterpreted as primary neuropathic pain. In my experience, some of these patients undergo local nerve block to address the neuropathic pain. If a hernia is the cause of the neuropathic type pain, I have noted that patients report an increase in their groin pain after the nerve block, whereas a nerve block should improve pain in the case of a true primary nerve injury without a hernia.

Though men do not typically present with pain as their primary complaint from their inguinal hernia, such is not the trend with women. Among women, groin pain is often the first presenting symptom. Many surgeons are trained to believe that pain alone cannot be due to an inguinal hernia. This may be true among most male patients; it is not the case in women. As a result, many women are labelled as having chronic pelvic pain, and inguinal hernia is not considered to be the cause of their groin pain.

As we already know, smaller hernia defects tend to present with more pain and less bulging, whereas larger hernia defects tend to present with a bulge without as much pain. So it may be the case that women with inguinal hernias, many of which are hidden hernias, present with pain as their original symptom and not with a palpable bulge. The patient may complain of radiating pain, which I found to be seen among almost half (48%) of my patients (Table 19.1). This includes pain radiating pain from the groin into the vagina, to the upper inner thigh, to the anterior thigh—but never below the level of the knee—and/or wrapping around laterally toward the hip and back. In my experience, 20% of patients have associated lower back pain that resolves after

hernia repair. Such patients may be misdiagnosed with spinal pathology. Notably, patients with lower back pain do not have groin pain, with the exception of sacroiliitis, which can cause pain radiating from the back to the groin and upper inner thigh.

Also, 39% of my female patients have radiating pain into the vagina (Table 19.1). This is analogous to the pain radiating to the base of the penis and/or testicle in men. Such a complaint can trigger a gynecologic workup of obscure diagnoses such as vulvodynia, pudendal neuralgia, and chronic pelvic pain. These diagnoses often have complex syndromes that are not seen among patients with inguinal hernia.

Symptoms unique to women include pain during menses. In my practice, 25% of women with symptomatic inguinal hernias report exacerbation of their symptoms during their menses (Table 19.1). This is considered to be due to fluctuations in hormones. As estrogen levels plummet at the onset of menstruation, pain levels increase. This phenomenon has been shown in multiple other disease processes, including joint disorders, autoimmune disorders, and gastrointestinal diseases. In such cases, women are commonly worked up for endometriosis, which is a cyclical disease. Unlike endometriosis, hernias are not pain-free in between menstrual periods.

Table 19.1 Key history and examination findings predictive of female symptomatic occult inguinal hernia, with expected outcomes after hernia repair

Symptoms	Prevalence
Pain as primary symptom	87%
Radiating quality to the groin pain	48%
– Radiating pain to the vagina	39%
– Radiating pain to lower back	20%
Worse with menses	25%
Pain during intercourse	
Pain with orgasm	
Examination findings	
Point tenderness over deep internal ring	96–100%
Hyperalgesia along ilioinguinal nerve	63%
Subtle fullness overlying inguinal canal	52%
Pelvic floor spasm	
Operative findings	
Preperitoneal fat only, no hernia sac	>30%
Significant improvement in preoperative symptoms after hernia repair	78–87%

In women, hernias can be painful during sexual intercourse as well as with orgasm. The reason for pain with intercourse is often a simple phenomenon of direct contact and pressure on the groin. Similarly, vaginal penetration can cause pain by direct pressure onto the external ring, which we noted earlier could be palpable transvaginally. Pain with orgasm is considered to be due to pelvic floor contraction against a full inguinal canal.

19.4 Subtle Physical Examination Findings

The concept of the occult inguinal hernia is based on the finding of a symptomatic inguinal hernia without obvious findings on physical examination. This includes no visible bulge and no detectable impulse. For example, a cough or Valsalva will typically not generate a bulging mass on external examination in this population. That said, in my experience, 96% of these patients have point tenderness at the level of the internal ring upon direct pressure. Spangen similarly reported 100% with point tenderness overlying the deep internal ring upon Valsalva. He also reported 63% with hyperalgesia along the ilioinguinal nerve distribution (Table 19.1).

With a very sensitive touch, the examiner can feel a subtle fullness in the area overlying the deep internal ring among those with a symptomatic hidden hernia. I have noted this in 52% of my patients with symptomatic occult inguinal hernias. This represents content and probably inflammation in the area of the inguinal canal. It is also often tender over the same area. If this area of vague fullness correlates with the area of pain, which correlates with the area over the deep internal ring, we have shown this to be the most sensitive predictor of a hidden hernia (Fig. 19.1).

Many women are first evaluated for their groin pain by their gynecologist. Pelvic exam can be painful on the side of the inguinal hernia. There may be finding of pelvic floor spasm as well. Some patients are referred to pelvic floor physical therapy for this reason. In my experience, I have noted that such therapy exacerbates the

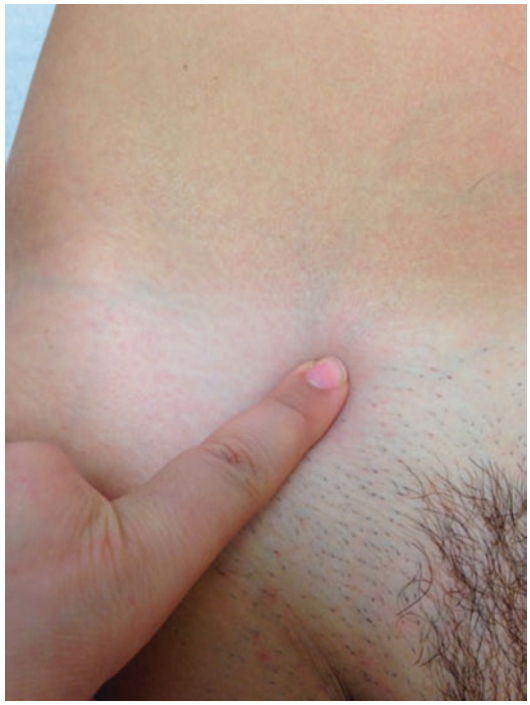

Fig. 19.1 Area of maximal tenderness and vague fullness notable in patients with symptomatic occult inguinal hernias. This area is approximately halfway between the anterior superior iliac crest and pubic tubercle on each side

patient's pain if she has an inguinal hernia and not primary pelvic floor dysfunction. Also, I have noted that the pelvic floor spasm resolves after successful inguinal hernia repair.

Thus, I have come to the conclusion that inguinal hernias can cause pelvic floor spasm in women. This results in the sequelae seen with this entity, including chronic pelvic pain, pain with sexual intercourse, urinary frequency, feeling of pain, or pressure at the vagina or rectum. The workup and treatment can be highly varied, and patients may be misdiagnosed with interstitial cystitis or pelvic floor dysfunction. These disorders are multifactorial and are defined by a series of objective findings, such as with cystoscopy or dynamic pelvic imaging, respectively. The workup would be normal in those with inguinal hernia.

Conclusion

Women can have inguinal hernias, and it is much more prevalent than we are led to believe historically. Women are more likely than men to present with groin pain without bulging mass, hence the term female occult inguinal hernia or hidden hernia. Carefully listening to the patient will allow the examiner to identify key details in their history that are suggestive of inguinal hernia. The most sensitive examination finding is that of point tenderness over the area of the deep internal ring. Operative findings may show preperitoneal fat content only, without peritoneal extension.

As more attention is placed on this entity, more women will be diagnosed, without delay, with a potential for improvement in their quality of life.

Suggested Readings

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Individualization Treatment of Inguinal Hernia in Children

20

Jie Chen, Yingmo Shen, Chengbing Chu, Zhenyu Zou, and Xin Yuan

The incidence of inguinal hernia in children less than 18 years of age ranges from 0.8 to 4.4% [1]. About 85% of children with an inguinal hernia present with a unilateral hernia. The incidence of incarceration in untreated hernias in infants and young children varies between 6 and 18%, but it increases to approximately 30% in infancy [2]. A surgical intervention for inguinal hernia is one of the most common operations performed in children [3]. The individualized treatment program was established for pediatric inguinal hernia in authors' department and provided a relatively reasonable surgical treatment. This chapter was mainly to describe the individualized treatment program applied to pediatric inguinal hernia.

20.1 Etiology

Indirect inguinal hernias in children are basically caused by embryologic development, which is mainly composed of patency of processus vaginalis (Fig. 20.1). At the early stage of gestation, the testes begin to descend from retroperitoneum and remain at the level of the internal inguinal rings as the kidney ascends into its usual position. The final descent of the testes into the scrotum through canalis inguinalis occurs between gestation weeks 28 and 36 [4], combining peritoneum, transversalis fascia, and abdominal wall muscles. The testes' descent is "guided" by the gubernaculums. Descending peritoneum ultimately forms the processus vaginalis, and the distal portion of the processus vaginalis wrapping around testes becomes the tunica vaginalis. In normal development, the processus vaginalis closes between 36 and 40 weeks of gestation or even shortly after birth [5]. The rate of patency is inversely proportional to the age of children, approximately 80% close by 2 years of age [4]. The left testis descends before the right one, and the closure of patent processus vaginalis on the left also precedes closure on the right; therefore, indirect inguinal hernia occurs more on the right side.

Though the embryology has been widely described, the cell-molecular mechanism is still unclear. The inguinal hernias most probably are inherited [6]. Yu Zhang et al.'s team have found that the functional sequence variants of some genes may be a risk factor for indirect inguinal hernia, such as gene TBX1, gene TBX3, gene SIRT1, and gene GATA6. These variants may affect the differentiation and proliferation of human skeletal muscles and fibroblasts [7–10].

20.2 Clinical Manifestation

A reducible bulge or mass in the inguinal region or unilateral or bilateral enlargement of the scrotum (Fig. 20.2a, b) is the main diagnostic finding

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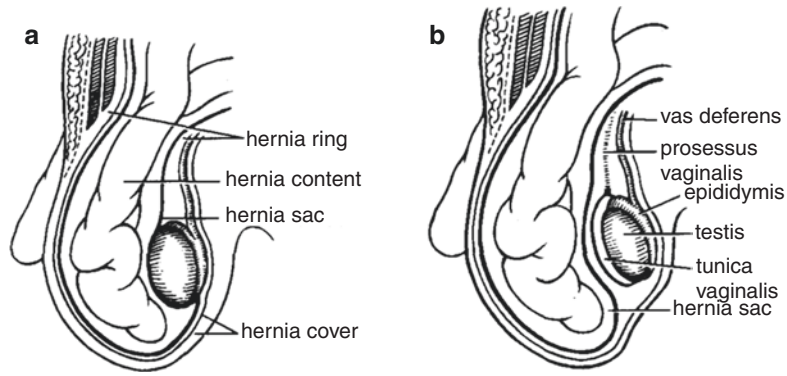

Fig. 20.1 (**a**) Congenital indirect inguinal hernia. (**b**) Acquired indirect inguinal hernia

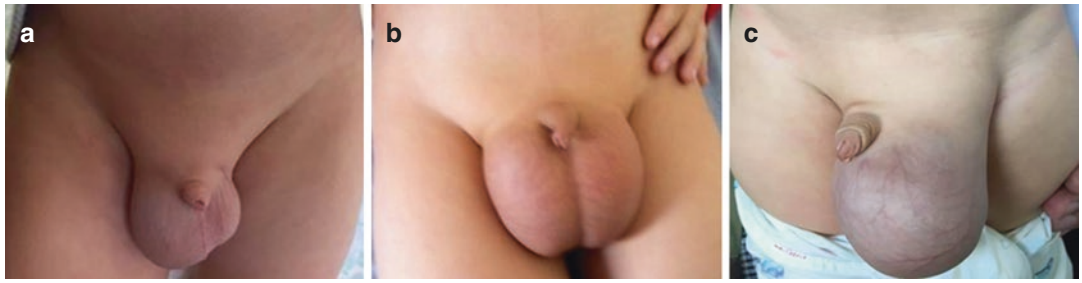

Fig. 20.2 Pediatric hernias: (**a**) right inguinal hernia, (**b**) bilateral inguinal hernia, (**c**) incarcerated left inguinal hernia

in most groin hernias. These symptoms can occur when abdominal pressure increased, such as standing, coughing, crying, constipation, and playing, and disappear when patients are lying down or falling asleep. Child ≤2y will express itself only by crying and screaming, so if the children continue crying without obvious reasons, the groin hernia should be considered.

There may be associated pain or vague discomfort in the region. Groin hernias are usually not extremely painful unless incarceration (Fig. 20.2c) or strangulation has occurred [11]. The bowels inside the hernia sac being incarcerated or strangulated may lead to intestinal obstruction, and the testis may turn red gradually. At this time, the spermatic cord is oppressed and the testicle may be ischemic necrosis. As the age increases, the size of hernia sac will gradually increase. The falling bowels pull down the mesentery and cause not only abdominal pain, nausea, and other gastrointestinal symptoms but also walking inconvenience. In addition, the spermatic cord being pressed continuously by the hernia sac will make the spermatic vessel reflux disorder and blood supply reduction, as well as the spermophlebectasia and testicular atrophy.

20.3 Physical and Accessory Examination

The inguinal region is examined with the child in the standing position or with the infant be held in the vertical position by parents. The examiner visually inspects and palpates the inguinal region, looking for asymmetry, bulge, or a mass [11]. Having the patient cough or cry can facilitate identification of a hernia. The examiner places a fingertip into the external inguinal ring by invaginating the scrotum to detect a small hernia. A bulge moving lateral to medial in the inguinal canal suggests an indirect hernia. If a bulge progresses from deep to superficial through the inguinal floor, a direct hernia is suspected [11].

Ultrasound is very useful in the diagnosis, which can avoid the adverse effects of radiation

in CT on children's development. There is a high degree of sensitivity and specificity for ultrasound in the detection of occult hernias [11]. An ultrasound can determine the hernia sac, the defect, the hernia contents (the bowel, the omentum, or the bladder), and the complications such as hydrocele, guiding the surgical treatment.

20.4 Diagnosis and Differential Diagnosis

The diagnosis of inguinal hernia in children is mainly suggested by the history of the bulges or masses in groin area, usually found in children crying or regular physical examination. For slightly older children, blowing bubbles, tickling them to make them laugh, or having them blow up balloons (e.g., examination gloves) will increase intra-abdominal pressure, and the hernias may appear. When they are in supine position, the bulges or masses may reduce by itself or by hands, which is called reduction.

For typical cases, it is generally not difficult to make the diagnosis, while for the unclear inguinal abnormalities, doctors can combined with the results of ultrasonic testing or further examination just like CT or MRI if it is necessary. Mainly depending on the different degree and level of processus vaginalis obliteration failure, these methods may help to find the abnormality of inguinal canal, including various types of hydrocele (communicating, non-communicating, funicular), spermatic cord cyst in males, hydrocele of the canal of Nuck in females, cyst of round ligament of uterus, and indirect inguinal hernias [12]. Communicating hydrocele results from the patent processus vaginalis throughout its length. The fluid collection communicates with the peritoneal cavity and the scrotum. Noncommunicating hydrocele happens at the time processus vaginalis obliterates and some fluid accumulates between the cavity of the tunica vaginalis enclosing the testis. Spermatic cord hydrocele results from an abnormal closure of the processus vaginalis, leading to a fluid accumulation alongside the spermatic cord, which is separated from and located above the testis. Transillumination test, an ordinary means to distinguish the hydrocele and hernia, is widely used in clinical works. The scrotum is exposed in a dark room with a flashlight under it. If it contains fluid, light is allowed to go through. When it is opaque, a hernia will be detected. Hydrocele and cyst of the canal of Nuck are caused by the incomplete obliteration of the processus vaginalis in girls, which is unusual. The hernia of the canal of Nuck is also an uncommon condition in females, which is homogenous to the indirect inguinal hernia in males. The distinction of these abnormalities, facilitating diagnosis for early surgical intervention, needs to be paid much attention in specific conditions.

20.5 Treatment

20.5.1 Indications for Surgery

The processus vaginalis is a fingerlike projection of peritoneum that typically closes between the 36th and 40th week of gestation. It is thought that 40% close in the first few months after birth and an additional 20% by age 2 years [13]. Congenital inguinal hernia is a common malformation in children that requires operative treatment [14]. Surgery is indicated for all pediatric patients in whom the diagnosis of inguinal hernia has been made. Infants younger than 6 months are usually booked on a soon-available operating list. Older children with few symptoms can be booked electively [15, 16]. Surgical treatment is offered for inguinal hernia to prevent the complications of incarceration and obstruction, potentially resulting in vascular insufficiency of the hernia contents (usually a loop of the intestine) as well as surrounding cord structures. In females, torsion/ischemia of the ovary is also possible [17, 18].

Repair of inguinal hernias is one of the most common pediatric surgical procedures. Indirect inguinal hernias are congenital in origin, due to a patent processus vaginalis. In recent years, with the development of material technology and minimally invasive surgical techniques, surgical treatments of inguinal hernia in children were transitioned from the traditional open surgery to

the laparoscopic high ligation of hernia sac and the use of biological patch in open surgery. The different techniques have their own indications and advantages. The authors carried out the individualized treatment of inguinal hernia in children, receiving the significant clinical results.

For younger children (<13 years) with a shorter medical history, smaller hernia ring diameter, and less severe inguinal canal posterior wall and transverse fascia defects, the traditional open operation with high ligation of the hernia sac can correct the conditions. Recently, laparoscopic hernia sac ligation has achieved good therapeutic results. The authors have performed laparoscopic hernia sac ligation for the patients younger than 13 years old and have obtained satisfactory results.

According to clinical experience, the authors found that the simple high hernia sac ligation is inadequate for adolescents (13–18 years old) with a longer medical history, larger internal inguinal ring diameter, and different degrees of transverse fascia defects. These adolescents with simple high hernia sac ligation are prone to postoperative recurrence; therefore, the similar procedure with the treatment of adult inguinal hernias should be adopted, i.e., repairing the transverse fascia and strengthening of the posterior wall of the inguinal canal.

The therapy for pediatric inguinal hernia carried out the individualized treatment program in authors' department, which can provide a relatively reasonable surgical treatment. Individualized treatment program consisted of three kinds of surgical procedure, as described below.

20.5.2 Modified Open Pediatric Inguinal Hernia Repair

The etiology of pediatric inguinal hernia is a patent processus vaginalis; therefore, the inguinal hernias were generally repaired with open simple high ligation of the hernia sac for the patient younger than 13 years old. The traditional open technique with high ligation of the hernia is the classic surgical treatment method for pediatric inguinal hernia. The traditional open technique of inguinal hernia repair requires an inguinal approach. A 3–4-cm-long inguinal incision is made on the side ipsilateral to the symptomatic inguinal hernia. The procedure involves the slit of external oblique aponeurosis, the isolation of the hernia sac from the surrounding cords structures which consist of cremasteric muscle, vas deferens, and the testicular vessel surround ligament. A ligature is applied to the proximal separated sac, and the distal sac is divided and reconstructed the external inguinal ring. Although the traditional open inguinal approach is effective for hernia repair in the pediatric population [19–21], it carries numerous risks, including immediate and long-term postoperative complication [22–24]. Children usually lasted 3–5 days for surgical trauma, local swelling, and pain postoperatively. In addition, visualization of possible contralateral defects is limited and there remains a risk of hernia recurrence [25].

For the patients with small hernia sac, the modified open operation of inguinal hernia repair with a small incision in the external inguinal ring could be performed to correct these pathological conditions without slitting of the external oblique aponeurosis and ligating highly the hernia sac. This modified approach can maintain the normal anatomy of the inguinal canal to reduce complications. The modified open operation is widely used in Chinese primary hospitals at present, which is relatively an easy-to-do operation with low recurrence rate but hasn't been done for a long time in the authors' department.

20.5.3 Operative Steps for the Modified Open Pediatric Inguinal Hernias Repair

Small incision about 1–1.5 cm skin incision is made along the skin crease, which is located on the surface projection of external inguinal ring supra pubic tubercle. Incision is carried down through the dermis to expose the subcutaneous fat, Camper's fascia. Using sharp and blunt dissection, Scarpa's fascia is identified, grasped, and

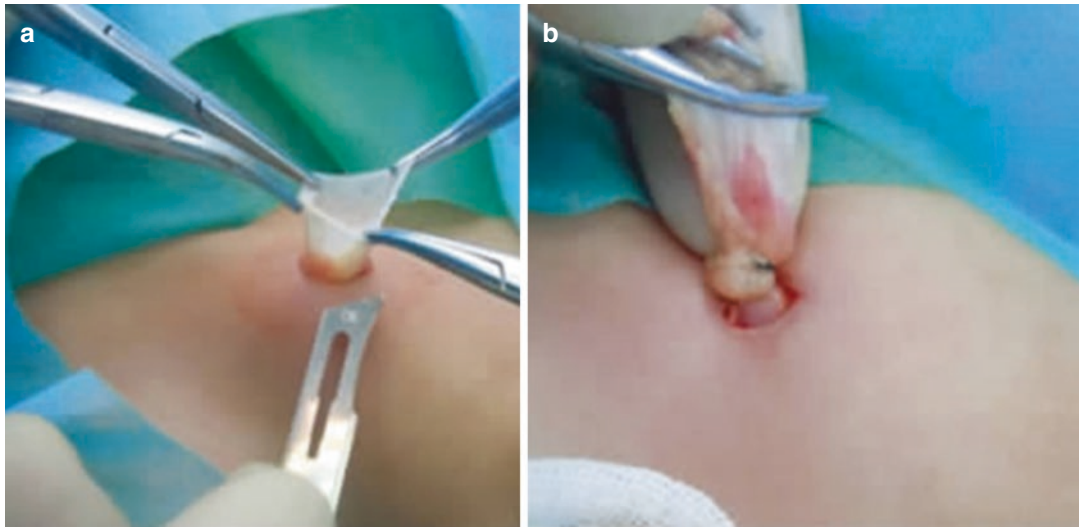

Fig. 20.3 (**a**) The hernia sac was opened. (**b**) The hernia sac was sutured and ligated at its neck

incised in the direction of the external inguinal ring. Gentle retraction is needed to maintain excellent exposure. Cremaster muscle was dissected to expose spermatic cord and the hernia sac within the external inguinal ring. The external inguinal ring was not opened. The hernia sac was elevated off the inguinal floor and isolated from the surrounding tissue with blunt dissection to internal inguinal ring. The hernia sac was opened (Fig. 20.3a). If the hernia sac is small, it is directly ligated at its neck where extraperitoneal fat can be seen. If it is large, it was cut about 2 cm away from its neck and then sutured and ligated at its neck (Fig. 20.3b). The internal inguinal ring was sutured 1–2 stitches to repair if it was large. Subcutaneous tissue and skin are subsequently closed after hemostasis was done carefully.

20.5.4 Laparoscopy High Hernia Sac Ligation Assisted with a Needle-Type Grasper

In the last two decades, the advent of minimally invasive surgery has completely changed the management of pediatric inguinal hernias [26, 27]. Laparoscopic surgery since its advent in the early 1990s is increasingly being preferred by the surgeons and patients worldwide due to its overall benefits evident by operative results and patient satisfaction [28]. Montupet is credited with performing the first intracorporeal laparoscopic pediatric hernia repair in 1993 [26]. The authors treated pediatric inguinal hernia with laparoscopy high ligation of the hernia sac with the aid of a needle-type grasper (Fig. 20.4) [29]. With almost similar results to open mesh repair, laparoscopy provides an alternative to inguinal hernia repair especially in bilateral or recurrent cases [30].

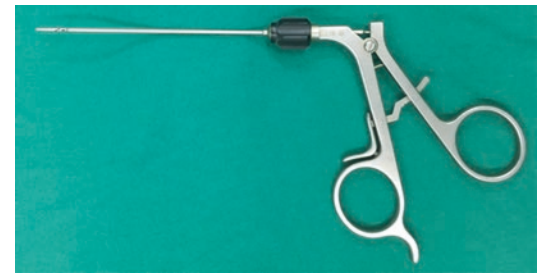

Fig. 20.4 Needle-type grasper

20.5.5 Preoperative Preparation

Preoperative preparation includes fasting 6 h. To be intraoperatively exposed better and minimize the risk of bladder injury, the bladder should be emptied before surgery.

20.5.6 Patient and Team Position

All patients underwent general anesthesia. The patient is positioned supine with both arms tucked (Fig. 20.6a). During the procedure, the patients are shifted in 15–20° of Trendelenburg position to improve exposure of the working area and to remove the intestine away from the operative area (Fig. 20.6b). The surgeon should stand on the opposite side of the defect to be corrected, the assistant with the camera is on the same side as the hernia to be treated, and surgical nurse should be located on the right side of the patient near the patient's knee. The monitor is placed at the foot of the operating bed.

20.5.7 Surgical Procedures

An incision at the infra or supra umbilicus is then made for placement of a 5 mm trocar (we use a 5 mm 30° laparoscope). Access of the peritoneal cavity is achieved using standard techniques with a Veress needle to create the pneumoperitoneum. The pneumoperitoneal pressure was maintained at 8–10 mmHg. Once access to the peritoneal cavity has been established, an inspection of bilateral internal inguinal ring is made in search of hernia defects. A 1.5 mm incision at or above the linea alba midpoint between umbilicus and pubic symphysis is made for entering the needle-type grasper. Another 1.5 mm small incision is made at the 12 o'clock surface projection of internal inguinal ring. Through it, the endo-closure device (Fig. 20.5) with No. 4 polyester thread was rotated back and forth and entered into the pre-peritoneal space at 11 (right side) or 1 (left side) o'clock of internal inguinal ring under laparoscopic monitoring. The endo-closure device was then advanced along the lateral side of inferior epigastric vessels within the extraperitoneal space and around internal inguinal ring and bypassed the vas deferens and spermatic vessels with the aid of needle-type grasper (Fig. 20.6d–f). The tip of the endo-closure device pierced the peritoneum into the abdominal cavity at 6 o'clock of internal inguinal ring. No. 4 polyester thread was pulled out from the endo-closure device with a needle-type grasper and cleaved it into the abdominal cavity (Fig. 20.6g), and the endo-closure device was pulled out of the body. The endo-closure device was inserted into the same skin incision again. From 12 o'clock of internal inguinal ring to begin, the endo-closure device was rotated back and forth and advanced along the lateral side of internal inguinal ring beneath the peritoneum. The endo-closure device was entered into the abdominal cavity at the same peritoneal hole as No. 4 polyester thread was gone through (Fig. 20.6h). The endo-closure device was then taken No. 4 polyester thread out the body. After squeezing the air of the scrotal and groin area, No. 4 polyester thread was then tighten and tied, and the knot was subcutaneously buried. The high ligation of hernia sac was finished (Fig. 20.6i). Bilateral indirect hernia was treated by the same way. An inspection of the abdominal cavity is made before ending operation. The needle-type grasper is removed under laparoscopic monitoring. A 5 mm trocar was removed after the abdominal cavity air emptied. Umbilical incision was sutured, and skin incision was intradermally sutured and stuck together with glue.

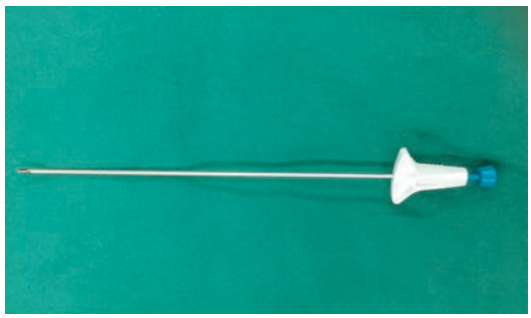

Fig. 20.5 Endo-closure device (COVIDIEN)

The manipulation of laparoscopy high hernia sac ligation with the aid of needle-like grasper is easy to bypass the structure of the vas deferens and spermatic vessels under direct vision and does not injure it. Laparoscopic approaches offer the superior visualization to potentially avoid trauma to the vas deferens and spermatic vessels and the opportunity to accomplish a safe high ligation of the hernia sac at the internal ring [23, 31–33].

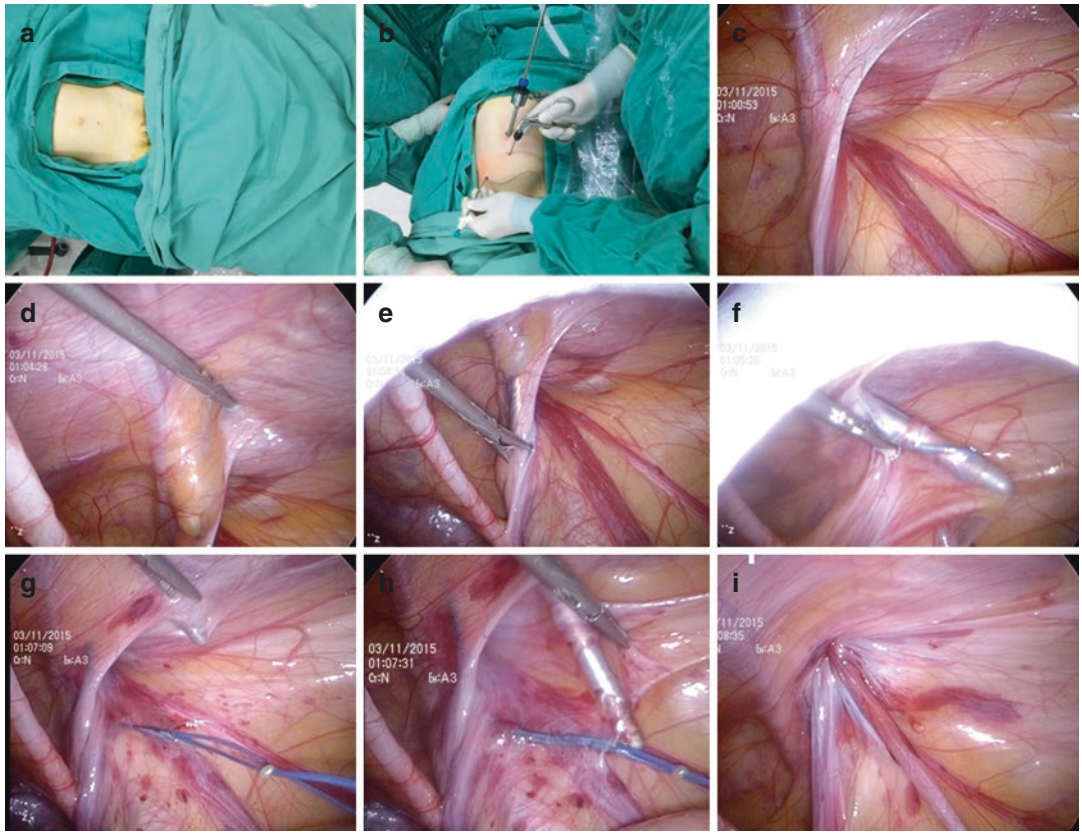

Fig. 20.6 (**a**) The child with inguinal hernia has been disinfected and drape. (**b**) Intraoperative location of the laparoscopic, needle-type grasper, and endo-closure device with thread. (**c**) Indirect inguinal hernia. (**d**, **e**) Endo-closure device with No. 4 polyester thread was entering into the pre-peritoneal space and then advanced along the lateral side of inferior epigastric vessels and around internal inguinal ring. (**f**) With the aid of needle-type grasper, the tip of endo-closure device was bypassed by the vas deferens which was under the tip of endo-closure device in this picture. (**g**, **h**) The endo-closure device was advanced along the lateral side of internal inguinal ring beneath the peritoneum and entered into the abdominal cavity at the same peritoneal hole as No. 4 polyester thread was gone through. (**i**) High hernia sac ligation was finished

Laparoscopic approaches offer the opportunity to visually inspect the contralateral canal for the presence of an occult hernia without incision, and the contralateral hernia, hiding hernia (Fig. 20.7), or other affections can be intraoperatively diagnosed and repaired at the same time while diagnosing unilateral cases preoperatively. The sensitivity and specificity of laparoscopic examination for detecting hidden PV patency have been reported to be 99.4% and 99.5%, respectively [1]. Reported advantages of laparoscopic hernia repair include excellent visual exposure, minimal dissection, less complications, comparable recurrence rates, and improved cosmetic results compared with the traditional open approach. In addition, laparoscopic hernia repair also allows contralateral patent processus vaginalis (PPV) hernias to be defined and repaired in the same operation [34–36]. Up to now, no scrotal hematoma or effusion has been found in author's department. At present, laparoscopy high hernia sac ligation assisted with needle-type grasper is more favorable than open pediatric inguinal hernia repair, which is one of the most common surgical procedures, in the authors' department. The operation could be implemented as long as there are no anesthetic or pneumoperitoneum contraindications.

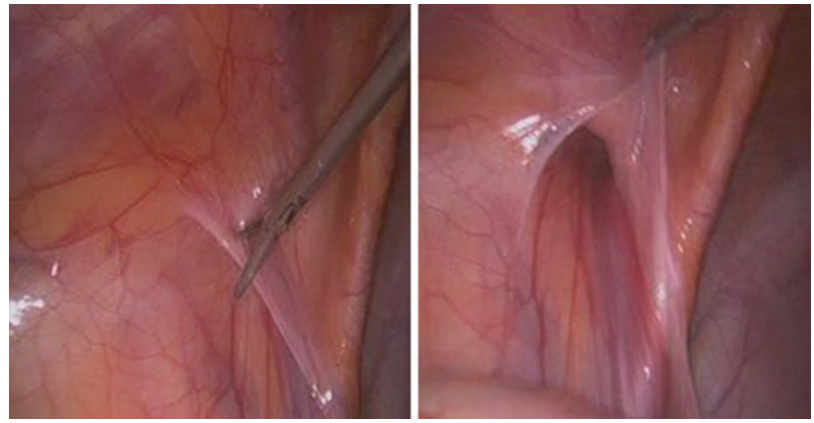

Fig. 20.7 Hidden hernia was found with the aid of a needle-type clamp

The laparoscopic high inguinal hernia sac ligation must establish pneumoperitoneum, which can only be used in general anesthesia, which needs the endotracheal intubation and ventilator-assisted breathing and increases surgical costs and anesthesia-related problems. In addition, the families of children have some psychological concerns with the side effects of general anesthesia, which had a bad effect on surgical treatment.

20.5.8 Lichtenstein Hernioplasty Using Biological Patch

As for the children from 13 to 18 years old, because simple hernia sac ligation surgery is not enough, the recurrence rate is high. The posterior wall of inguinal canal should also be repaired and strengthened in order to prevent recurrence. At present, it wasn't advocated for the children with hernia from 13 to 18 years old to be repaired with non-biological synthetic patch (e.g., polypropylene) because they are still in growth and development stage. Not stretching or contracting, the nondegradable patch can result in local postoperative obvious traction, local foreign body sensation, and chronic pain, which may also cause spermatic cord adhesion and even affect fertility. For children and adolescents, their muscle and fascia tissue will be gradually strong in the growth and development stage. The absorbable biological materials can rely on their own characteristics to repair defects in early stage and generate the new tissue plate through tissue replacement to prevent recurrence of hernia in long-term. After the biological materials were absorbed or degraded gradually, the biological patch will be replaced by autologous tissue without affecting the growth and development. According to author's clinical experiences, we found that for adolescents (13–18 years old) with long medical history, large internal inguinal ring diameter, and transverse fascia defect, high ligation of the hernia sac was inadequate. These adolescents are prone to postoperative recurrence; therefore similar procedure for the treatment of adult inguinal hernias should be adopted, repairing the transverse fascia and strengthening the posterior wall of the inguinal canal. The authors proposed the application of biological patch to the treatment of the inguinal hernia of the patients aged 13–18 years old, and results show that, compared with the traditional high ligation of hernia sac, the biological patch tension-free hernia repair surgery did not significantly increase the wound infection, male scrotal effusion, chronic pain or local foreign body sensation, and other complications.

Open "tension-free" mesh repair technique pioneered by Lichtenstein in 1984 is still considered the method of choice for primary inguinal hernia [37, 38]. For children from 13 to 18 years old, inguinal hernia was treated with Lichtenstein hernioplasty with biological patch, in which biological patch is placed in front of the transversalis fascia to reinforce the posterior wall of the inguinal canal.

20.5.9 Surgical Procedures

The operative steps include dissection of the spermatic cord, dissection and resection of the hernia sac with high ligation (Fig. 20.8b–d), and reconstruction of the floor of the inguinal canal. The inguinal canal is dissected to expose the shelving edge of the inguinal ligament, the pubic tubercle, and sufficient area for biological patch. The biological patch must be large enough to extend 2–3 cm superior to Hesselbach's triangle. The lateral portion of the patch is split into two tails such that the superior tail comprises 2/3 its width, and the inferior tail comprises the remaining 1/3 (Fig. 20.8e). The lateral tail of biological patch was passed through beneath the spermatic cord from medial to lateral and then sutured together with the medial tail using two Vicryl 2/0 interrupted stitches, leaving a hole as large as the diameter of the spermatic cord, which were placed around the spermatic cord at the internal ring but not too tight to strangulate it (Fig. 20.8f). Two interrupted sutures with Vicryl 2/0 thread were used to fix the inferior edge of the patch to the shelving edge of the inguinal ligament. The upper edge of the patch was then fixed to the inferior surface of external oblique aponeurosis with two Vicryl 2/0 interrupted stitches. The tails were then placed on the surface of internal oblique muscle and fixed with glue. The medial edge of the patch was overlapped the pubic tubercle by 1.5–2 cm and fixed with medical glue in order to prevent medial recurrence. The reinforcement of the floor of the inguinal canal was finished (Fig. 20.8g). External oblique aponeurosis was sutured with Vicryl 2/0. Subcutaneous tissue is closed with Vicryl 4/0. The skin incision was intradermally sutured with Vicryl 4/0 and stuck together with medical glue.

Generally, it is not difficult to diagnose inguinal hernia in children; however, before surgery there is not an effective auxiliary examination to diagnose how much the hernia ring defect ranges, which is the basis on the options of individualized treatment of pediatric inguinal hernia. For some patients 13–18 years old, if the extent of hernia ring defect belonged to Gilbert type I or II, laparoscopic high hernia sac ligation could still be used. Preoperative noninvasive examinations, such as ultrasound, which can define the size of

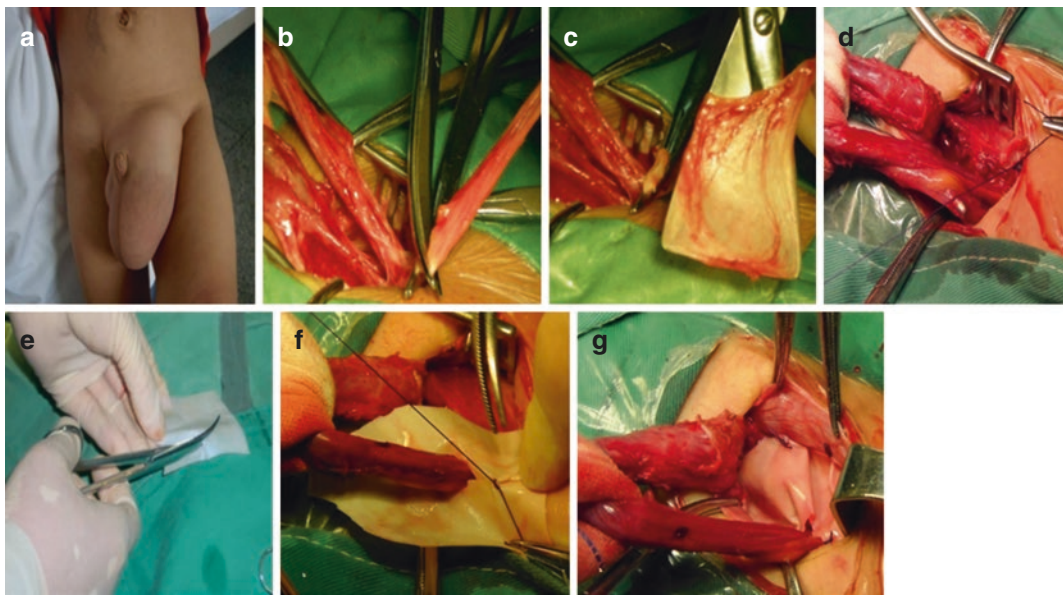

Fig. 20.8 (**a**) The child with big indirect inguinal hernia. (**b**, **c**) The hernia sac was dissected and sheared. (**d**) The hernia sac was sutured and ligated at its neck. (**e**) Acellular tissue matrix patch (Grandhope Biotech Co., Ltd.) was prepared. (**f**) The two tails of biological patch were sutured together with 2/0 Vicryl to surround the spermatic cord. (**g**) The fixation for biological patch was finished

the hernia ring defect in most cases, are helpful to choose the surgery and carry out the individualized treatment program of inguinal hernia in children.

The individualized treatment of inguinal hernia in children is currently an effective and relatively reasonable treatment program to better treat morbidity. However, laparoscopic high hernia sac ligation and the biological patch repair are not for long-time use. It must be further observed for its long-term effects and needs to be studied on the basis of the present in order to improve the clinical effects and reduce the postoperative complications.

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Indications for Pure Tissue Repairs

21

A. Koch, R. Bendavid, J. Morrisson, C. Hill,
K. Petersen, and V. Iakovlev

21.1 Broad Aperçu of the Scientific Literature

"I tore myself away from the safe comfort of certainties through my love for truth—and truth rewarded me". Simone de Beauvoir.

As a disciple of Jean-Paul Sartre, Simone de Beauvoir in her existentialist philosophy sends her own powerful message in her autobiography "All Said and Done" [1]. She stood as a frail beacon of truth and integrity. Would that our surgeon-scientists emulate her!

John Ioannidis, professor of Medicine and of Health Research and Policy at Stanford University, stated that: "There is increasing concern that in modern research, false findings are the majority or even the vast majority of published research claims" [2]!

No less emphatic in his criticism, Barbour who is aware and attuned to a similar drumbeat declares that: "Journals may increasingly become close to works of fiction, telling stories dictated by lobbyists, rather than Works of Science" [3].

G. R. Steen, to limit these disquieting ethical references, buttresses our concerns by raising doubts about the integrity of modern authors. He authenticates a sobering if somber thought … that: "In 2010, it was revealed that the United States leads the world in retracted Journal articles and its scientists were cited as the most prone to engage in deliberate fraud" [4]. In short, readers beware!

21.2 Statistical Relevance

The commonest statements or implications nowadays in all submissions and publications which feature groin hernias are the following: "… mesh has reduced the incidence of recurrence in hernia surgery" and "mesh repairs are the Gold Standard" [5, 6]!

Another notion which seems to permeate the extant references on hernias is that polypropylene mesh has been used since the mid-1950s when introduced by Francis Usher, suggesting that polypropylene has been used for the last 60 years with satisfactory results, free from any significant complications. Nothing is further from the truth [7].

In fact frequent use of polypropylene meshes did not spread until the early 1990s when the first gadget was introduced [8], after which the attitude seemed to be that if mesh is good in complicated cases then it must be good for all cases, hence the panoply of ready-made gadgets such as plugs, PHS, precut patches, and countless varieties of mesh.

Another document from the website of HerniaSurge [herniasurge.com] sponsored by Bard, Ethicon, and Medtronic attempts to disseminate a "guideline" on adult hernias, recommending that all groin hernias in all adults be done with

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G. Campanelli (ed.), *The Art of Hernia Surgery*, https://doi.org/10.1007/978-3-319-72626-7_21

mesh, while all women must be done with mesh laparoscopically, a conclusion which is far and away not in keeping with the experience of the average general surgeon, nor do they agree with the reports and statistics from the Shouldice Hospital (presented herein) which agree most closely with the recommendations of Herniamed, the data base of the German Hernia Society. Both data base, Shouldice and Herniamed, have nearly 400,000 patients each. HerniaSurge by the EHS on the other hand has no data base but relies on looking for "level 1" evidence within randomized controlled trials and meta-analyses in publications deemed worthy of consideration. RCTs are not without criticisms as they should be planned by a methodologist beforehand, not after as one seeks in meta-analysis. On the other hand, a data base allows a more accurate propensity score matching and random registry trials in assessing outcomes.

21.3 Pure Tissue Repairs

The era of successful hernia repairs began with Bassini in 1887 [9]. Since then, there have been numerous imitations and modifications. Alfred Iason in his colossal historical review had already reported 46 inguinal and 80 femoral variations of the two Bassini operations "Bassini devised two operations one for inguinal, the other for femoral hernias" [10]! Of all the repairs, not one divided the posterior inguinal wall as Bassini described except for the Shouldice repair. The McVay repair, which appeared in 1948, does gain access to the pre-peritoneal space, while individual modifications do not and, instead, do the procedure blindly which represents a dire risk for any aberrant obturator artery should one be present. In this failure to divide the posterior wall lies the failure of all the modifications of Bassini which had always been poorly taught. The Shouldice repair respected all the tenets of Bassini and added a significant improvement in the muscular reconstruction of the internal ring by wrapping the lateral stump of the cremasteric around the spermatic cord at the internal ring; a second muscular layer to protect, reinforce, and secure the primary "triple layer" of Bassini is added; a continuous suture to seal evenly the suture line is a further improvement. Significantly, the pre-peritoneal space is always entered to verify the presence or absence of femoral and prevesical hernias. Figure 21.1 illustrates the secret of the success in pure tissue repair: access to the pre-peritoneal

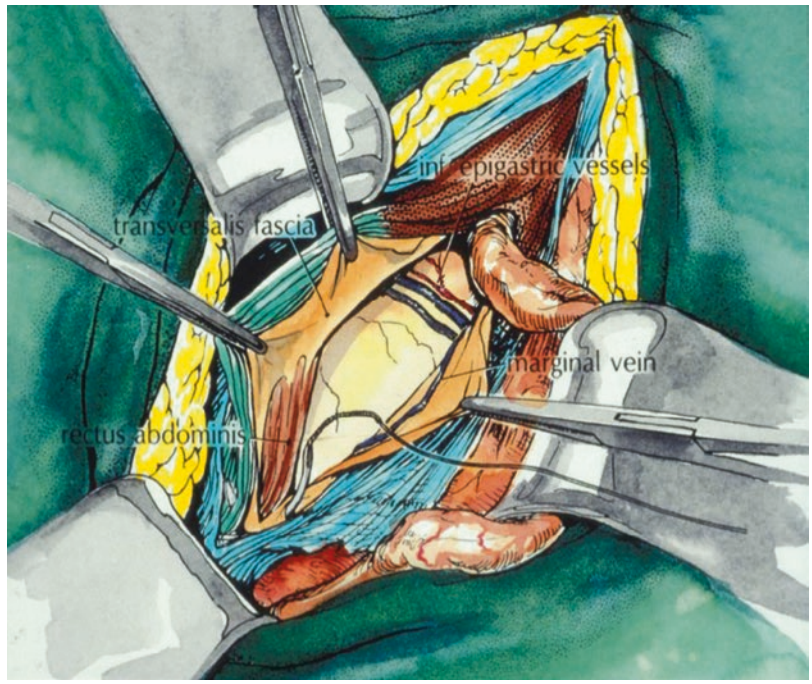

Fig. 21.1 The pre-peritoneal space, once entered, offers the possibility of all mesh and non-mesh repairs, for all groin hernias. Copyright: Shouldice Hospital

space. A step which takes 15–20 min under local anaesthesia, following which, any conceivable repair, with or without mesh, becomes feasible.

21.4 Indications for Pure Tissue Repair

In 2013, the Shouldice Hospital carried out 6665 hernia operations. Men accounted for 89.45% and women for 10.55% of the patient population. The majority of abdominal wall hernias are in the groin, 5657 out of 6665 (84.8%).

Twenty years ago, the Shouldice repair for groin hernia was considered the gold standard against which new mesh repairs were measured.

The industry, abetted by many surgeons swayed by the concept of tension-free repair, has been successful in convincing the surgical world that mesh is better and that pure tissue repairs ought to be abandoned. The Shouldice surgeons were not convinced. Yet, as any physiatrist will know, lack of tension will lead to atrophy of the skeletal muscle and alter the physiology of the groin muscles. With mesh coverage, the posterior wall becomes a permanent fibrosed plate. As a result of aggressive sponsoring by the industry, few publications have appeared in defense of pure tissue repairs. However, two landmark, epiphanic papers have appeared in December 2015 and March 2016 which have subdued this broad, industrial, marketing maneuver of mesh for all and which have further confirmed the stance of the defenders of pure tissue repairs, namely: David Urbach's paper reviewing 235,000 hernia operations [11] and Lange and Meyer's insightful dissertation which highlighted the incidence and severity of the new chronic post-herniorrhaphy pain syndrome linked to mesh [12].

The paper by David Urbach detailed 235,192 patients, the world's largest single study ever undertaken through the data base of the Ontario government, the sole payer of healthcare in Ontario, Canada. The population of Ontario is 13.6 million. The period surveyed was a 14-year span from 1993 to 2007, thus providing an 8–24-year postop follow-up. All patients were between 18 and 90 years of age. All patients had a primary groin hernia. The Shouldice Hospital performed 65,127 operations (27.7% of all operations in Ontario). All other hospitals in Ontario managed 170,065 patients (72.3%).

An advantage of a government data base is that patients who may have a recurrence but consult a different surgeon would be recorded and the recurrence assigned to the former surgeon!

The recurrence rates in Ontario hospitals were 5.21% (95% confidence interval [CI] 4.94–5.49%) in the lowest-volume general hospitals and 4.79% (95% CI 4.54–5.04%) in highest-volume general hospitals.

In contrast, the Shouldice Hospital had a 1.15% (95% CI 1.05–1.25%) recurrence rate [11].

The David Urbach study did not approach the Shouldice Hospital for participation nor to obtain statistics on the types of hernias involved. Nor did the Urbach team know whether we used mesh or how often.

We identified within our data base the 65,127 Shouldice Hospital patients covered by the Urbach study. Our numbers were larger, more exactly 70,519 patients which included out-of-province and out-of-country patients. Our results were as follows:

Considering men alone, mesh use was seen in 1.16%, men and women combined 1.36%, and women alone 5.45%. Women present a different clinical picture and they are dealt with separately in the next section.

The results of the Shouldice Hospital recommend, except in cases of femoral hernias in men and women, that all hernias be attempted with a pure tissue repair first, reserving mesh for recurrences, if the recurrence is not an indirect hernia which was overlooked or missed!

Polypropylene meshes were introduced at Shouldice Hospital in 1986, and by 1992, we had published a set of statistics which reflected the need for mesh and constituted what would be eventually called a "tailored approach" [13]. The recommendations in the hands of the surgeons of the Shouldice Hospital have not changed significantly to reflect the drive of the medical devices industry to universalize mesh surgery! Table 21.2 stands as a witness to that constancy! The only difference being that femoral hernias are treated

more aggressively with mesh, but this still represents a small segment of the hernia population. Compare Tables 21.1 and 21.2.

Because of the reliable results of the Shouldice repair over the years, the low recurrence rate, and the volume of surgery of each surgeon (600–1000 per year), we classified hernias as small, medium, and large. We are adopting the simple EHS classification and will, in the near future, review any correlation between size and recurrence within the already low incidence of recurrences (Table 21.3).

Table 21.1 Results of the Shouldice repair by well-known authors in the 1990s all with corresponding follow-ups

Author	# Cases	% Follow-up	Years follow-up	Recurrence (%)
Shearburn [56]	550	100	13	0.2
Volpe [57]	415	50	3	0.2
Wantz [58]	2087	–	5	0.3
Myers [59]	953	100	18	0.7
Devlin [60]	350	–	6	0.8
Flament [61]	134	–	6	0.9
Wantz [62]	3454	–	1–20	1.0
Shouldice [63]	2748	–	35	1.46
Moran [64]	121	–	6	2.0
Berliner [65]	591	–	2–5	2.7

21.5 Indications for Pure Tissue Repairs in Women

We have reviewed a 5-year period of surgery on female patients for the years 2008–2012, both years inclusive. There were 894 patients who responded out of 1430 patients, amounting to a 62.5% response rate.

This table can be examined and interpreted in light of anyone's curiosity. Salient features are that indirect inguinal hernias amount to 65% of all hernias in women and can be much higher in some series and will seldom if ever require mesh, especially when the absence of a femoral hernia is established. The unfortunate 11 recurrences within the indirect hernia group, when traced, revealed that they were done by novice surgeons! A seasoned surgeon would rarely miss an indirect inguinal hernia. This is an area where our recommendations are totally at variance with the EHS' guidelines and more in line with Herniamed, the large and explicitly informative data base of the German Hernia Society.

Direct hernias can also result in higher recurrence rate (9.4%) as do pure femoral hernias

Table 21.3 Incidence of use of mesh in various hernias in 1992, compared to a more recent Table 21.2 from 2016

Ventral hernia	154/729	2.00 (%)
Groin hernias	98/7085	1.30
Direct hernia	26/2890	0.90
Indirect hernia	4/4028	0.10
Femoral hernia	48/144	33.30
Inguinofemoral hernias	20/23	87

Table 21.2 Incidence of various hernias and mesh use at Shouldice Hospital in males (M) and females (F)

Sex	Op type	Mesh	No mesh	Grand total	Mesh use (%)
F	Femoral	130	257	387	33.59
	Inguinal direct	22	289	311	7.07
	Inguinal indirect	20	2587	2607	0.77
	Inguinofemoral	9	5	14	64.29
F Total		181	3138	3319	5.45
M	Femoral	215	146	361	59.56
	Inguinal direct	355	24,868	25,223	1.41
	Inguinal indirect	161	41,405	41,566	0.39
	Inguinofemoral	46	4	50	92.00
M Total		777	66,423	67,200	1.16
Grand total		958	69,561	70,519	1.36

Table 21.4 Summary of all hernias in 894 female patients

Research survey results	Totals	% of all hernias	Pure tissue	Pure tissue recurrences	% of recurrence	Mesh	Mesh recurrences	% of recurrence	Total recurrences
Pure Femoral	151	16.9%	84	8	9.5	67	2	2.9	10
Direct	55	6.2%	53	5	9.4	2		0	5
Indirect	578	64.7%	578	11	1.9	0		0	11
Direct & Indirect	37	4.1%	37	2	5.4	0		0	2
Direct & Femoral	8	0.9%	5	3	60	3		0	3
Indirect & Femoral	35	3.9%	24	1	4.3	11	1	9.1*	2
Direct & Indirect & Femoral	4	0.45%	3	3	33.3	1	1	100*	2
Inguino-Femoral	1	0.1%	0			1		0	
Other	25	2.8%	24			1		0	
Apparent incidence cf recurrence					3.80%			4.70%	
	894		808	31		86	4		

(9.5%) when mesh is not resorted to. The combination of a direct and a femoral hernia would appear, though numbers are too low (0.9%) for accurate prediction, to be an absolute indication for the use of mesh in the repair.

It would appear by extrapolation that if 20 more cases (for femoral, direct, or combination thereof) had been performed, the total recurrence rate would be 1.2%.

Even if one were to blindly use mesh for all femoral, direct inguinal hernias, and combinations thereof, this use would cover a third of female patients rather than the 100% suggested by the EHS International guidelines (Table 21.4).

21.6 Indications for Pure Tissue Repairs as Assessed at Arm's Length from Outside Shouldice Hospital: A Comparative Statistical Study—The Contribution of Herniamed

The international guidelines and recommendations by the EHS-HerniaSurge Group (www.herniasurge.com) [14] call for a detailed and serious critical analysis. They have strongly recommended the use of mesh-based hernia repairs in every adult patient! HerniaSurge has concluded that large numbers of patients and consistent results convey a seal of approval to the available findings so that they may be translated as a sign of usability and reliability in current practice. Is there really evidence to support such strong recommendations as we dissect the scientific and ethical aspects of these designated publication?

A publication in *Annals of Surgery* pointed out that industry funding of surgical trials leads to exaggerated positive reporting of outcomes [15]. The Cochrane review by Amato underlined that the quality of the included studies assessed according to the Jadad scale was low [16]. Are the results truly valid to give such a weighty recommendation? The Shouldice technique which was the standard procedure for many years, with good results, should still remain the benchmark by which every new technique is gauged.

The Jadad scale (out of three) or the expanded version (out of five) assigns a category to a study depending on its rating. Four and five points only are deemed consistent with good quality. Only the study by Miedema has four points and no difference existed between the Shouldice and mesh

repairs. There is also a lack of reports on funding. Conflict of interests should be included in the evaluation of all available data.

In hernia surgery in particular, it was found that not all COI are properly declared or recorded [17] (Comparison of Conflicts of Interest among Published Hernia Researchers Self-Reported with the Centers for Medicare and Medicaid Services Open Payments Database. Oscar A Olavarria, MD, Julie L Holihan, MD, Deepa Cherla, MD, Cristina A Perez, MD, Lillian S Kao, MD, MS, FACS, Tien C Ko, MD, FACS, Mike K Liang, MD, FACS published in JACS, Volume 224, No 5, May 2017. pp: 800–804).

The authors concluded that a COI can influence the validity of the design, conduct, and results of a study. Finally poorly designed studies without disclosure of potential conflicts of interests could not and should not form the basis for a "strong recommendation" to use any particular technique in every case.

The evaluation of these studies with respect to their statistical power reveals an additional and interesting fact that most of the studies do not have the statistical power to discriminate between evidence and happenstance! So the differences were not evident (Tables 21.5, 21.6 and 21.7).

With this background, we did a multivariable analysis of 50,153 primary inguinal hernias with a complete 1-year follow-up in the German Database Herniamed. For recurrences, individual risk factors such as hernia localization (direct) and BMI were more significant than the technique of repair. The technique and the size of the

Table 21.5 Shows the studies which were included into the decision tree

Year	First author	Groups	Number of patients	Follow-up duration (months, mean)	Follow-up number (percentage with physical examination)	Recurrence (%)	Chronic pain (%)
1998	McGilliguddy	Lichtenstein vs. Shouldice	708	60	476 (67%)	0.5 vs. 2.1	1.1 vs. 0.3
2000	Leibl et al.	TAPP vs. Shouldice	102	70	Probably 91 (89.2%)	2.1 vs. 4.7	0 vs. 0
2001	Tschudi et al.	TAPP vs. Shouldice	127	60	107 (84%)	3.0 vs. 8.2	1.5 vs. 14.8
2002	Nordin et al.	Lichtenstein vs. Shouldice	297	36	284 (96%)	0.7 vs. 4.7	5.6 vs. 4.2
2004	Miedema et al.	Lichtenstein vs. Shouldice	101	85	50 (50%)	7.7 vs. 4.9	37.9 vs. 7.1
2004	Köninger et al.	TAPP–Lichtenstein vs. Shouldice	280	52	231 (83%)	–	24.2 vs. 37.8
2005	Arvidsson et al.	TAPP vs. Shouldice	1.068	61	920 (86%)	6.6 vs. 6.7	–
2007	Butters et al.	TAPP–Lichtenstein vs. Shouldice	280	52	231 (83%)	1.3 vs. 8.1	–
2007	Berndsen et al.	TAPP vs. Shouldice	1.068	60	867 (81%)	–	8.5 vs. 11.4
2007	Van Veen et al.	Lichtenstein vs. Shouldice	182	128	80 (44%)	1.4 vs. 12.5	–
2008	Pokorny et al.	TEP/TAPP/ Lichtenstein vs. Shouldice	272	36	249 (92%)	3.3 vs. 4.7	5.4 vs. 6.3

There were about 3000 patients included in the randomized trials. Long-term follow-up (36 months) of RCTs comparing Shouldice with different mesh techniques—analysis of the EHS guidelines [66]

Table 21.6 Jadad evaluation of relevant references

Author	Year	Sample size	Funding	Jadad
Barth	1998	105	Not reported	1
Danielsson	1999	200	Not reported	2
Hetzer	1999	385	Not reported	1
Miedema	2004	146	Not reported	4
Zieren	1998	160	Not reported	3
Nordin	2002	300	Not reported	3
McGillicuddy	1998	672	Not reported	1
Butters	2007	186	Not reported	3

Table 21.7 Power analysis for the sample size needed so that the differences can be considered significant and evident

		Sample size per group	
		Recurrence	Chr. Pain
1998	McGilliguddy	838	1817
2000	Leibl	191	–
2001	Tschudi	330	71
2002	Nordin	273	3856
2004	Miedema	1239	33
2004	Köninger	–	195
2005	Arvidsson	976,466	–
2007	Butters et al.	162	–
2007	Berndsen et al.	–	1733
2007	Van Veen et al.	88	–
2008	Poorny et al.	3195	10,881

hernia were also factors influencing the risk of chronic pain (small hernias, young patients, and mesh repairs being significant) (Table 21.8).

There is a significant place for the Shouldice repair in a tailored concept for inguinal hernia repairs. In the available literature, there is no evidence to exclude the technique from a daily application [18].

21.7 Chronic Post-Herniorrhaphy Pain Syndrome: The Newest Indication for Pure Tissue Repair

A patient who develops groin pain any time after mesh inguinal hernia surgery is most likely having pain caused by the mesh. Mesh elicits chronic inflammation to some degree in 100% of patients [1]. This leads to chronic pain in 11–20% of patients [12], while in 2–4% of patients, the pain leads to "functional and socioeconomic disability" [19]. The hernia recurrence rate after mesh inguinal hernia surgery is 1.1–5.1% [11].

A recurrence can cause pain but without an obvious bulge to support the diagnosis; mesh pain should remain at the top of the differential in a patient with pain after hernia surgery with no other clear cause for such pain.

Mesh pain can start in the recovery room or decades after the implant surgery with no prior hint of the pain to come [20]. Waiting can further complicate the patient's condition because it hardens the chronic pain state through a phenomenon

Table 21.8 Independent risk factors for outcomes and their correlations with *p*-values

Target	Type/surgery	Hernia type	ASA	Age/elderly	BMI	Risk factors	EHS class	*p*-value
Intraop complication	*	*					*	<0.001
Postop complication	***	***	***	***	**	**	**	<0.001
Reoperation	*		***	***	*	*		<0.001
Recurrence	*				***		***	<0.001
Pain at rest	***	***		***	***			<0.001
Pain on effort	***	***	**	***	***		*	<0.001
Requiring treatment		***	**	***	***	*		<0.001

From Herniamed

called central pain sensitization [21]. As we acquire experience with this new clinical syndrome, we may learn to recognize clinical features which would lead us to remove an offending mesh much sooner, perhaps even before the 3–6 months suggested by most authors to wait before diagnosing the chronic nature of the pain or perhaps still even consider explantation of an offending mesh before the pain becomes established centrally making any treatment nearly futile! (Tables 21.9 and 21.10).

Mesh pain affects patients of all ages. Although mesh is not typically used on prepubescent patients, it is being used on older children. Mesh pain in an adolescent is particularly devastating. Ages of patients at the time of mesh removal ranged from 15 to 73 with a mean age of 45.

Conventional therapy for mesh pain does not help all patients and rarely is a permanent solution. Patients who find some relief with medications frequently do not tolerate the side effects and may run the risk of addiction as pain becomes severe and relief is nowhere in sight. It is not necessary to try other treatments prior to mesh removal, when one is convinced of the etiology of the pain.

Imaging studies are usually unremarkable in mesh pain cases but may be useful for ruling out other causes of groin pain such as hip joint disease or renal calculi. But these most often can be ruled out clinically.

Mesh pain typically is centered where the mesh is but frequently involves the testicle and may radiate down the thigh and leg and around to the back. Patients may experience pain to touch, known as allodynia. They may have widening of their pain field and experience pain on the contralateral side due to central pain sensitization. Patient's mesh pain is typically aggravated by activity. Some patients experience dysejaculation [7].

Mesh pain is classified as nociceptive versus neuropathic. Neuropathic may be central neuropathic or peripheral neuropathic. Most patients with mesh pain have mixed nociceptive and neuropathic pain.

The claim that peripheral neuropathic pain may be effectively treated with retroperitoneal neurolysis is yet to be confirmed on long-term follow-up [22].

Pain may be assessed by a physician using the visual analog pain score or asking about what important activities the pain interferes with. A patient who cannot work, cannot exercise, avoids sex, cannot stand, and cannot drive a car is suffering a lot of pain. On the VAS score, seven and greater is a lot of pain.

Table 21.9 Distribution in onset of pain

Delay in onset of pain	Cases	(%)
Immediately	51	50
One week	7	7
Two weeks	5	5
One month	3	3
Two months	6	6
Three months	5	5
Six months	6	6
One year	7	7
Three years	2	2
Five years	2	2
Six years	1	1
Eight years	3	3
Ten years	4	4
	102	

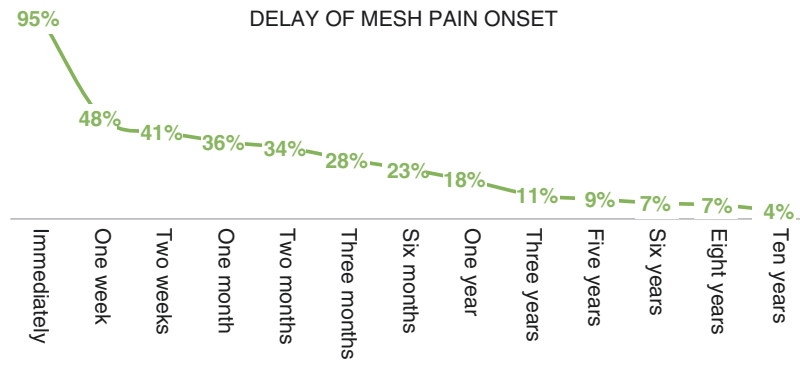

Table 21.10 Linear graph of onset of pain over 20 years

A patient who has typical mesh pain, with no other likely cause and whose pain is significant, is a good candidate for mesh removal. The results are likely to be positive when relying on these indications. In a series of 140 patients from a single surgeon's follow-up (KP), the results with an average follow up of 2.5 years were the pain was cured in 27% of patients and the pain was much better with a little residual pain but not enough to affect quality of life or interfere with activities in 43% of patients. That is a 70% chance of a very positive result. Two percent of patients said their pain was worse; 5% said their pain was a little better, enough that they were glad they had their mesh removed. So overall there is a 93% chance of a positive result. The average pain score in these patients' preop was 8.5/10. The average VAS score postop mesh removal was 2.5 (Tables 21.11 and 21.12).

Table 21.11 Follow-up at 2.5 years

Pain improvement with mesh removal	Cases	(%)
Cured	29	27
Much better	45	42
A little better	24	22
No change	5	5
A little worse		0
Much worse	2	2
	107	

Table 21.12 Associated symptoms in patients with severe post-herniorrhaphy inguinodynia

Symptom or problem	Affected	Affected (%)
Fatigue	50	56
Tender scar	42	47
Insomnia	36	40
Constipation	30	34
Irritable bowel	26	29
Achy joints	24	27
Difficulty passing urine	23	26
Neuropathy	22	25
Headache	21	24
Pruritus	19	21
Indigestion	17	19
Memory loss	16	18
Weight loss	15	17

21.8 Understanding the Pathology of Mesh-Body Interactions and Its Importance in Understanding and Retaining Pure Tissue Repairs

On a histological level, mesh-body interactions can be separated into three categories: nonspecific processes associated with the presence of any foreign body, the specific processes seen with porous meshes as large compartmentalized objects, and changes in the mesh material itself:

21.8.1 Foreign Object

Despite progress in other fields of medicine, implantable devices still act as foreign objects. They do not become an integral part of the tissues. They cannot be remodeled or adapted by the tissues as would normally occur with native tissues. There are several phenomena generally shared by all implantable devices:

Initial body response following implantation. During the first hours and days after implantation, the space surrounding an implant becomes filled with blood and acute inflammatory cells. Then, the blood clot and the damaged tissues become invaded by capillaries signifying the first step in the repair (healing) process—the formation of granulation tissue (Fig. 21.2) [23].

Foreign body type inflammation. The initial inflammatory response to surgical trauma is gradually replaced by a foreign body-type (granulomatous) inflammation. This type of inflammation is composed mainly of macrophages recruited to degrade the foreign object. The degree of inflammation is generally greater in degradable materials shedding particles than in nondegradable materials [24]. As the inflammation is nonspecific, it damages the surrounding tissues and stimulates fibrosis. When pronounced, it also plays a role in the mechanisms of pain [25, 26]. In hernia mesh implants, a higher degree of inflammation was observed in meshes removed due to pain [27]. In our experience, in cases of

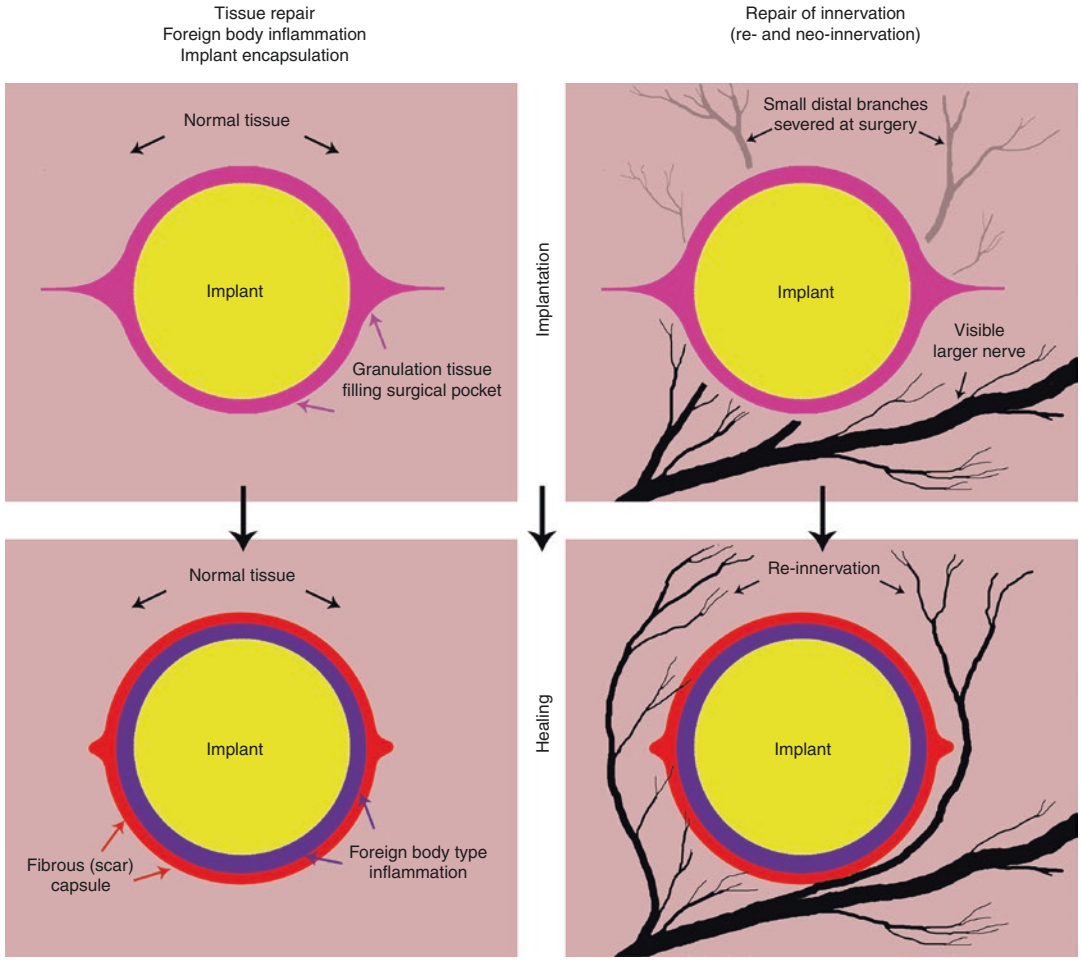

Fig. 21.2 Healing and tissue reaction associated with implantation of a foreign object. Spaces around the object are initially filled with granulation tissue. As healing progresses, the granulation tissue matures into a scar while disrupted nerve branches reinnervate their target tissues. The object, if it cannot be resorbed by the macrophages of foreign body-type inflammation, becomes surrounded indefinitely by the foreign body-type inflammation and a fibrous capsule. The inflammation continues attempting to degrade the object while the capsule isolates it from the normal tissues

mesh-related pain, there is a trend for the foreign body-type inflammation to stay at high levels over the years, while meshes sampled during revisions for hernia recurrence without pain tend to show lower levels of the inflammation. Nevertheless, in all cases the inflammation persists indefinitely [28].

Fibrous (scar) encapsulation. The granulation tissue laid down initially matures into scar tissue within weeks after implantation. It needs to be remembered that human soft tissues cannot regenerate and are repaired by a nonspecific process of filling the defects by collagen or scar tissue. The terms "scar" and "fibrosis" are used interchangeably, but "fibrosis" is usually used for repair of internal organs damaged by a chronic inflammation (cirrhosis, pulmonary fibrosis, etc.), while "scar" is more appropriate for wound repair [23]. Encapsulation of a foreign object is a defense mechanism by the body for objects which cannot be resorbed by the inflammatory cells (Fig. 21.2).

Bacterial adhesion. Any surface of a foreign body can shelter bacteria. The degree of bacterial

colonization is greater in objects with irregular surfaces since there are more opportunities for the microorganisms to adhere and be out of reach of the acute inflammatory cells (neutrophils). This was widely accepted for the multifilament meshes; however, mesh designs with larger pores and monofilament fibers are not immune to infection, albeit at lower rates.

21.8.2 Mesh as a Porous (Compartmentalized) Structure

As we have learned over the last three decades of mesh use, the porous nature of mesh has advantages and disadvantages. Mesh porosity has been the main subject of research and development in mesh designs. The initial research was focused on aspects of the mesh affecting its incorporation into the tissues as well as lowering the risks of infection. It was learned that larger pores (compartments) allow growth of the tissue elements and cellular traffic within the pores. Later research was focused on how this design could lead to complications and how to correct it [27, 29, 30]. There are several important, recognized mechanisms for the understanding of these complications:

Bridging fibrosis. The term "bridging fibrosis" is used in other human conditions, for example, liver cirrhosis [23]. The term was later borrowed to describe scar tissue that fills the mesh pores or bridges between the adjacent mesh fibers across the pores (Fig. 21.3) [31]. The entire direction in research and development in the last three decades was aimed at minimizing the scarring and its negative effects [29–31]. This led to the development of lighter-weight/larger-pore mesh designs. The concept is to space mesh fibers far apart to allow displacement of normal tissues into the pores. The central areas within large pores would also be away from the damaging and scar-stimulating effect of the foreign body-type inflammation. However, the concept would only be applicable to designs with correct "effective porosity" as pores can deform in the body and become bridged by scar [30]. The concept is also applicable only to flat single-layered mesh. Folded and multilayered mesh results in a solid scar plate regardless of its design (Fig. 21.3) (lower panel). Paradoxically, larger pore-softer mesh types are more prone to folding which defeats the purpose of the design [27].

Mesh contraction. After implantation, the pores and folds become filled with granulation tissue that later matures into a scar. As for any wound, the process of maturation involves contraction of the tissue. Since configuration and size of pores can change and mesh can wrinkle/gather/fold as a knitted fabric, the contraction forces pull the fibers and folds together and contract the mesh (Fig. 21.3). Most of mesh shrinkage is due to the physiological tissue contraction within the mesh [23, 32, 33]. The resultant mesh contraction has been shown in multiple studies [32, 34, 35]. The aim to minimize mesh contraction was also behind the larger-pore (lightweight) designs, where the rationale was that a lesser amount of scar tissue generates lesser forces to contract and wrinkle the mesh. Also, contraction forces would not act across a pore if it were not filled with scar tissue. However, it appears that mesh contraction is also dependent on individual variations between patients and a number of mesh parameters beyond just pore size [31, 33, 36, 37].

Nerve involvement. As any scar tissue, scar within and around mesh becomes innervated during healing (innervation of new tissue or neoinnervation) (Fig. 21.4) [38]. This feature indicates that not only the tissue within and around mesh is viable but also that it can generate sensation signals, including those of pain. The noxious stimuli can be either mechanical, from mesh contraction and distortion, or inflammatory. These mechanisms of pain would be of nociceptive type. Additionally, tissues that lost innervation due to the surgical disruption of smaller (not visible by naked eye) nerve branches are subject to reinnervation. As a porous structure, mesh allows growth of nerve branches through the mesh (Fig. 21.4). Some nerves pass freely while some, not being able to pass through the mesh, form a neuroma-type lesion [39]. Involvement of larger nerve branches before they reach their target tissues indicates neuropathic mechanisms of

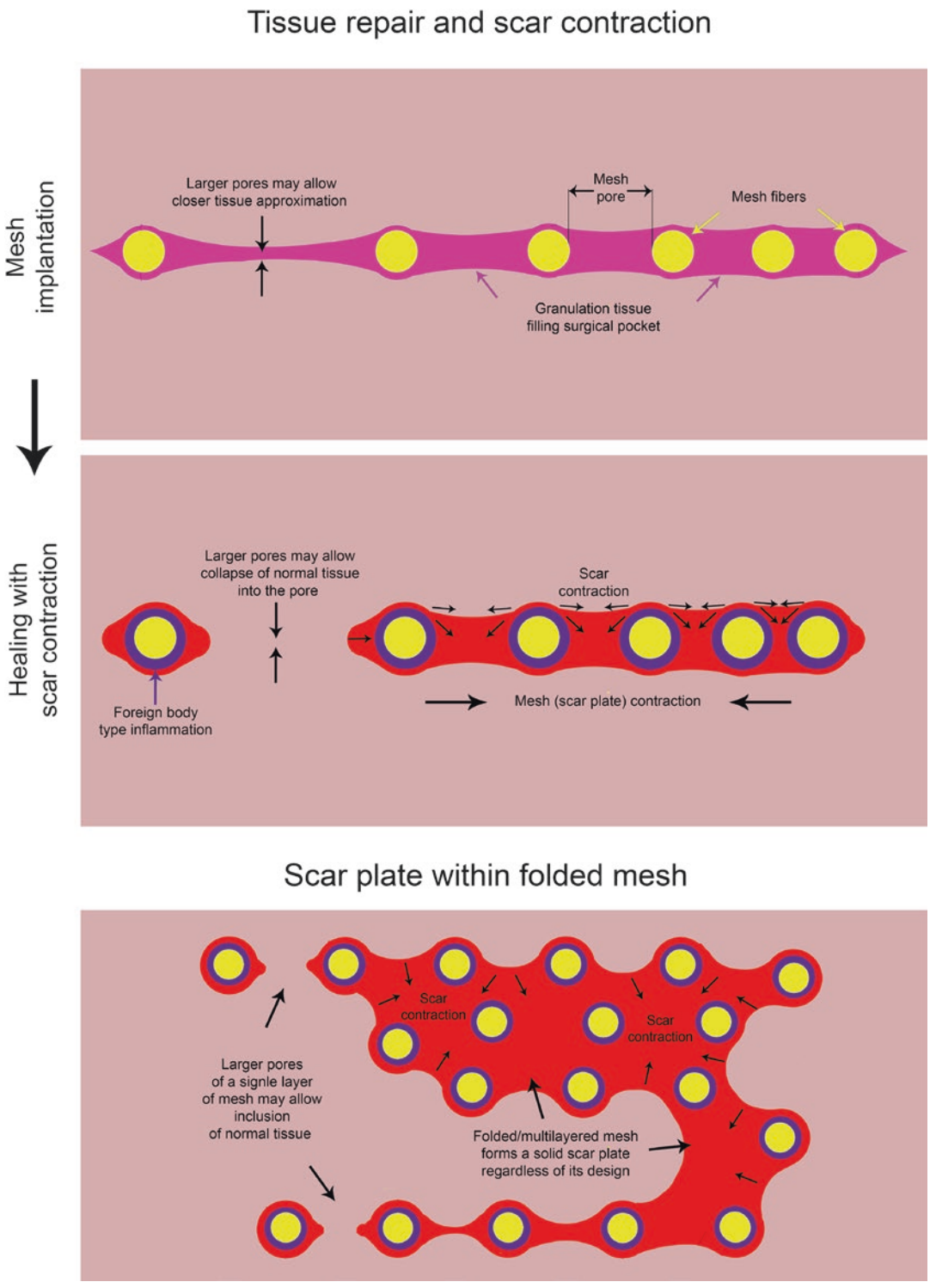

Fig. 21.3 Healing after implantation of a macroporous (heavy- or lightweight) mesh. After implantation, spaces within mesh (pores and folds) become filled by granulation tissue. If pores are large enough, the normal tissue may collapse deeper into the pores minimizing the amount of granulation tissue. As in any wound, the granulation tissue matures into scar which contracts during the maturation process. The contracting forces pull mesh fibers together and contract the mesh. Scar tissue is then remodeled—it can be either reduced if there is no further stimulus or expanded due to the action of foreign body-type inflammation. Some larger pores may eventually include normal tissue if mesh remains flat. Folded multilayered mesh will form a solid scar plate regardless of its pore size and weight

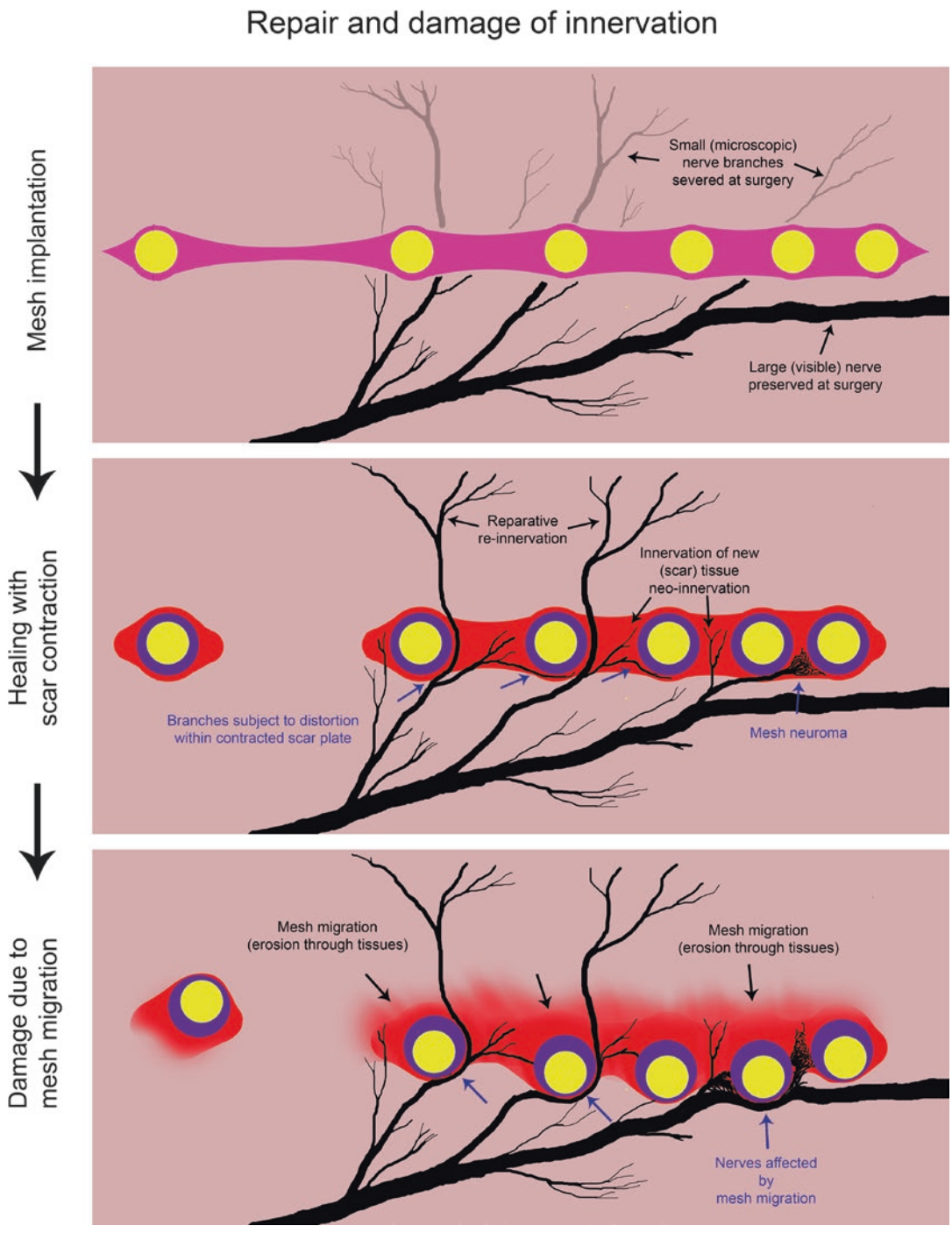

Fig. 21.4 Effect of mesh on innervation. As with any wound, healing is associated with reinnervation of the targets disrupted during surgery. The new tissue is also subject to innervation (neo-innervation). As a porous structure, mesh allows ingrowth of granulation tissue along with nerve branches and blood vessels. The nerves can either pass through the pores or form a neuroma-type lesion (mesh neuroma). The nerves can also be distorted and disrupted later by mesh migration through the tissues. These processes provide mechanisms for nociceptive pain when tissues feel mechanical distortions, as well as for neuropathic pain when nerves become affected before they reach their targets in the tissue

pain. Noteworthy, we observed that younger individuals tend to show higher nerve density within the mesh. The observation correlates with the established fact that younger patients are more prone to develop chronic pain after hernia repair [40–42]. It is not surprising to see more efficient innervation within mesh in younger individuals. Higher nerve density indicates more opportunities for either nociceptive or neuropathic mechanisms of pain [39].

Mechanical damage of the tissues by mesh migration (erosion through tissues). The ability of foreign objects to migrate or erode through tissues has been known for a long time and has been reported for implanted mesh as well [43–47]. The mesh can migrate either gathered into a meshoma (plug) or in a flat configuration. It is the porous nature of mesh that allows a flat mesh to erode through the tissues (Figs. 21.4 and 21.5) [7]. There can be two types of mesh migration: primary migration and folding within the surgical pocket during the immediate postoperative period and secondary migration or erosion of mesh through healed or intact tissues. The latter is caused by tissue forces acting on the mesh and forcing its displacement while tissue disruption and inflammation-related tissue resorption provide a path for migration. It is likely that all meshes move to a degree in the body, and some, as we observed, can erode through thick muscular structures such as the vas deferens (Fig. 21.5).

21.9 Material-Related Changes

Most of the currently used macroporous meshes are made from polypropylene. Multiple studies showed that polypropylene degrades (ages) and becomes brittle while in the body (Fig. 21.6) [48–50]. The degraded (aging) material forms a continuous embrittled shell on the fibers. The layer has a rapid growth phase within the first 3–4 years after implantation (Fig. 21.6) [49]. Noteworthy, for vaginal mesh devices, where erosion through

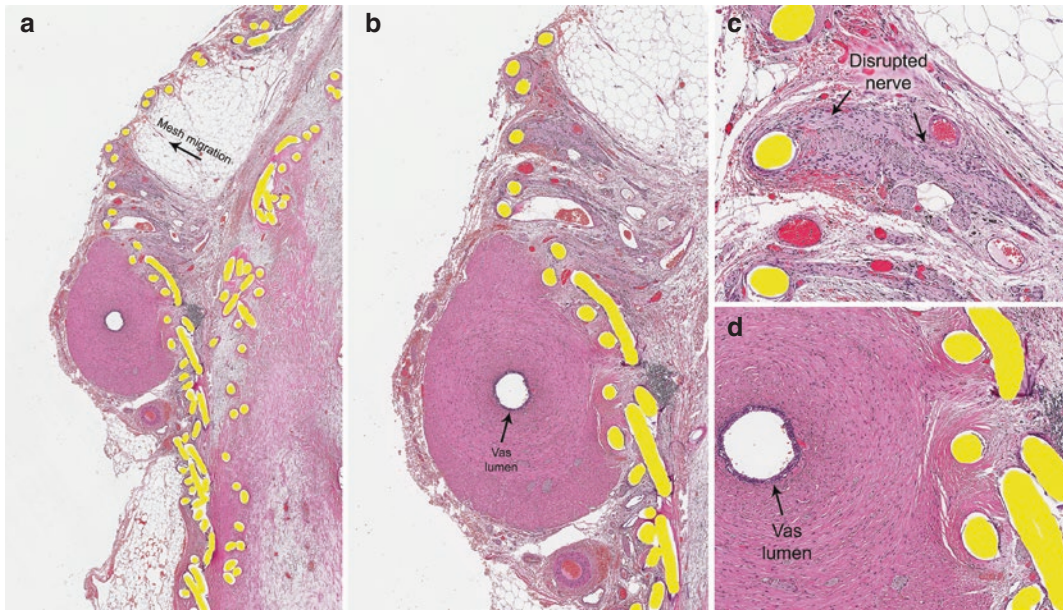

Fig. 21.5 Histological section of a mesh migrating through the tissues and damaging them on its path. This patient had a laparoscopic mesh placement for inguinal hernia and then presented with chronic pain, sexual pain, and dysejaculation. All images of an H&E-stained section. (**a**) Low- and (**b**) intermediate-power magnification images showing mesh migration and erosion into the vas deferens and adjacent nerves. (**c** and **d**) High-power magnification. (**c**) shows a severely stretched and disrupted nerve. (**d**) shows vas lumen and mesh fibers eroding into the muscular layer of the vas. Note that lumen is not affected indicating that it can remain patent for months and years after the symptom onset

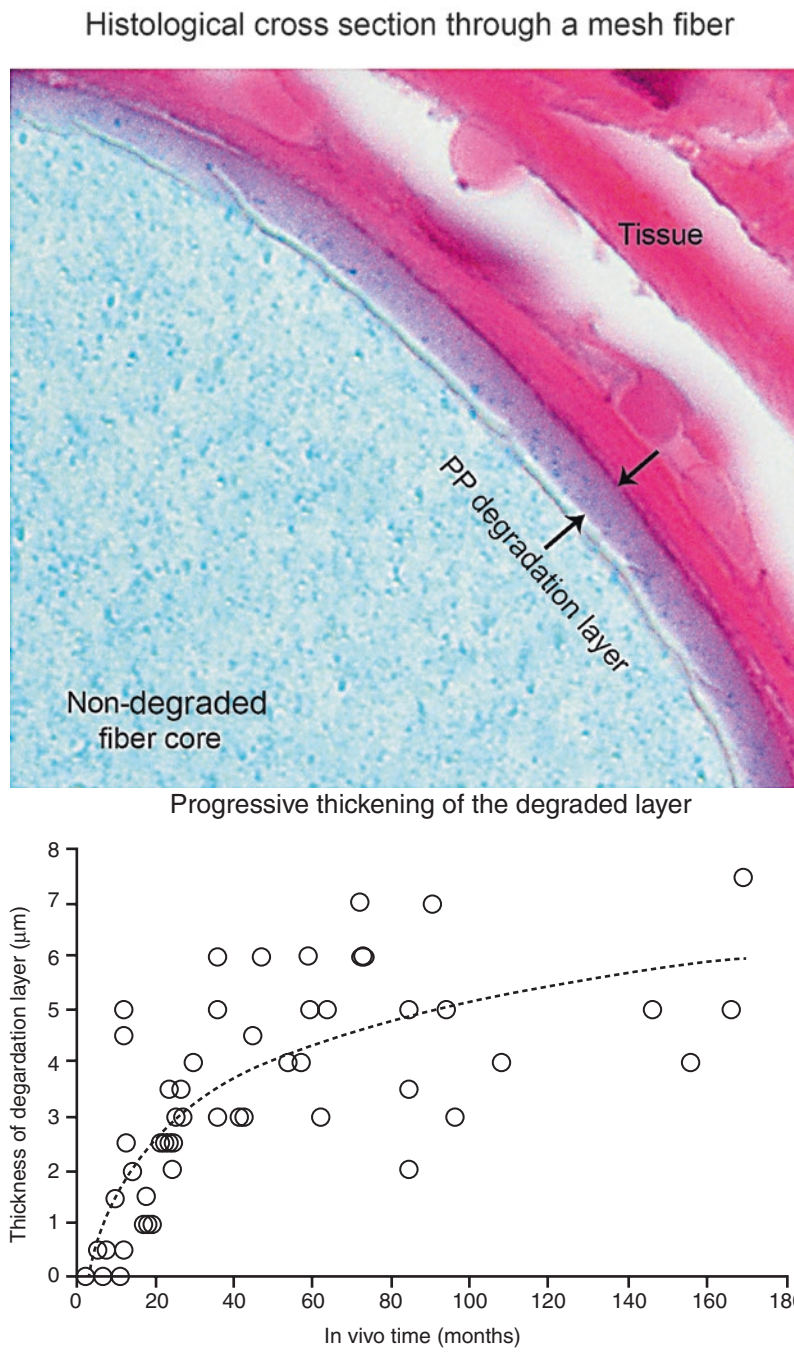

Fig. 21.6
Polypropylene degradation. In the body, polypropylene of mesh fibers undergoes slow aging (degradation) forming an outer shell over the entire surface of the fibers, similarly to a tree bark. In blue fibers, the degraded material retains premanufactured blue granules that were added to resin during manufacture to color the fibers. The material becomes porous and can retain histological dyes (hence, purple color in the image), while the nondegraded core does not stain with the dyes. The layer is brittle and cracks under stresses or spontaneously. Although the layer is only several microns thick, it is structurally compatible with a tube, therefore affecting stiffness of the fibers. Its effect on the mesh grows over time

vaginal mucosa is one of the main complications, average timing of mesh excision is 3–4 years after implantation [51]. For later complications, it needs to be considered that the mismatch between the tissues and the mesh grows over time since the mesh material ages and becomes brittle/stiffer while human tissues become older and weaker.

Overall, although we learned that macroporous mesh performs better than other attempted designs, it is still a foreign object that is recognized by our bodies as such. Its reinforcement capabilities come with a package of negative effects on the tissues. Importantly, over the decades of use, we still cannot predict which

mesh will fold, induce chronic pain, or erode into an important structure. We learned that younger individuals are more prone to develop chronic pain. These younger individuals will also have longer exposure to the risks of complications and aging of both the mesh material and their own tissues. These observations raise a pertinent question, namely, whether there should be a preplanned strategy for the safe removal or replacement of the devices that cannot perform for the lifetime of a patient, as seen with cardiac valves and joint prostheses, which are replaced after a certain period [52–55]. It needs to be remembered that we still have not discovered a technology to replace native tissues. At the present time, the only way to avoid the pitfalls of our still crude implant technology is to use the patient's own tissues as is warranted more often than not.

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Local Anesthesia in Inguinal Hernia: Indications and Techniques

22

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22.1 Introduction

Large epidemiologic and consecutive series and several retrospective and randomized controlled trials [1–8] have shown the superiority of local anesthesia (LA) over general (GA) and spinal-epidural regional anesthesia (RA) for inguinal hernia repair in terms of less postoperative pain, less anesthesia-related complaints, less micturition difficulties, faster discharge, and faster short-term recovery.

So, LA can obviate the stress and risk of GA and insufflation in patients who are at higher risk for. LA provides cost advantages over both RA and GA, regarding both total intraoperative as well as postoperative costs [4, 9, 10].

Despite the advantages in using LA, inguinal hernia repair under this kind of anesthesia is not a common procedure.

According to the Swedish hernia register, a voluntary quality register which now covers more than 95% of all groin hernia operations performed on patients aged 15 years or older in Sweden, during the period between 2002 and 2011, 132.792 elective groin hernia repairs have been performed, subdivided in 21.9% in LA, 10.4% in RA, and 67.7% in GA.

The proportion of patients with RA in the SHR has dropped from approximately 80% in 1992 to 10% in 2012, in favor of GA. This reduction is probably due to results of different studies, reporting an increased number of cardiovascular events after RA compared to local and general anesthesia [5, 11]. Bay-Nielsen et al. showed that 55% of patients dying within 7 days of groin hernia surgery had received RA, even though regional anesthesia was only used in 18% of patients [12]. Furthermore, all fatalities after RA were cardiac deaths with suspected or confirmed myocardial infarction. Prospective studies confirm that bradycardia and cardiac arrest are fatal and important complications associated with spinal anesthesia, with up to seven arrests for every 10,000 patients [13]. For this reason, the European Hernia Society guidelines stated that RA is to be avoided for groin hernia surgery [14].

But, if the research is refined, data show us that LA is the preferred anesthesia in high-specialized hernia center; performing LA in fact requires training, excellent knowledge and confidence in anatomy and technique, patience, and gentle handling of the tissues [15, 16].

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Intraoperative pain seems to be the most common reason for dissatisfaction with local anesthesia [11, 17], but this depends only on the skill of the surgeon; some patients may prove to be unsuitable for local anesthesia, notably very young patients, anxious patients, the morbidly obese, and patients with suspected incarceration or strangulation. Whether scrotal hernias and obese patients are suitable depends entirely upon the surgeon's familiarity with the technique [16].

Remember also that some patients are not eligible for local anesthesia because they are highly emotional so forcing them to an awake surgery should be an error; in this case, a proper sedation, even a general anesthesia if required by patient, is mandatory.

Local anesthesia should not be considered just a surgical step performed by a surgeon, but it is quite a philosophy, like a methodology to approach the patient, in which the patient is the center of the attention and all the people in the operating theater work with the aim to reduce the patient perception of undergoing surgery, not only the pain feeling.

So, the anesthetist and nurse should talk to and distract the patient and be ready to proceed with a sedation, if necessary, case by case. Playing soft and lounge music could be a way to relax the patient.

The circulating and scrub nurse should set the surgical instruments and field with discretion and in silence, to avoid inspiring fear in the patient with disturbing noise.

The patient should be covered and protected from a jump in the temperature, as far as it is possible: for example, disinfection solution should be warmed to avoid shivers. Lights in the OR should be soft, with exception for those for the operating table that should be pointed and turned on just when the field is already done.

Furthermore, in surgical team very close, surgeon can abstain from calling instruments: their names (e.g., scalpel knife, scissors, and so) could suggest dread concept in the patient.

In other words, cooperation in the surgical team should be so harmonious that patient perception by eyesight, by hearing, by pain, and by touch feeling is reduced to minimum.

Only in this way the patient at the end of the procedure will be able to get up and go home satisfied. This is the real mini-invasive surgery philosophy and approach.

22.2 Personal Experience

We proposed inguinal hernia repair under local anesthesia for the first time in 1988 [18, 19], and nowadays, after a large experience with more than 8000 surgical procedures for abdominal wall pathology (by both open and laparoscopic approach), from simple cases to very complex situations, we set up a real "tailored" approach [20].

In simple words, we try to find for every single patient the more suitable approach (laparoscopic or open, anterior, posterior, or combined), anesthesia, kind of mesh (absorbable or not absorbable, synthetic, composite, or biological), and fixation of the mesh (absorbable or not absorbable suture, fibrin glue, or sutureless).

22.3 Indications

We usually use the following criteria for select patients for LA surgery:

- Primary inguinal hernia, not complicated and reducible. If not reducible we ask for a slight sedation; if strangulated we require deep sedation or GA.
- Recurrence inguinal hernia: according our classification [21].
- Size: all sizes, except giant inguinoscrotal hernias with loss of domain that require GA.
- Weight: obese patients, with BMI over 30 kg/m^2, are excluded.
- Age: only adults (>18 years old) because children are not compliant.
- Compliance of the patient: the surgeon has to inform the patient previously and properly that during the procedure, he will be awake and conscious; he could feel handling in the region of the surgery, like touching, stretching, or pushing; and he should not oppose to

these perceptions. In cases of easily frightened or panicking patients, we usually ask the anesthetist to give some sedation or we propose a different kind of anesthesia, in very selected patient (GA or SA).

Obviously, LA is contraindicated in patients with previous allergic reaction to it.

22.4 Surgical Technique

We normally use an anesthetic solution with 10 mL of 1% mepivacaine without adrenaline, buffered with 10 mL of sodium bicarbonate (so the concentration is 0.5%) in a 20 mL syringe with a 20 G spinal needle for skin and superficial subcutaneous infiltration; so with just one prick, it is possible to perform anesthesia along all the incision lines and superficial planes (Fig. 22.1). We buffer local anesthetic with sodium bicarbonate to reduce burning sensation and improve patient satisfaction.

We choose mepivacaine for its low risk in cardiopathic patients and for its fast onset effect.

After skin incision, we usually use a watered-down solution for a step-by-step infiltration: 40 mL of ropivacaine and 60 mL of 0.9% saline (so the concentration is 0.4%). In this step, ropivacaine is selected for its long-term effect (about 6 h) and for the pain control in the postoperative time.

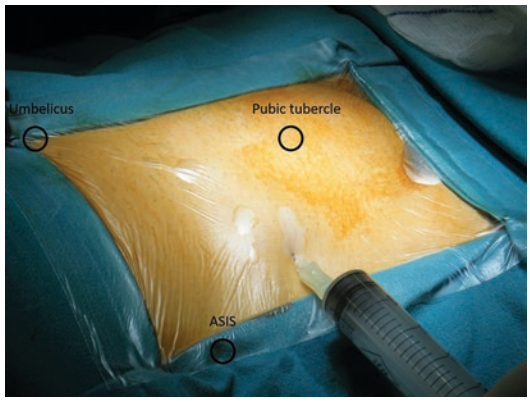

Fig. 22.1 Anatomical landmarks in right inguinal region. ASIS: anterior superior inguinal spine. The skin and subcutaneous infiltration is done with a 20 G spinal needle

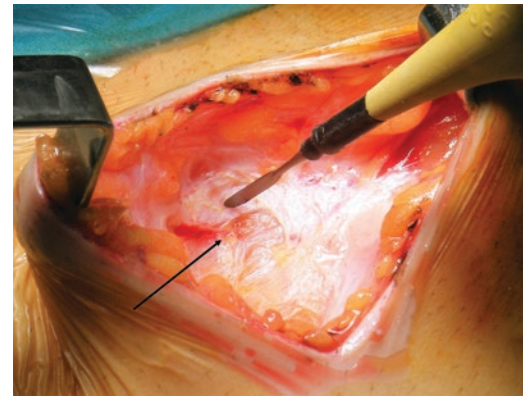

Fig. 22.2 The external femoro-cutaneous nerve piercing the Scarpa's fascia is visible

The external femoro-cutaneous nerve is identified, infiltrated, and, if possible, preserved during the subcutaneous dissection (Fig. 22.2). Its identification sometimes is very challenging because it is very thin; the trick for its recognition is looking for its vasa nervorum.

During this step, it is important to remind that external oblique aponeurosis is very sensitive, so first assistant is required to pull up with the retractors so that the aponeurosis is not touched by the cautery during the dissection of subcutaneous.

Before proceeding with the opening of the inguinal canal, the external oblique muscle aponeurosis is properly infiltrated so that it is dissected from the nerves running above it in a blunt way (Fig. 22.3). For the same reason, we prefer always to open it with the scalpel and the scissors, never with the cautery.

Identification, infiltration, and respect of the three sensitive nerves of the groin region (iliohypogastric, ilioinguinal, and genital branch of the genitofemoral nerve) is mandatory for a pain-free procedure and optimal patient satisfaction, but it is important also for the postoperative pain.

Studies reporting the results of the role of the identification of all three inguinal nerves [21] concluded that identification and preservation of all the three nerves during open inguinal hernia repairs reduces chronic incapacitating groin pain to less than 1%, and the risk of developing inguinal chronic pain increased with the number of nerves concomitantly undetected [21].

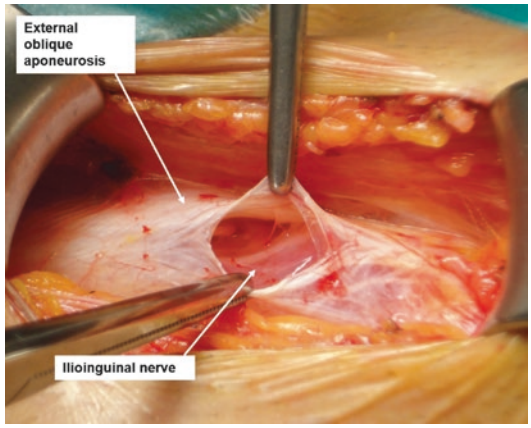

Fig. 22.3 Left inguinal region: incision of the external oblique aponeurosis and the ilioinguinal nerve is visible running underneath

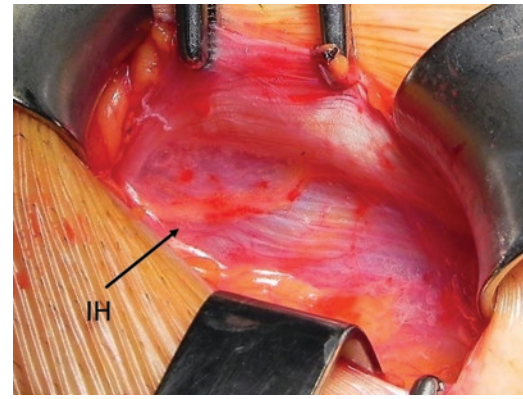

Fig. 22.5 Right inguinal region: iliohypogastric (IH) nerve running underneath the external oblique aponeurosis, along the conjoint tendon

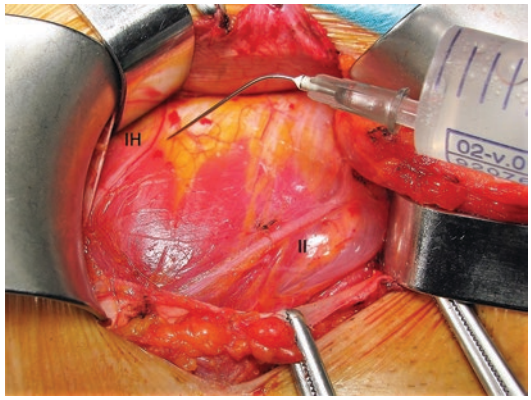

Fig. 22.4 Left inguinal region: after the external oblique aponeurosis is open, identification of iliohypogastric (IH) and ilioinguinal (II) nerve

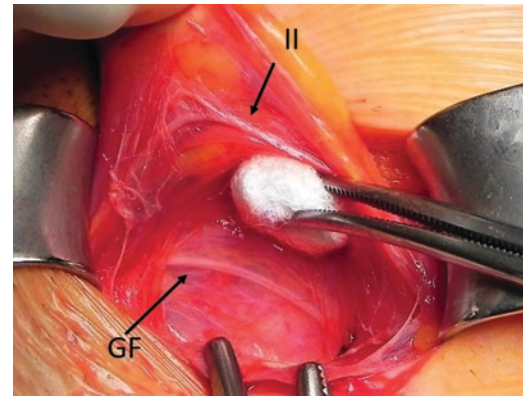

Fig. 22.6 Left inguinal region: the ilioinguinal (II) nerve runs ventrally to the spermatic cord, the genital branch of genitofemoral nerve (GF) runs parallel to the blue line (BL), along the inguinal ligament

Evidently, the preservation of nerves requires a perfect knowledge in the anatomy of the inguinal canal. Iliohypogastric nerve pierces the internal oblique muscle in a point placed at a mean of 2.4 cm cranially to the internal ring, and it is possible to be identified running along the conjoint tendon, underlying the external oblique aponeurosis (Figs. 22.4 and 22.5), and perforating it at a mean of 3.8 cm cranially from the external ring.

Ilioinguinal nerve runs parallel with iliohypogastric nerve, caudally to it. In 57% the ilioinguinal nerve pierces the internal oblique muscle laterally closed to iliac spine. In the other 43%, the ilioinguinal nerve pierces the internal oblique muscle just laterally from the internal ring. The ilioinguinal nerve runs ventrally and parallel to the spermatic cord (Figs. 22.4 and 22.6), and it leaves the inguinal canal by passing through the external ring.

The vast majority of genital branches of genitofemoral nerve enters the inguinal canal laterocaudally through the internal ring in the frontal plane and then joins the cremasteric artery and vein. After running through the inguinal canal at the dorsocaudal side of the sper-

matic cord, it passes through the external ring. The genital nerve is protected by not removing the cremasteric sheet and keeping the easily visible blue external spermatic vein (the blue line) en bloc with the spermatic cord when it is being lifted from the inguinal floor [22] (Figs. 22.6 and 22.7).

During a procedure under LA, handling the peritoneal sac can be painful, and its overstretching could cause even a vagal reaction, so gentle gesture is required (Fig. 22.8), and LA can be used for its hydro-dissection effect. In this way a less traumatic and more safe isolation of the hernia sac from the spermatic cord components is possible [23] (Figs. 22.9 and 22.10).

During a procedure in LA, other steps that can be unpleasant are the preparation of the pubic tubercle (Fig. 22.11), especially if the technique chosen requires a suture on it, and the isolation of the internal inguinal ring, the upper part of the posterior wall, and the medial edge of the external oblique aponeurosis.

Another advantage in LA is that it allows the patient to have a fit of coughing, by surgeon's demand, during the intraoperative exploration, so any hidden and unknown hernia defect (Spigelian and femoral region included) can be discovered or, at least, better explored [23].

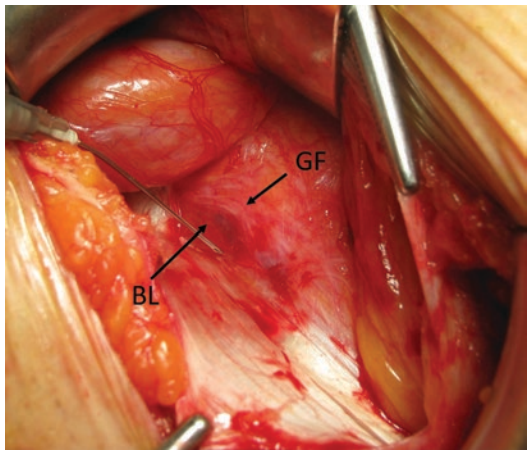

Fig. 22.7 Left inguinal region: genital branch of genitofemoral nerve (GF) runs parallel to the blue line (BL), along the inguinal ligament

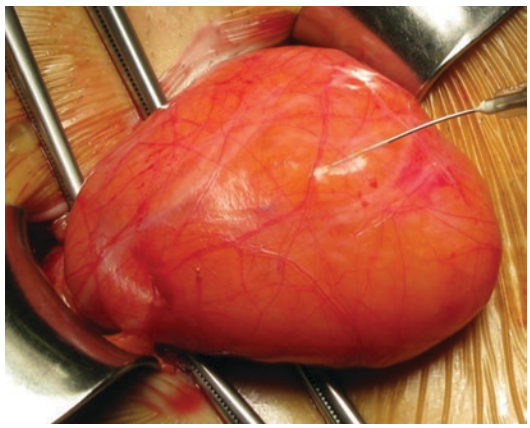

Fig. 22.8 Local anesthesia is advisable in peritoneal sac before handling it

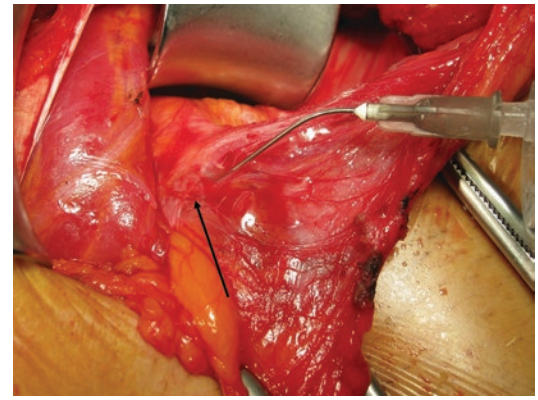

Fig. 22.9 Right inguinal region: local anesthesia is used for hydro-dissection of a small indirect sac

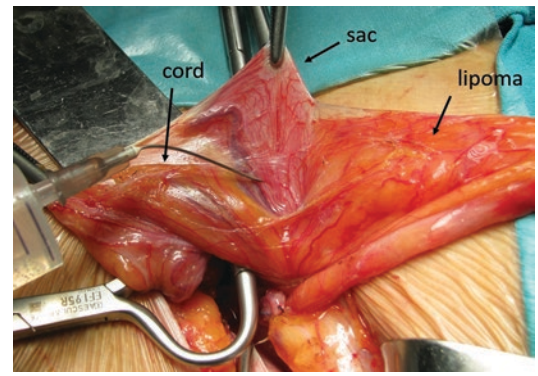

Fig. 22.10 Left inguinal region: hydro-dissection of an indirect inguinal sac from the cord

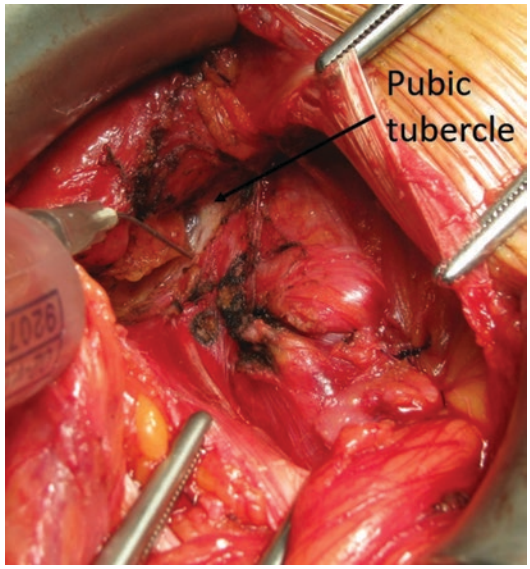

Fig. 22.11 Left inguinal region: isolation and anesthesia of the pubic tubercle

Conclusion

Being able to perform an inguinal hernia repair under a "real" LA is proof of deep knowledge, great professionalism, and serious dedication to this kind of surgery.

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Bassini Repair

23

Enrico Nicolò

23.1 Introduction

In 1889, Edoardo Bassini published his epoch-making monograph of 106 pages, *Nuovo Metodo Operativo per la Cura Radicale dell'Ernia Inguinale.* This chapter describes Bassini's original repair technique.

Edoardo Bassini became personally convinced that the current operations of Wood and Czerny (which consisted of introflexing the hernia sac and loosely closing the external inguinal ring, relying on a single layer of scar tissue, which was further weakened by the passage of the cord) were inadequate to resist intra-abdominal pressure, and that the patients would show signs of recurrence as soon as they abandoned the use of the truss. All of these indicated to Bassini the need for another operative method to achieve and secure the radical cure of inguinal hernia, thus eliminating the necessity of wearing a truss.

Bassini's intuition was that in large external oblique hernias, the inguinal canal became shorter and straight, losing its obliquity and length. Both the internal and external rings became dilated. In this manner, the physiological shutter mechanism was completely lost. Bassini emphasized the need to restore the obliquity and length of the inguinal canal. This consists of physiologically reconstructing the inguinal canal, so that it once again possesses two openings, abdominal and subcutaneous, and two walls, anterior and posterior, through which the spermatic cord passes.

On December 23, 1884, Bassini operated for the first time on an inguinal hernia using his new method. The operation consisted of high ligation and excision of the hernia sac, as well as his new tech-

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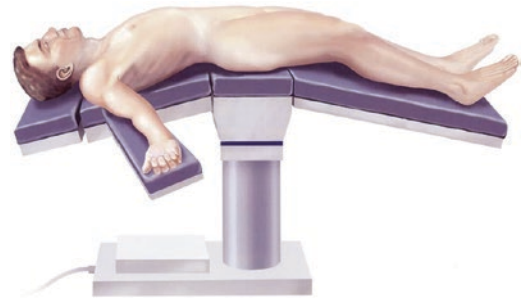
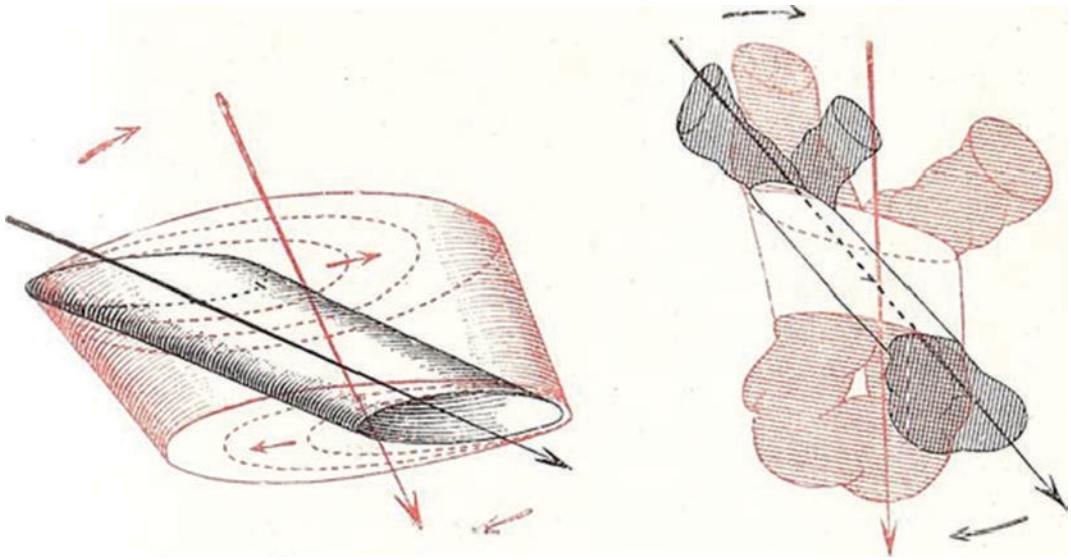
nique of reinforcing the inguinal floor. For the reinforcement of the floor, Bassini separated, from the external oblique aponeurosis above and from the subjacent properitoneal fat, the outer margin of the rectus muscle and the "triple layer" corresponding to the internal oblique muscle, transversus muscle, and "*fascia verticalis Cooperi*" (transversalis fascia), and sutured the "triple layer" to the shelving edge of Poupart's ligament with interrupted, tension-free silk sutures. The two lowermost medial sutures included the outer margin of the rectus muscle, so that the obliquity and the length of the canal were restored and the plasty of the musculoaponeurotic posterior wall would resist intra-abdominal pressure. In his monograph, Bassini reported his astonishing results: an extensive follow-up of more than 90% of his patients for a period of up to 4½ years revealed in a series of 262 patients an infection rate of only 4%, no mortality, and seven recurrences (2.6%). His postoperative care orders included early ambulation, shortened hospital stay, and, most importantly, no truss—the so-called radical cure.

23.2 Position of the Patient

The patient is placed on the OR table in a supine position with the pelvis elevated ("Paziente col. bacino rialzato."—Bassini).

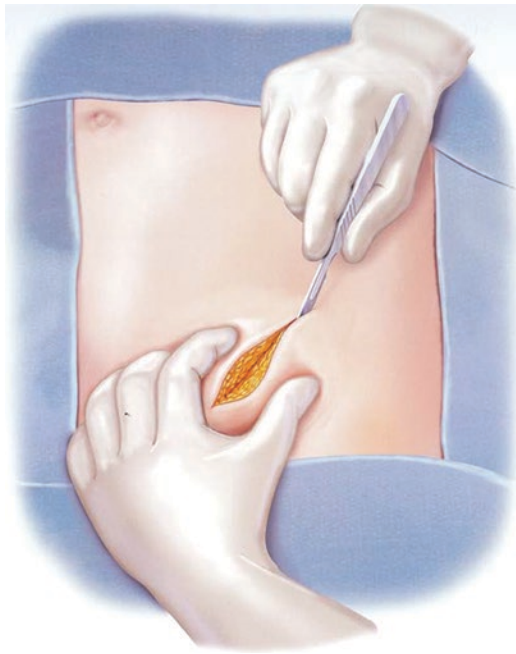
This can be achieved by *breaking* the OR table or by placing a pillow under the patient's buttocks.





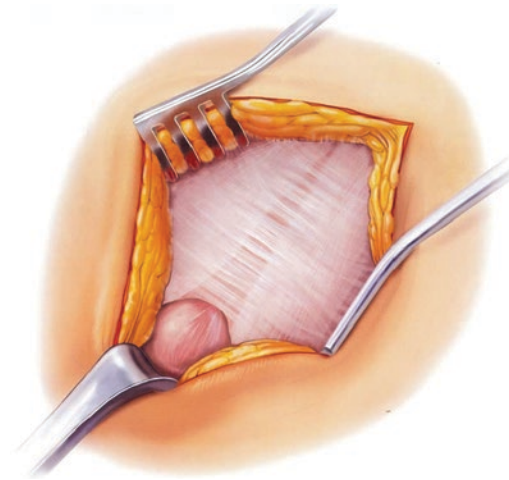
23.3 Skin Incision

A parainguinal skin incision is carried out 2 cm medially and parallel to the Poupart ligament from the anterior superior iliac spine (ASIS) to the external inguinal ring.



23.4 Exposure of the Aponeurosis of the External Oblique Muscle

After the incision of the skin of the subcutaneous tissue and the fascia superficialis (Scarpa's fascia), and after completion of an accurate hemostasis of the superficial epigastric vessels, the whitish and shiny surface of the aponeurosis of the external oblique muscle, the external inguinal ring, and the hernia sac exiting from it are all well exposed. A self-retaining retractor is applied.



23.5 Incision of the Aponeurosis of the External Oblique Muscle: Opening of the Anterior Wall of the Inguinal Canal and of the External Inguinal Ring

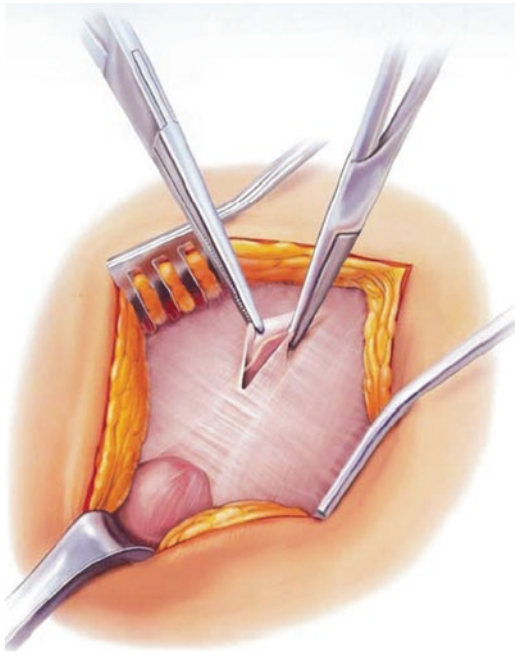
With a knife, a small incision is performed over the aponeurosis at the superior angle of the wound in correspondence with and parallel to the medial pillar of the external inguinal ring. The two lips of the incised aponeurosis are grasped with a Kelly clamp on each side. With a closed scissor, back of the knife, or a Kittner, the aponeurosis is separated from the underlying tissue, internal oblique muscle, and the iliohypogastric nerve, which invariably lies immediately beneath the aponeurosis (Fig. 7).

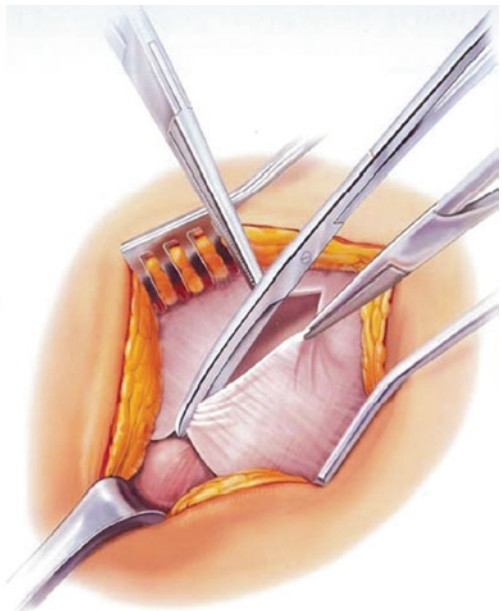
Then the tip of the index finger is inserted in the opening to completely free the aponeurosis from the underlying tissue. The finger is pushed all the way down to the external inguinal ring, breaking through the external spermatic fascia with the fingertip so that the external inguinal ring is completely open;

the aponeurosis is served and split with scissors along its fibers, caudally, all the way down to the external inguinal ring bisecting it, and cranially, about 3 cm the internal inguinal ring (Fig. 8).

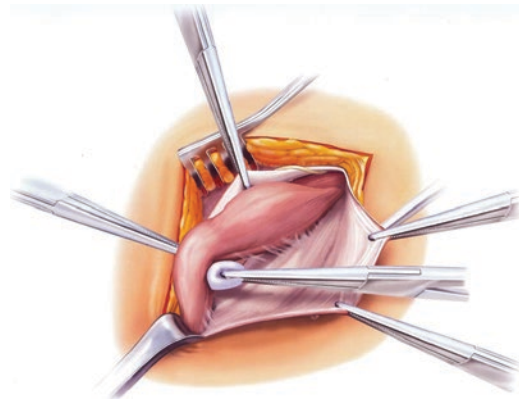
Note: The incision of the aponeurosis is medial and parallel to the skin incision.

The lateral plat of the aponeurosis of the external oblique muscle is larger than the medial flap.



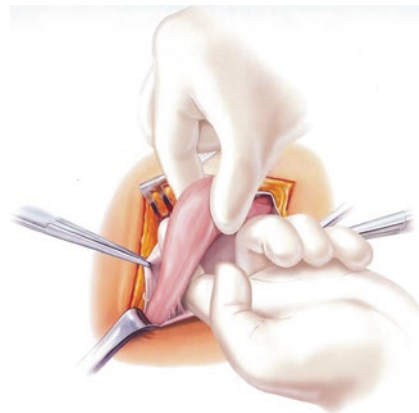


At the superior aspect of the block, in proximity to the internal inguinal ring, the left index and middle fingers on one side, and the right index and middle fingers of the other hand on the other side are positioned under the block, with the thumb of each hand on the surface of the block so that the block is now included between the five fingers. With a special movement of the fingers, digitoclasia, squeezing while sliding the tissue, transversely and longitudinally, the fibers of the cremasteric muscle are dissociated from the cord and the sac easily and completely, in two branches, one lateral and one medial.



The hernia block ("tumor") is formed by the spermatic cord, the hernia sac with its content, a lipoma, the cremasteric muscle and tunica, internal spermatic fascia (vaginalis comune), and accessory layers that may be more or less developed and present.

The entire block is grasped with the thumb and middle finger of the right hand with the help of the index finger, in the most distal part just close by the pubic spine, and is elevated perpendicularly.



23.6 Excision of the Cremasteric Muscle and Suture Ligature of the Stumps

The dissociated lateral and medial branches of the cremasteric muscle can be united medially as one branch, which is clamped proximally and distally. The part in between is excised and removed, and the two stumps suture-ligated to avoid slipping of the ligature and possible bleeding of the cremasteric vessels.

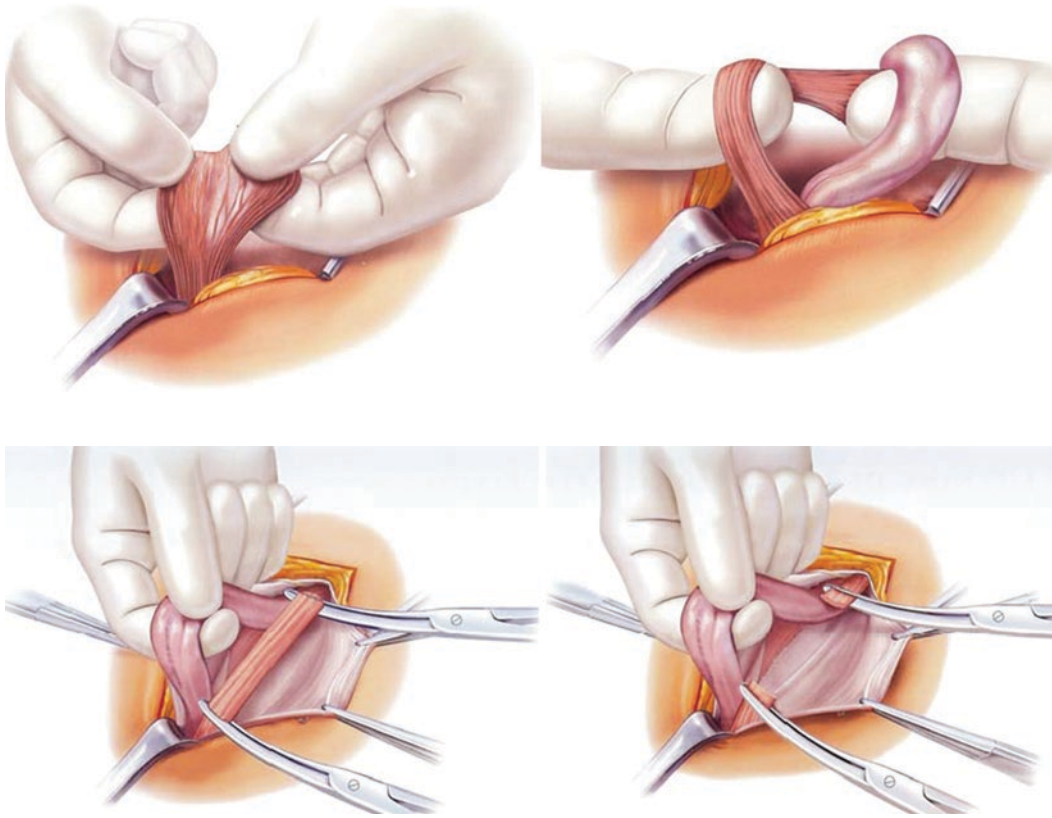
Note: The excision of the cremasteric muscle is indicated because:

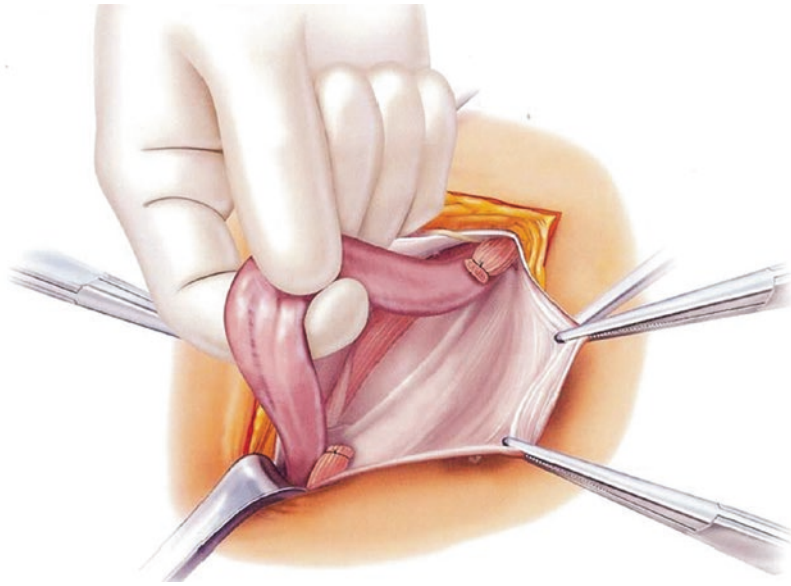
It clearly uncovers the sac and the spermatic cord, enveloped by the internal spermatic fascia (vaginalis comune).

"When the cremasteric muscle is dissociated from the internal oblique muscle, it loses its continuity with the internal oblique muscle, losing its function and consequently atrophies" (Bassini).

Excision of the sac, the lipoma, and the cremasteric muscles will prepare and clear the area for a clean reconstruction of the internal inguinal ring.

With a very small hernia in a young patient, or in small and thin patients, the cremasteric muscle may be left intact and saved (Fig. 17a–c).

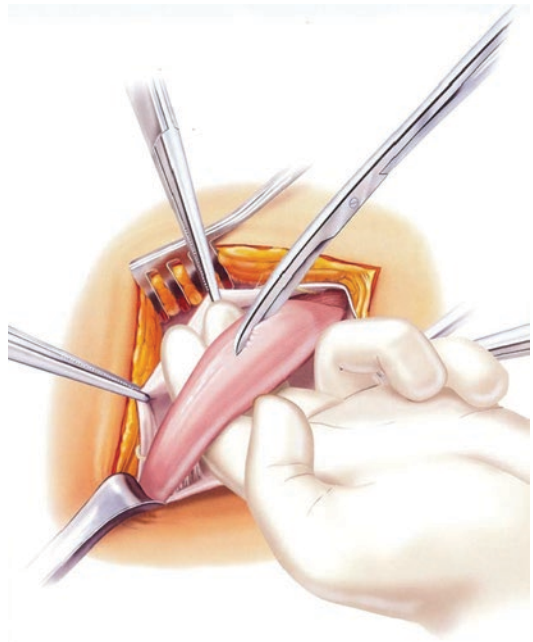




23.7 Opening of the Internal Spermatic Fascia

After the excision of the cremasteric muscle, what remains of the hernia block are the spermatic cord, the sac, and a lipoma, all enveloped by the internal spermatic fascia (vaginalis comune) or transversalis fascia.

Keeping the left index and middle fingers under the cord, the internal spermatic fascia is nicked on top of the cord with the tip of the scissor, incised longitudinally, and separated, so that the sac, the lipoma, and the structures of the cord are uncovered, clearly identified, and easily dissociated (Figs. 18 and 19).



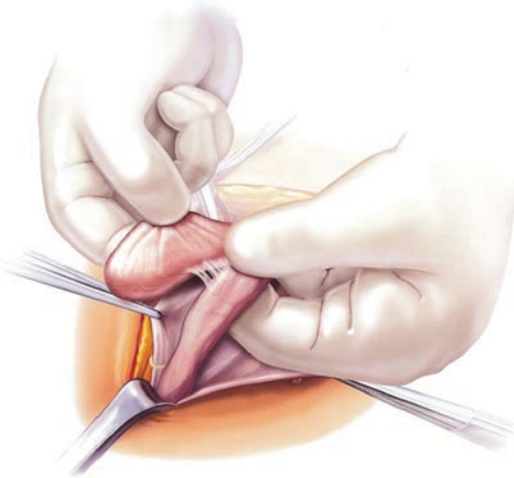
23.8 Isolation of the Sac

The indirect sac is invariably located and found at the medial and superior aspect of the spermatic cord, close to the internal inguinal ring.

With the same method of digitoclasia used for the separation of the cremasteric muscle, starting from the neck and going down the fundus, the sac is bluntly dissociated from the spermatic cord.

If a lipoma (prolapsed properitoneal fat) is present, it is clearly recognized by its yellowish appearance and is easily separated from the sac and the structures of the cord, all the way up to the internal iliac fossa, where it is clamped, severed, excised, and suture-ligated.

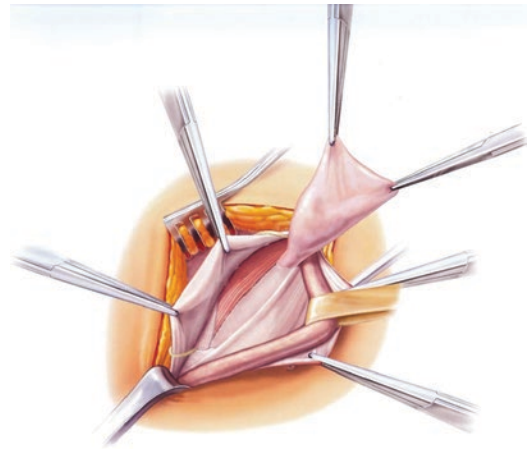
The sac is now completely free all the way up into the internal iliac fossa.



23.9 Opening of the Transversalis Fascia

In the indirect or external oblique hernia, after the isolation of the sac has been completed, the fundus of the sac is pulled upward and laterally by the assistant, who at the same time with the other hand pulls laterally and horizontally the spermatic cord, encircled and protected by a penrose.

With this maneuver, the opening of the hernia defect is well exposed and visible—exteriorized. Close to the defect, the deep epigastric vessels are seen in transparence, covered only by the transversalis fascia in continuity with the neck of the hernia sac (Fig. 21).



Holding two forceps, a smooth one in the left hand and a toothed one in the right hand, the transversalis fascia just adjacent to the medial border of the neck of the sac is grasped and *lacerated*. This creates a small opening on the transversalis fascia and exposes the properitoneal fat. With prudence and care, this small opening is enlarged just enough to expose the deep epigastric vessels, which are now separated from the transversalis fascia and will fall down on the properitoneal fat, on which they run medially and upward (Figs. 22 and 23).

Next, an Allis clamp grasps the triple layer, i.e., the inferior or caudal margin of the internal oblique muscle, transversus muscle, and transversalis fascia.

Using the tip of the right index finger, the operator separates the transversalis fascia from the contour of the neck of the sac all the way down to the internal iliac fossa (Fig. 24).

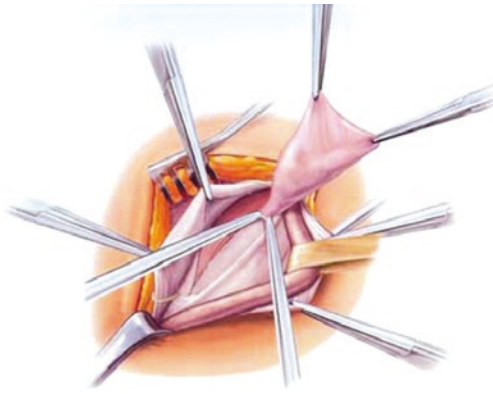
Proceeding medially and caudally in the direction of the pubis, the detachment of the transversalis fascia from the properitoneal fat can be accomplished by using a closed scissor, the back of a knife, a Kittner, or a finger, proceeding medially, at least 3–4 cm until the lateral border of the posterior belly of the rectus muscle is palpated or exposed.

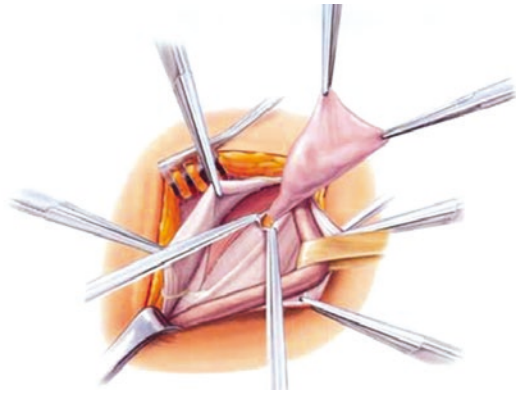
Originally, Bassini (the Maestro) incised the so-prepared triple layer for all the length of the

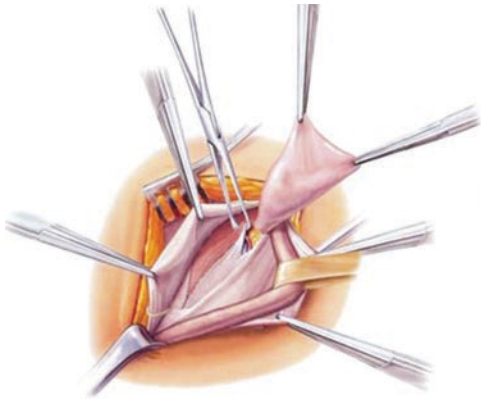
inguinal canal, and parallel to it, so that the transversalis fascia was completely detached from the inguinal ligament.

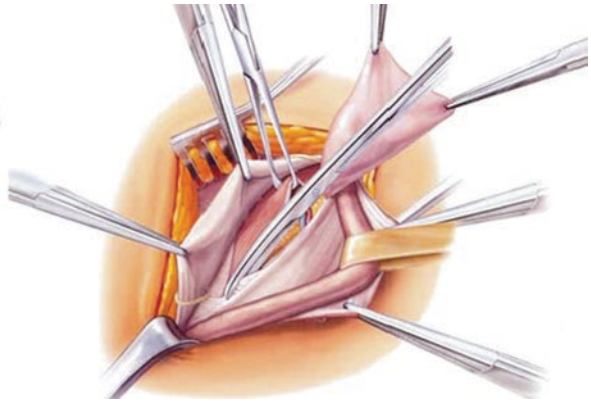
Later on, the Maestro omitted this separation for indirect inguinal hernias only to assess a secure mobilization of the triple layer from the underlying tissue (the properitoneal fat and the peritoneum), and as well for the eventual possible presence of another hernia (vesical, sliding, or femoral).

An Allis clamp grasps the three components of the triple layer—the marginal caudal extremity of internal oblique muscle, the transversus muscle (the conjoint tendon when present), and the transversalis fascia—to keep them together as one (Fig. 25).

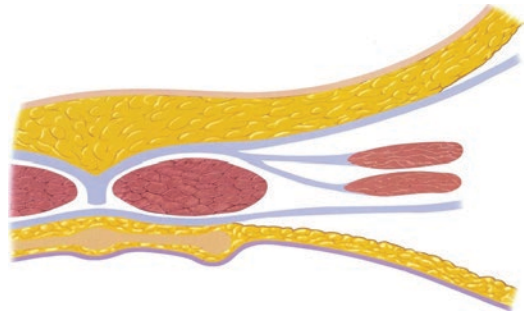








"Then, I detach by dissection from the aponeurosis of the external oblique and from the subserosal adipose connective tissue the external margin of the anterior rectus muscle of the abdomen and the triple layer formed by the internal oblique muscle, transversus muscle, and fascia verticalis of Cooper, until this reunited triple layer can be approximated without difficulty to the isolated posterior border of the Poupart ligament."



23.10 Opening of the Sac Ani

For Bassini, the management of the sac represents one of the most important steps of the operation.

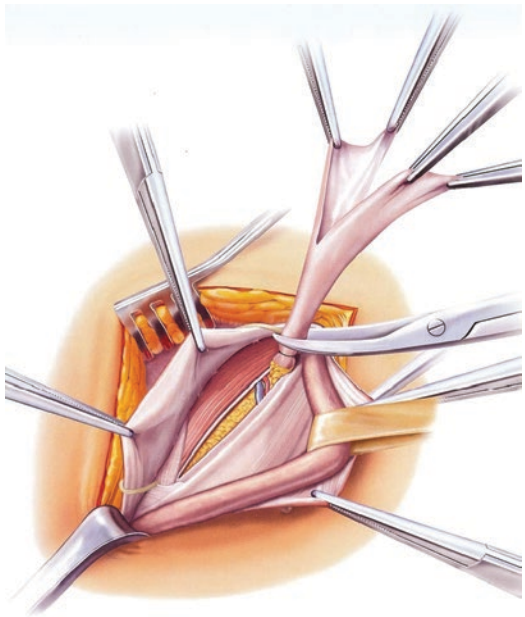
This step consists of suture-ligating the neck of the sac as high as possible beyond its very mouth into the iliac fossa through healthy peritoneum.

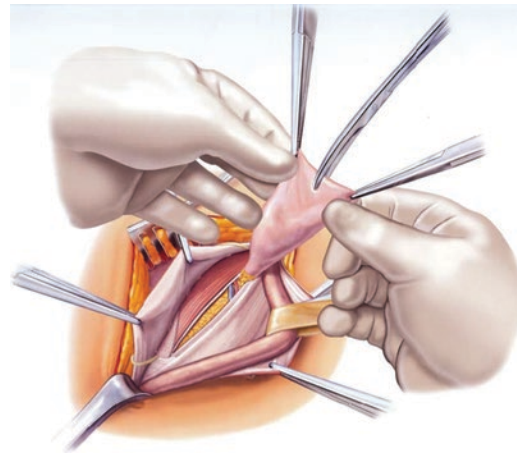
If the ligature is not high enough, a small portion of the sac can be left behind, forming an infundibulum that, under the pressure, can become the site of a new hernia.

Therefore, as a rule, the hernia sac, diligently isolated from the transversalis fascia and the properitoneal fat in its totality, must be highly ligated beyond its neck throughout healthy peritoneum.

Only in a small hernia, or a hernia with a large neck, such a small direct hernia, the sac can be introflected, without opening the peritoneum, over which the posterior wall is reconstructed.

In a larger hernia, the opening of the sac is always recommended.





23.11 Reconstruction of the Posterior Wall of the Inguinal Canal and the Internal Inguinal Ring

The reconstruction of the posterior wall is achieved by suturing the triple layer (internal oblique muscle, transversus muscle, and transversalis fascia) to the isolated posterior border of the inguinal ligament using a filzetta stitch. The first two stitches medially also include the lateral border of the rectus abdominis muscle.

1. Triple layer.
2. Isolated posterior border of the inguinal ligament.
3. Filzetta stitch.
4. The first two stitches medially also include the rectus abdominus muscle.
5. Laterally, the first stitch includes the insertion of the inguinal ligament to the pubic spine, just by the periosteum of the pubic spine, and also includes the ligament of the Colles, and the second stitch also includes the Cooper's ligament.

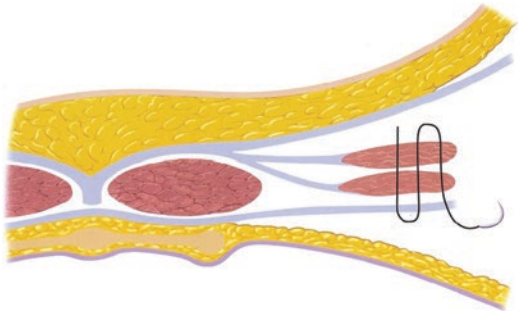
23.12 The Filzetta Stitch

Filzetta stitch is an everting stitch applied as a purse-string suture, which includes the triple layer, “in and out,” and “in and out”. The first “in” starts about 3–4 cm from the outer border of the triple layer and comes “out” including 2 cm of the triple layer, and the second “in-out” is applied at 0.5 cm from the border of the triple layer.

The tied filzetta stitch is neither constrictive nor rigid.

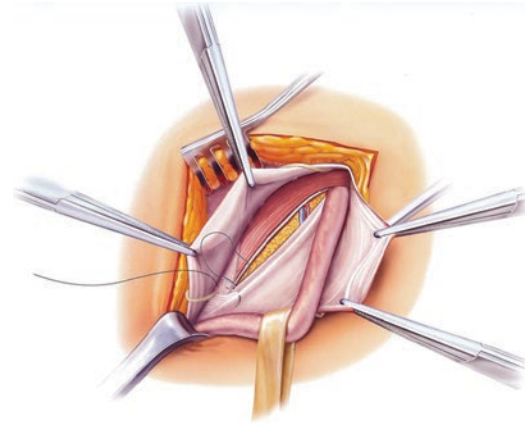
The filzetta stitch, being an everting stitch, will approximate the transversalis fascia of the triple layer in direct contact with the transversalis fascia of the opposing side, the iliopubic ligament and the inguinal ligament, so that the coaptation is between tissues of the same histologic type.

All the knots of the filzetta stitch should be tied on the muscle and not on the inguinal ligament (Fig. 32).



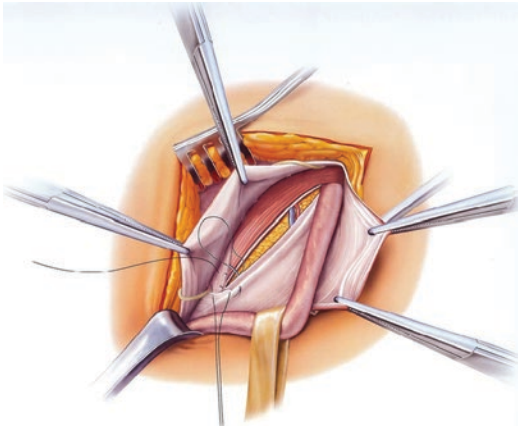
23.13 The First Stitch

The first stitch is applied at the inferomedial corner of the wound. With the left index finger retracting the properitoneal fat and inserted under the transversalis fascia, the right hand is used to needle-transfix first the rectus muscle, and, when present, also the triple layer from outside in. The needle should come from inside out, including 2 cm of the tissue. Once out, the needle again transfixes the triple layer from outside in 0.5 cm from the outer border, when present, or the lateral border of the rectus muscle. This is the filzetta stitch. At this point, the needle is out. Laterally, the needle transfixes the inguinal ligament just at its insertion to the periosteum of the pubic spine and then comes out. The suture is not tied, and the two free ends are held together with a Kelly clamp.



23.14 The Second Stitch

The second stitch is applied 1 cm proximal to the first stitch in the same fashion. Laterally the filzetta stitch includes the rectus muscle 3–4 cm from the border of the triple layer, including 2 cm of the tissue, and then the needle comes out. Then the needle transfixes 0.5 cm of the lateral border of the triple layer, when present, or the lateral border of the rectus muscle, and then comes out. Laterally the tip of the needle is aimed at the pectineal crest, is passed under and includes the ligament of Colles, then transfixes, in total, the isolated posterior border of the inguinal ligament.



23.15 The Third Stitch

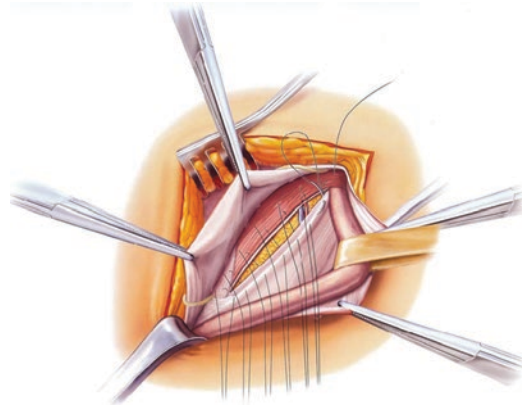
Medially, the third stitch includes only the triple layer. The rectus muscle is no longer part of the inguinal region. Laterally, the stitch includes the isolated posterior border of the inguinal ligament.

We proceed in this way.

23.16 The Last Stitch

The last stitch for the reconstruction of the internal inguinal rings is applied in a slightly different manner. This stitch is not applied in front of the internal opening and parallel to the other stitches but in a more oblique fashion. The needle transfixes obliquely the triple layer, starting at 1 cm above the exit of the cord and at 3–4 cm from its border (filzetta). Medially, the needle transfixes the isolated posterior border of the inguinal ligament, 0.5 cm below the exit of the cord.

When this suture is tied, the newly reconstructed internal inguinal ring will be well calibrated (not too loose or too tight); the cord is moved laterally, closer to the anterior superior iliac spine so that the perpendicular direction from back to front is lost, and the cord does not exit directly from the newly reconstructed internal inguinal ring but takes an oblique course surrounded by the triple layer, and then descending medially in a parainguinal direction (Fig. 36).



The remaining stitches are applied at 1 cm proximal to the previous one in the same fashion, medially and laterally. Usually they are 5–8 in number as needed.

23.17 Tying the Sutures

The ends of all replaced sutures are held up by the assistant, who keeps the two lines of sutures separated by a finger passed between them. The operator takes these threads in a pair, tying them successively, while the assistant depresses the underlying properitoneal fat with a closed Kelly clamp, with a finger or a small flat retractor.

1. Before tying the sutures, the “break” of the operating table is removed; the patient is now lying supine with the legs slightly elevated so that the sutures can be tied with less tension.

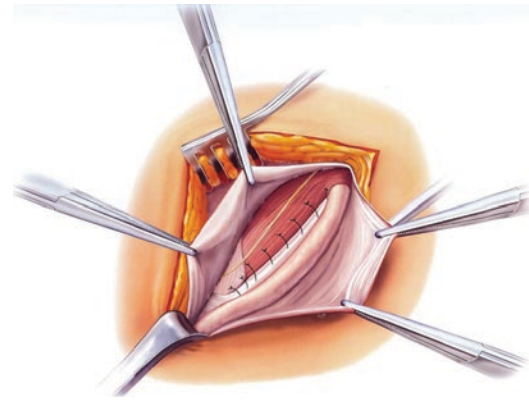
2. The knot should be surgical for a more secure and better calibration of the coaptation of the tissues. Too tight will constrict and compromise the viability of the approximated tissue; too loose will compromise the appropriate healing.
3. The tying of the sutures will start medially, (the first stitch) continuing laterally (to the last stitch) from the site of less tension to that of more tension. If a stitch accidentally breaks during the tying, it can be reapplied much easier.
4. All the knots must fall on the muscle and not on the inguinal ligament. This can be easily accomplished if the operator ties the suture from the other side of the operative table, at the assistant position.

As already mentioned, the first two stitches, medially, must also include the lateral margin of the rectus abdominis muscle.

The last stitch, the most lateral, is applied more obliquely than the others, as described, for the reconstruction of the internal inguinal ring. When this suture is tied, the spermatic cord is moved slightly lateral, close to the ASIS, and in this way will exit from the neo-formed internal inguinal ring in an oblique fashion. The cord is surrounded by a snuggling of the musculoaponeurotic tissue, well calibrated, not too tight as that would constrict the blood supply of the testis and not too loose as that would jeopardize a recurrence.

The freedom of the cord can be tested by moving it, so that it should run freely on the newly formed internal inguinal ring.

After the sutures are all tied, the excesses of the sutures can be cut above the knot.



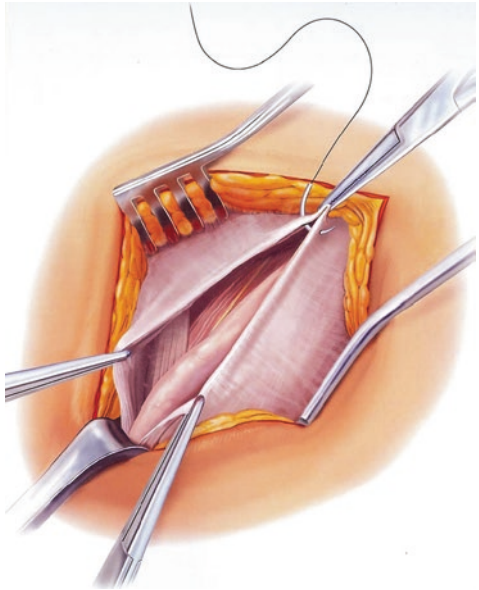
23.18 Reconstruction of the Anterior Wall of the Inguinal Canal and of the External Inguinal Ring

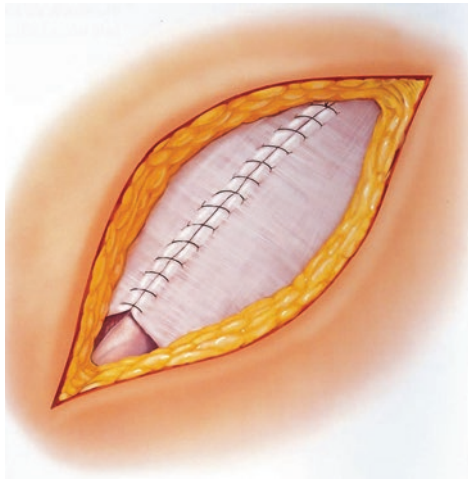
A Kelly clamp is applied superiorly at the angle of confluence of the two flaps of the aponeurosis of the external oblique muscle, another Kelly at the lower part of the medial flap, and another at the lower part of the lateral flap of the aponeurosis.

The upper Kelly clamp is held up by the operator with his left hand, and the assistant holds up the two lower clamps with one hand, while with two fingers of the other hand depresses and protects the spermatic cord.

The free medial flap of the aponeurosis is sutured to the lateral flap in a continuous manner and from lateral to medial starting at the upper corner. The needle should include 2 mm of the margin of the aponeurosis in each side and about 3 mm apart from one stitch to the other. The last stitch should approximate the

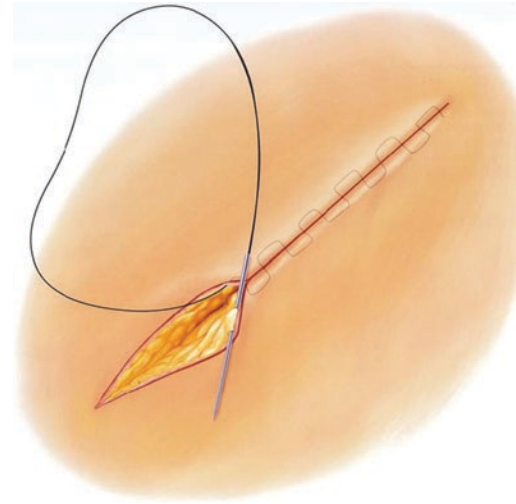
medial and lateral pillar for the reconstruction of the external inguinal ring. This should accommodate the tip of the little finger, and the cord should move freely throughout the newly formed external inguinal ring. If the ring is too tight, it will compromise the blood supply to the testicle (Fig. 39).

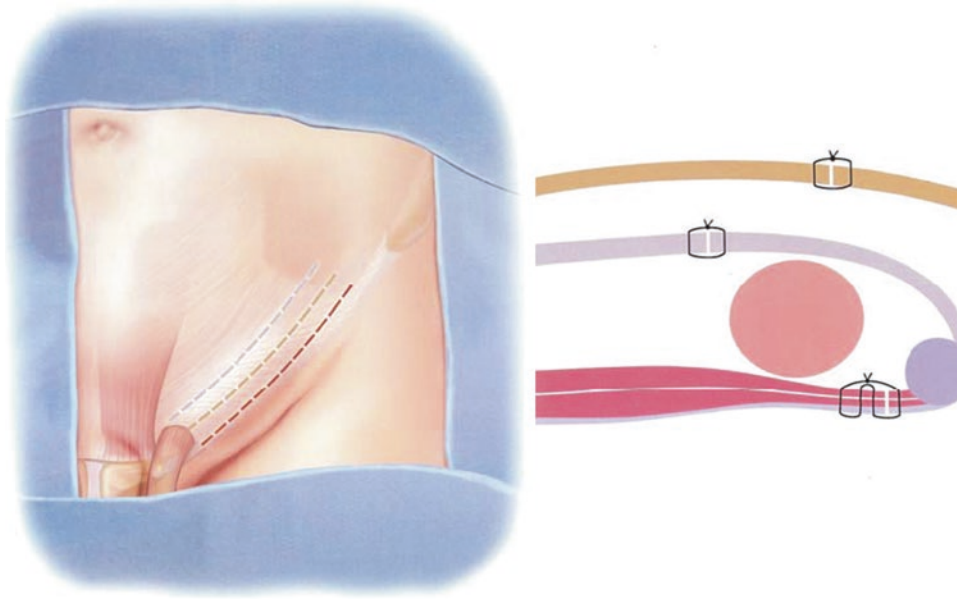




23.19 Closure of the Skin

The skin is closed with subcuticular stitches.





Note: The suture line that approximated the two flaps of the aponeurosis lies medially to the skin suture line and medial to the suture line of the deep repair on the inguinal ligament, so that the three suture lines do not overlap but are scattered, making them more resistant to the increased intra-abdominal pressure (Fig. 43).

The Shouldice Repair

24

Paolo Bocchi

24.1 Introduction

The Shouldice repair for inguinal hernia, also referred to as the 'Bassini-Shouldice' or the 'Canadian repair', was performed for the first time in 1936 by Dr. Edward Earle Shouldice. It was later modified in 1952, when it finally acquired its current aspect. At the time, the Shouldice repair undoubtedly represented the ultimate milestone of inguinal hernia repair [1].

The Shouldice repair does not make use of any prosthetic material, and it remains today the gold standard of pure tissue repair for inguinal hernia [2, 3]. This technique applies to both indirect and direct inguinal hernias.

The Shouldice repair revolutionized hernia surgery as it allowed the use of local anaesthesia, the patient's early ambulation and the quick resumption of life routines.

The Shouldice repair is also considered an evolution of Bassini's operation [4]. Until this evolution, Bassini's operation was widely performed by surgeons, but so very often misunderstood, misinterpreted and poorly performed that it became known as a 'corruption of the Bassini operation' [5].

In the Shouldice repair, the principles of the Bassini operation are followed, in particular with regard to the opening of the posterior inguinal wall during the dissection, and to the suture of the true, thin transversalis fascia (which is a part of the endopelvic fascia) and the fasciae, and muscles of the transversalis and internal oblique muscles to the inguinal ligament all together (the so-called triple layer) during the reconstruction. This suture is performed with four lines. It minimizes the traction and progressively reinforces the new posterior wall of the inguinal canal.

The Shouldice repair corrected several shortfalls of the Bassini technique:

1. The incision of the cribriform fascia distal to the inguinal ligament permits further mobilization of the shelving edge of the inguinal ligament and reduces the traction on suture lines; this incision of the cribriform fascia may reveal a femoral hernia which may otherwise be missed.
2. Continuous suture lines distribute tension and traction on the muscles and fasciae and progressively correct possible imperfections and gaps within the sutured layers.
3. The internal ring is not only reinforced and calibrated by using the lateral cremasteric stump which is swung around the spermatic cord like a scarf.

The careful dissection needed by this technique is one of the very reasons for the improvement of its results.

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24.2 Local Anaesthesia

The use of local anaesthesia is central to the encouragement of a gentle and atraumatic surgical approach as well as avoiding excessive traction on tissues. Local anaesthesia also allows to test a repair in a cooperating patient.

The anaesthesiologist can associate sedation to maintain the patient in a completely relaxed state.

The technique used is called 'sandwich anaesthesia': 10 mL ropivacaine solution for injection 10 mg/mL subcutaneously before entering the operating room, followed by 1% lidocaine up to 60 mL during the dissection, and then again 100 mg in 10 mL of ropivacaine injected subcutaneously to conclude the surgery.

24.3 Surgical Technique in Male Patients

It is thanks to Dr. Robert Bendavid that the Shouldice repair technique spread in Europe in the 1980s. I have, myself, learnt the technique, visiting him in Canada in those years. The following description derives from Bendavid's work [6].

24.3.1 Dissection

The skin incision runs anterior to the inguinal ligament rather than 2–3 cm superior to it. This incision, from experience, provides a better access to the working area of the groin. The incision will be 6–10 cm in length. The external oblique aponeurosis readily appears under the subcutaneous tissue.

One proceeds then with a subaponeurotic infiltration of lidocaine when the external oblique aponeurosis is still intact to block the ilioinguinal and iliohypogastric nerves as well as the genital branch of the genitofemoral nerve.

As soon as the cribriform fascia, in the region of Scarpa's triangle, is opened, the inguinal ligament becomes more mobile. If present, a femoral hernia can now be identified.

Proceed with the incision of the external oblique aponeurosis up to the external inguinal ring, and prolong it 2–3 cm lateral to the internal ring. This incision has to be as medial as possible to preserve a larger lateral flap of the external oblique aponeurosis.

The incision shows the internal oblique muscle, the spermatic cord and the sulcus of the inguinal ligament.

Gently separate the external oblique aponeurosis from these elements with a peanut gauze. It is now that the ilioinguinal nerve can be identified along the cremaster and the iliohypogastric nerve on the internal oblique muscle.

After infiltrating the cremasteric fibres with lidocaine, it is incised longitudinally to obtain two flaps: a medial flap and a lateral one with the spermatic cord lying on top of the longitudinal mid-portion of the splayed cremasteric fascia (muscle). The cord can now be lifted with a Penrose drain. An indirect hernia sac, if present, becomes easily identifiable.

The medial flap is resected with adequate haemostasis. The lateral flap is sectioned between two clamps. The ilioinguinal nerve is preferably sectioned and ligated separately, if need be. Two stumps remain: a proximal (lateral) and a distal (medial) one.

The two cremaster muscle stumps are doubly ligated: it is between these two ligatures that the needle will pass throughout at the end of the first suture line.

The external spermatic vessels and the genital branch of genitofemoral nerve can be ligated separately or together with the cremasteric lateral flap, depending on their anatomic configuration.

It is now necessary to search for an internal oblique hernia sac. If a sac is present, it has to be separated from the spermatic cord, isolating it as much as possible inside the internal inguinal ring in the preperitoneal space. Resection and ligature of the sac are not necessary; furthermore, they could lead to early postoperative pain.

Once the indirect hernia sac disappears deep to the internal inguinal ring, the cord has to be retracted laterally.

Now the posterior wall of the inguinal canal, represented by the triple layer, is in full view. This area is vaguely shaped like a triangle (Hesselbach's triangle): the base in the latero-

cranial position, the triangle's apex at the pubic tubercle, the two sides represented medially by the internal oblique muscle and laterally by the inguinal ligament. The inferior epigastric vessels run just a little underneath the transversalis fascia at the base of this triangle.

Whether or not a direct hernia is present, the transversalis fascia must be incised from the internal ring to the pubic tubercle. The transversalis fascia should be incised closer to the oblique muscle rather than to the inguinal ligament for two main reasons: firstly, in case of accidental lesion of the epigastric vessels, the ligature will be easier if more distal from the iliac vessels, and, secondly, in order to leave a larger portion of the fascia towards the inguinal ligament (iliopubic tract).

The fascia's portion closer to the inguinal ligament is the iliopubic ligament (iliopubic tract, Thomson's ligament), and it is generally quite resistant.

In case of a direct hernia, the transversalis fascia is quite thinned out. Any excessive, thin or redundant portion of the posterior wall should be excised.

Once the transversalis fascia is incised, the preperitoneal fat can be seen as a glistening yellow layer.

With the help of a gauze, the fat is separated in order to medially highlight the posterior aspect of the transverse and rectus muscles and laterally the posterior aspect of the iliopubic tract.

Often, a small vein, called by Bendavid 'the iliopubic vein', runs adherent and parallel to the deep portion of the iliopubic tract. This marginal vein can cause disturbing bleedings and must be avoided.

24.3.2 Reconstruction

The reconstruction of the posterior inguinal wall is done with four continuous lines using two non-absorbable sutures. The first suture is used for the first two lines and the second suture for the third and fourth lines.

The first line of continuous suture starts at the level of the pubic tubercle (Fig. 24.1).

Firstly, the needle passes through the more medial corner of the iliopubic tract and then through the so-called triple layer and the lateral edge of the rectus.

The suture continues towards the internal ring. It must include, laterally, the iliopubic tract and, medially, the posterior aspect of rectus muscle for the first two or three sutures, and then, again, the iliopubic tract and the posterior aspect of the transverse and internal oblique muscles, up to the internal inguinal ring (Fig. 24.2).

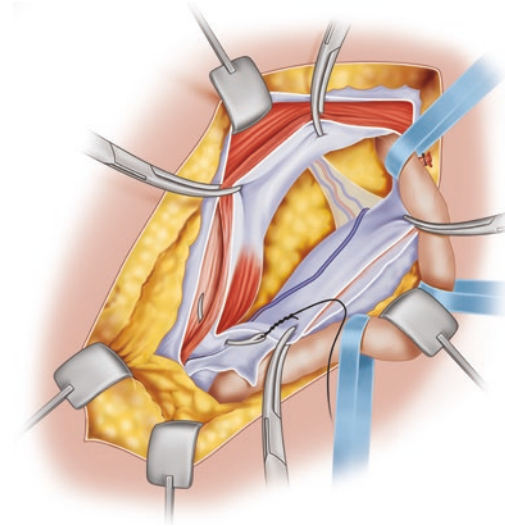

Fig. 24.1 Beginning the first line of suture

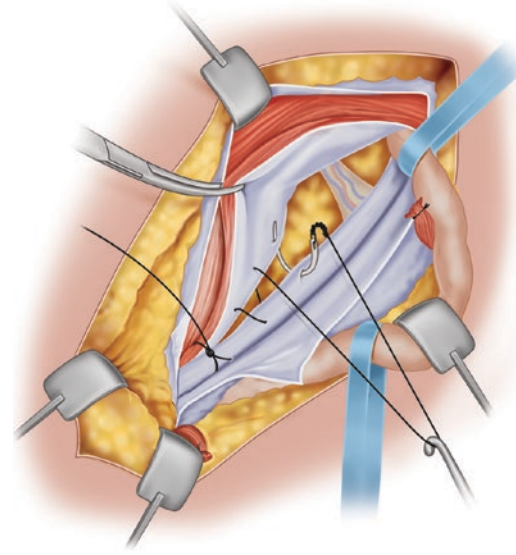

Fig. 24.2 Continuing the first line of suture

This first suture line is correctly done if the border—composed by the transversalis fascia, the transverse muscle, and the internal oblique muscle—is not included in the suture and remains medially free by forming an edge or a flap.

The last bite of the first suture line will incorporate the proximal stump of the cremaster muscle before crossing over to start the second line of suture at the free edge or border just described, just medial to the internal ring (Fig. 24.3).

The continuous suture (second line) goes back (Fig. 24.4) towards the pubic tubercle and includes medially the triple layer left free earlier (the border formed by the transversalis fascia, the transverse muscle and the internal oblique muscle) and the area of the inguinal ligament up to the initial tie. It is then knotted to the tail clamped earlier (Fig. 24.5).

The posterior inguinal wall is now reconstructed.

The third line of suture starts at the level of the internal inguinal ring where it will be knotted, clamping again the tail of the suture. This suture line continues towards the pubic tubercle remaining slightly more superficial than the previous one. The internal oblique muscle is sutured again to the area of the inguinal ligament, but more superficially than the previous inguinal suture line (Fig. 24.6).

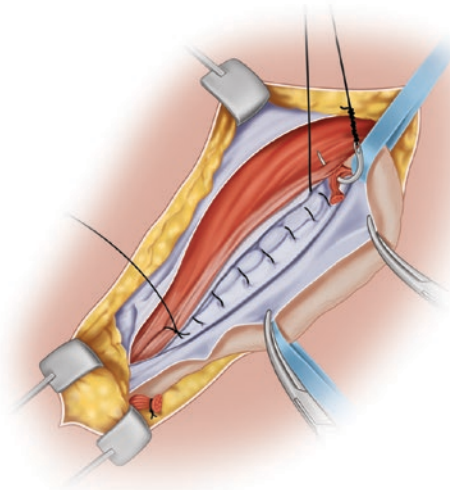

Fig. 24.3 End of the first line with the doubly ligated lateral cremasteric stump

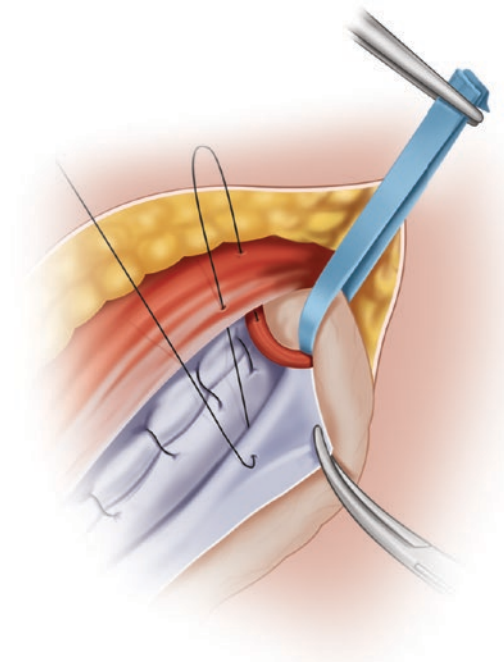

Fig. 24.4 Beginning the second line of suture

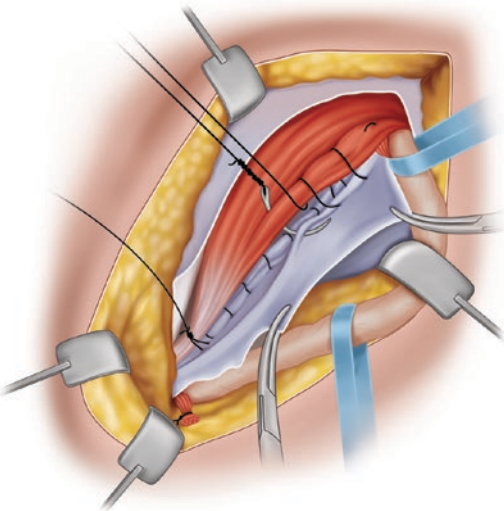

Fig. 24.5 Continuing the second line returning to the pubic tubercle

The division of the cremaster may cause a drooping of the ipsilateral testicle. To avoid this event and support the testicle, the most distal stitch of the third suture line can include the distal cremasteric stump previously doubly ligated.

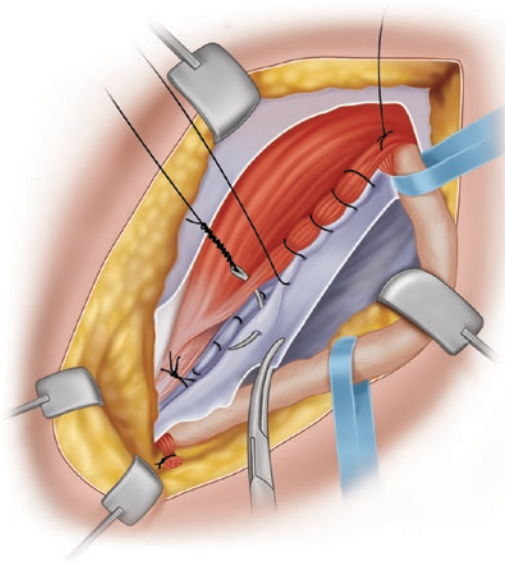

Fig. 24.6 The third line of suture

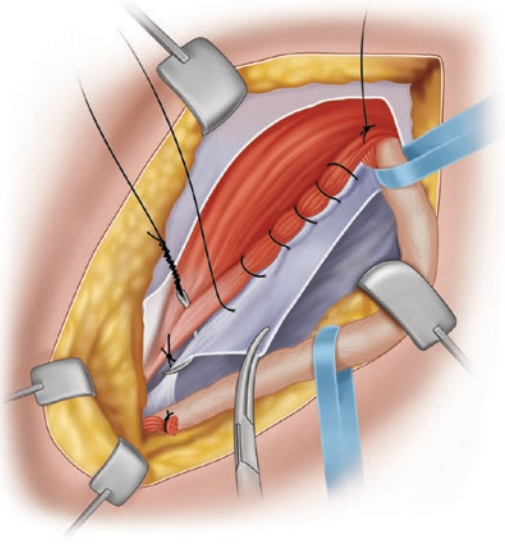

Fig. 24.7 The last stitch of the third line of suture

At the level of the pubic tubercle, the suture returns towards the internal ring (fourth line) remaining even more superficial than the third suture line (Fig. 24.7).

Arriving at the internal ring, the fourth line has to be knotted to the suture tail knotted at the beginning of the third line (Fig. 24.8).

The posterior wall is now extremely resistant.

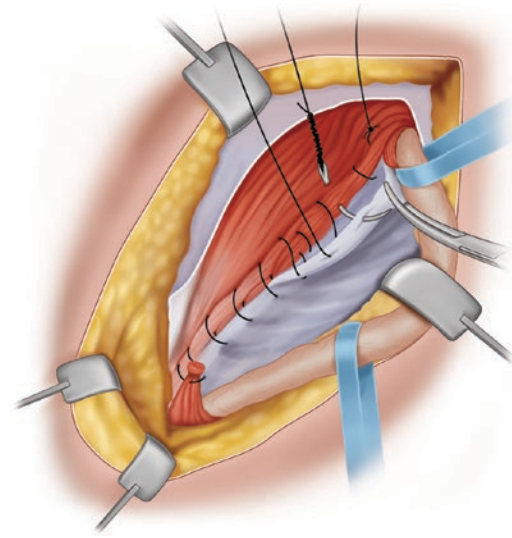

Fig. 24.8 Fourth (and last) line of suture

The cord is repositioned in its original site. Now the external oblique muscle aponeurosis can be re-approximated.

To better balance the external ring, it is appropriate to start the suture of the external oblique muscle aponeurosis from the new external inguinal ring and proceed laterally.

The repair ends with another subcutaneous injection of 100 mg of ropivacaine to prolong the effects of local anaesthesia.

At the end of surgery, the patient can get up from the operating table with some assistance.

Generally, antibiotic and antithrombotic prophylaxis are not necessary.

24.4 Shouldice Repair in Female Patients

It is a well-known fact that inguinal hernia occurs in females with a 10 times lower incidence than in males [7]. The posterior wall of the female inguinal canal is generally more resistant than the male ones, resulting in much lower direct hernia occurrence [8].

In females the Shouldice repair is performed mainly following the same steps used in males, although, the different anatomy demands some distinctions in the surgical approach.

24.4.1 Dissection

The incision of the external oblique aponeurosis shows the round ligament of the uterus surrounded by fibres and small vessels. Its size varies greatly among patients: it could be just residual or sized almost as a spermatic cord.

If the round ligament is only residual, it can be clamped and accurately ligated. If it is of noticeable size, it should be treated as a spermatic cord and preserved accordingly.

Search for an indirect hernia sac and dissect it from the round ligament up to the internal ring as high as possible as done in male patients.

Open the transversalis fascia using the same criteria applied in male patients.

In the majority of cases, the Hesselbach triangle is narrower than in males because of the female pelvic conformation. The Henle's ligament (that is a reinforcement of the transversalis fascia) is more evident, thus making unnecessary—counterproductive, actually—the complete opening of the posterior wall up to the pubic tubercle.

Preserving the genital branch of the genitofemoral nerve is particularly important in females. In fact, its dissection may impact on the sensitiveness of the labium majus [9].

24.4.2 Reconstruction

The reconstruction is done with a similar technique and accuracy (four lines of suture) as in male patients.

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25 Primary Inguinal Hernia: Sutureless Open Anterior, Trabucco Repair

Giampiero Campanelli, Piero Giovanni Bruni, Andrea Morlacchi, Francesca Lombardo, and Marta Cavalli

25.1 Introduction

In 1974, Lichtenstein adopted a new "tension-free" approach using a polypropylene prosthesis to improve results [1, 2].

Ermanno Ennio Trabucco (August 15, 1926–March 9, 2015; Fig. 25.1) improved on the tension-free concept by introducing his complete "sutureless" technique for all primary groin hernia repair which is based on the utilization of a universal pre-shaped mesh that will virtually always fit into subaponeurotic inguinal space of every individual [3, 4]. In effect, it had been observed that the size and shape of this anatomical space has minimal variations from one individual to another.

A medium-weight pre-shaped mesh with controlled memory [5], like a monofilament polypropylene prosthesis (middle weight), does not need to be sutured once placed into a closed space.

Fig. 25.1 Ermanno Ennio Trabucco (August 15, 1926 to March 9, 2015)

Based on Pascal's principle, the intra-abdominal pressure is evenly distributed over a large surface area of mesh: the prosthesis will remain stretched uniformly in the inguinal box, without a tendency to wrinkle or curl, without the need to be secured with sutures. In other words, such a mesh, thanks to its optimum rigidity and memory shape, is positioned without sutures and will always lie flat and will not move or form dead space [3, 5, 6] avoiding complications such as seroma, hematoma, or even relapse, remaining flat and adhering to the underlying tissue during the fibroblastic infiltration into its pores, a process that seals the mesh into place [6].

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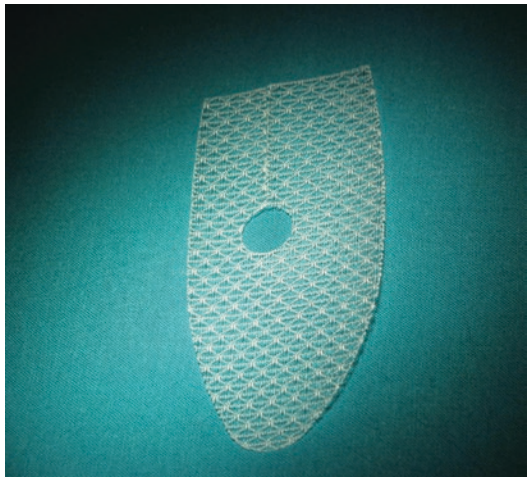

Fig. 25.2 Universal pre-shaped polypropylene mesh developed by Trabucco

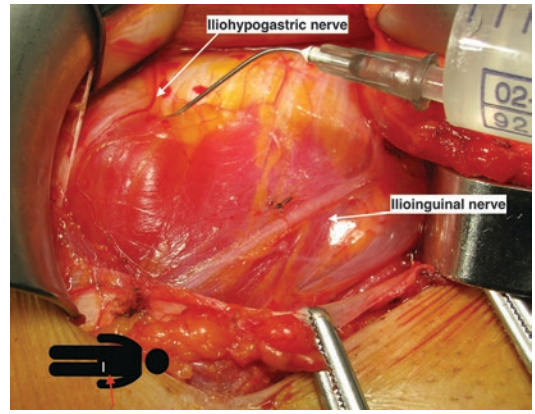

Fig. 25.3 Local anesthesia during Trabucco's primary hernia repair: sub-fascial infiltration of iliohypogastric and ilioinguinal nerves

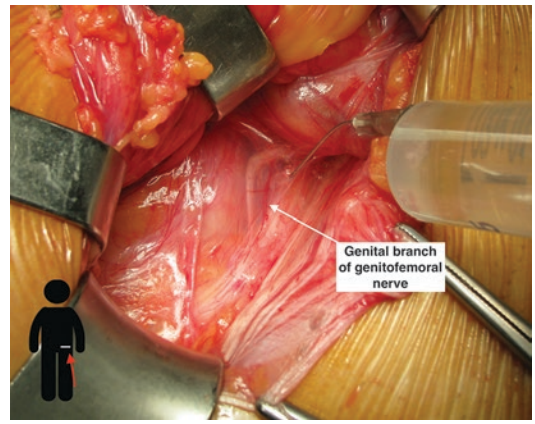

Fig. 25.4 Local anesthesia during Trabucco's primary hernia repair: infiltration of genital branch of genitofemoral nerve on the flattened floor of the inguinal box

Ideated and developed by Trabucco in the 1988, the Hertra Herniamesh® pre-shaped prosthesis (n.1–6: from most rigid meshes to the softest ones, which are ideal for athletes and for young patients; Fig. 25.2) is time-saving and easy to implant, was never found to curl or to shrink after implantation [7], and for our experience is one of the possible good choices for all simple, not complicated, primary inguinal hernias [8, 9].

We clearly believe that the main advantage of a tension-free and sutureless repair is given by the relevant reduction in postoperative pain and neuralgia [10, 11]. The chronic postoperative inguinodynia occurs in about 10% of patients undergoing inguinal hernioplasty with prosthesis and sutures [10, 12]; it is not an uncommon complication and, depending on its intensity, can also potentially jeopardize patient's work and social activities.

The Trabucco repair, which requires a perfect knowledge of the inguinal anatomy, maximizes the preservation of physiology of the abdominal wall, through the correct recognition and respect of the noble structures and the sparing of the three nerves of the groin region (iliohypogastric, ilioinguinal, and genitofemoral; Figs. 25.3 and 25.4), minimizing postoperative pain in order to ensure the best patient comfort with a more rapid and efficient recovery of his usual daily activities.

The intentional section of one or more nerves, when it is not possible to achieve a satisfactory nerve sparing, or special tricks to create tailored fenestrations in the prosthesis to prevent the scar tissue to involve the spared nerves during fibroblastic processes, ensures a further reduction of the rate of neuralgia [10].

Moreover, the Trabucco repair can be easily and routinely performed under local anesthesia [8, 9], permitting some useful tricks during the surgery, like the hydro-dissection of infiltrated tissues, for a less traumatic and more safe isolation of the hernial sac (Fig. 25.5), the spermatic

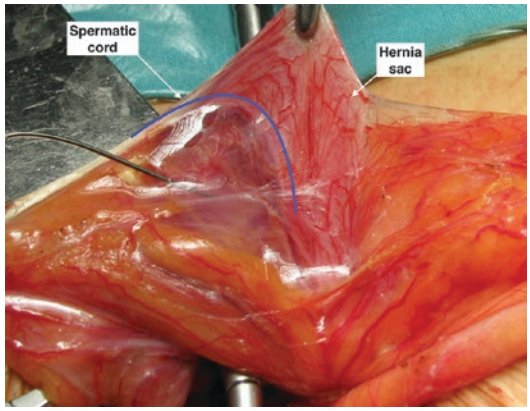

Fig. 25.5 Isolation by hydro-dissection of an indirect external oblique hernial sac

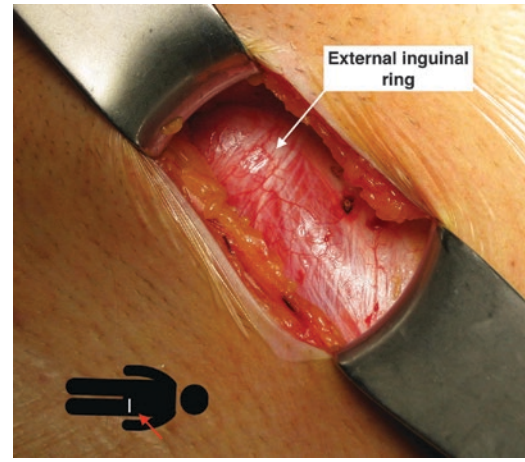

Fig. 25.6 Exposure of the external oblique aponeurosis

chord components, and the nerves from the adjacent structures within the inguinal region.

The mastery of this technique under local anesthesia gives also a further advantage, helping the surgeon to discover any hidden and unknown hernial defect (Spigelian included) simply by asking the patient to give a cough during the intraoperative exploration of both the inguinal box and the femoral canal (that always should be explored). It allows also the patients to return home just a few hours after the intervention (by keeping down hospitalization costs), going back to a sedentary work the day after and to their full activities rapidly [8, 9, 13, 14].

25.2 Surgical Indications

An open anterior sutureless and tension-free repair is indicated for all simple, not complicated primary inguinal hernia.

25.3 Surgical Technique

Every repair should start with a horizontal left/right sovrapubic incision, at the aim to respect the cutaneous sensory nerves of the inguinal region that would be more traumatized by a classical transverse incision because of their line of metameric distribution through the skin at that precise level. Normally, in normal BMI patients, the incision length is 3–5 cm.

After the ligature of subcutaneous vessels and after the incision of the external oblique aponeurosis (Fig. 25.6), a blunt dissection of the subaponeurotic space is made by finger to accommodate the sutureless prosthesis; it goes without saying that the complete exposition of the right anatomy of inguinal canal is mandatory.

The conjoint tendon and rectus sheath, pubic tubercle with the horizontal portion of pubic bone, inguinal ligament till anterior inferior iliac spine, and internal ring, all these "normal" structures must be not only recognized but carefully prepared in order to have the "bed" where to lie the mesh: with the same attention, all the external oblique aponeurosis subspace has to be fully prepared from above to below in order to cover the prosthesis completely and uniformly, from pubic tubercle to its upper opening. Only if this closure, putting the chord in the subcutaneous space, is perfectly realized, from the point 1.5 cm on the pubic bone to the upper part, the mesh can be completely stable without stitches or sutures.

The iliohypogastric, ilioinguinal, and genitofemoral nerves must be always detected, carefully isolated, and when possible well preserved, paying particular attention to never leave them in direct contact with the prosthesis, by practicing in some specific cases some small tailored cutouts on the edge of the pre-shaped mesh itself (small

window), at the aim to protect each single nerve from possible entrapment in the later fibroblastic processes. In a few cases, an intentional section of nerves could be needed showing an abnormal position within the inguinal box, but only when, after careful thoughts of the operator on the surgical anatomy of that particular individual, no other solutions for their sparing are seen.

Small indirect hernias should be repaired by careful isolation and reduction of the sac into the deep ring, which is then narrowed with absorbable sutures. A sutureless Hertra Herniamesh® is then implanted on the posterior wall and the external oblique aponeurosis always closed over the mesh and under the spermatic chord.

Medium and large indirect hernias should be repaired by dissection and reduction of the sac. In the beginning of the experience, these kinds of hernia were followed by implantation of a T4 flat plug positioned around the spermatic chord in the preperitoneal space (Fig. 25.7). Recently, depending on the real size of the defect that is found case by case, through a very careful and tailored choice, is adopted or a direct narrowing of the internal ring with absorbable suture or the use of T4 flat plug. A pre-shaped Hertra Herniamesh® is always then implanted on the flattened posterior wall of the inguinal canal.

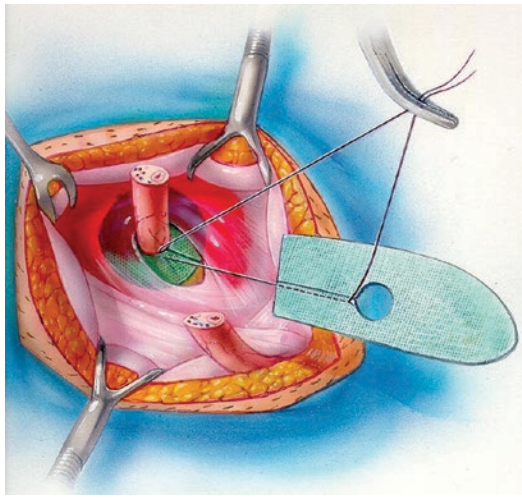

Fig. 25.7 T4 flat plug into a large internal inguinal ring, anchored to the pre-shaped onlay mesh—*original drawings supplied by E. E. Trabucco* [6]

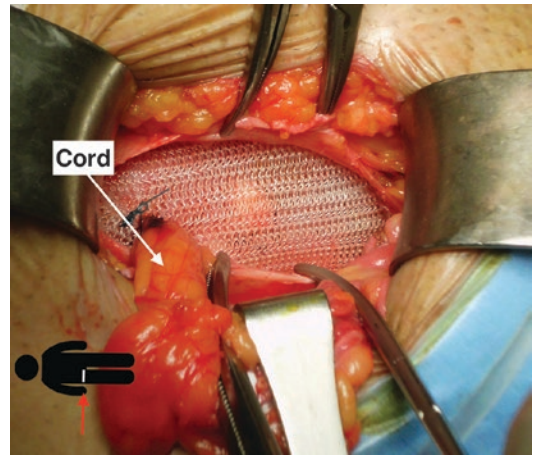

Fig. 25.8 Final view of a polypropylene pre-shaped mesh implanted in the inguinal box

Direct hernias with partial or total wall involvement should be repaired by reduction of the sac with a continuous absorbable running suture, which flattened the floor of the inguinal canal, thus allowing for a better apposition with a pre-shaped Hertra Herniamesh®. Distal tip of the mesh must be placed upon the pubic tubercle with enough overlap, laterally to the hollow of the inguinal ligament and medially at the sheath of abdominal rectus muscle. With an absorbable stitch, the two tails of the mesh are approached; in this way the surgeon recreates a new internal inguinal ring, and no stitches are positioned on the surrounding tissues (Fig. 25.8).

25.4 Tips and Tricks

- For the Law of Pascal, the pre-shaped prosthesis developed by Trabucco remains stretched uniformly in the inguinal canal, without the need to be secured with sutures at conditions that all the mesh is completely covered from external oblique aponeurosis, without forming dead space which is the cause of infections, pain, and recurrences.
- The identification and the sparing of the three nerves of the inguinal region is of crucial importance to reduce the rate of neuralgia in the short and long term, and the use of a local anesthesia imposes the surgeon to properly

recognize those nerves and to respect them during the repair.
– The intentional section of one or more nerves, when it is not technically possible to achieve a satisfactory nerve sparing, or special tricks to create proper fenestrations (small window) on the edge of the prosthesis to prevent the scar tissue to involve the spared nerves, ensures a further reduction of the rate of neuralgia and excellent patient outcomes.

25.5 Outcomes

The main advantage of a tension-free and sutureless repair is given by the relevant reduction in postoperative chronic neuralgia, which is not an uncommon complication and, depending on its intensity, can also potentially jeopardize patient's work and social activities.

With the complete sutureless repair ideated by Trabucco (eventually performed with some little modifications regarding the choice of an absorbable plug for indirect large defects), the postoperative discomfort is minimal, the nerve injury is rare, and the recurrence rate is very low. The identification and the respect of the three nerves of the inguinal region is of crucial importance to significantly reduce the rate of neuralgia in the short and long term.

The use of local anesthesia imposes the surgeon to properly recognize those nerves and to respect them during the repair, providing precious advantages, but certainly requires more attention and care by the surgeon, in order to avoid useless discomfort to the patient. The Trabucco's technique can be routinely performed in a day surgery regimen, under local anesthesia, obtaining the maximization of comfort for the patients and offering excellent results for the repair of any type of primary inguinal hernia.

Compared to the Lichtenstein's technique and TAPP, which are at now the golden standard treatment for primary inguinal hernias worldwide [12], there are no significant differences in the observed recurrences and chronic pain rate [12, 15, 16].

With our experience of over 4.000 open hernia repairs using this safe technique, the results (prospective database) have been extremely satisfactory, as compared to Lichtenstein's tension-free technique, translating into an overall risk for the patients of developing chronic groin pain well below 1%.

Then even if our personal convinced approach to all hernia diseases is a real "tailored" approach, using open and laparoscopic, anterior and posterior and combined, synthetic and biologic, with local and spinal and general anesthesia, with sutures, sutureless and/or glue, ambulatory or hospitalized, so in other words to choose the better option for each single patient, we think that Trabucco technique for primary inguinal hernia should be in the armamentarium of each hernia and general surgeon.

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26 Lichtenstein Onlay Mesh Hernioplasty: Original Technique and Personal Modifications

Ezio Gianetta and Cesare Stabilini

Several years have passed from the last time we read Irving Lichtenstein's *Hernia Repair Without Disability* published in 1986 [1], and, despite changes and "corruptions" introduced by different authors during the years, the technique described by Lichtenstein still shows its value standing still and valid in the present days. The concept of tension-free repair for inguinal hernia represents one of the turning points of abdominal wall surgery: it was a paradigm shift from traditional tissue repair to modern mesh repair from the technical, physiopathological, and organizational standpoint.

This innovative technique however was not perfect at its very beginning [2] but went through several refinements before getting to its final form [3]. Major and minor changes with time allowed Lichtenstein hernioplasty to become a "one-size-fits-all" procedure for the cure of primary and recurrent inguinal hernia and the current recommended technique by international guidelines [4].

Accordingly, in our daily practice, this procedure represents the first approach to inguinal defects except for those cases of bilateral and recurrent inguinal hernia suitable for a laparoscopic repair.

26.1 Indications

In 2009 and 2014, the European Hernia Society published guidelines [4, 5] on the treatment of inguinal hernia in adult patients. Several recommendations were done, and accordingly in our practice patients of both sexes complaining of symptomatic primary unilateral inguinal hernia are operated with an anterior approach under local anesthesia. In the past, recurrent and bilateral inguinal hernias were approached through the anterior route [6], and starting from 2010 we moved to TAPP by laparoscopy. All those patients not suitable for a general anesthesia or unable to tolerate pneumoperitoneum are offered a Lichtenstein procedure under local anesthesia. Patients complaining of inguinal pain with or without radiological signs of hernia but no clinically detectable defects are referred for watchful waiting.

26.2 Patient Preparation

Before hospitalization, the patient is given information concerning surgery, type of anesthesia, and recovery in dedicated visit. At our hospital, according to current guidelines, the patient is accepted the morning of the procedure, fasting from midnight. A dose of subcutaneous low molecular weight heparin is given in patient judged at high risk of thrombosis the night before the procedure. The inguinal region is shaved the

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day of admission with clipper. The antibiotic prophylaxis is adopted only in cases with predisposing comorbidities [4].

The patient lies in the supine position, leg adducted, and the surgeon stands on the site of the hernia with the first assistant on the opposite site. In our division, if not first operator, the first assistant is always a resident, and a second assistant, if available, is a first-year resident who uses retractors.

26.3 Original Technique

26.3.1 Anesthesia

We consider local anesthesia as the "gold standard" technique for the repair of unilateral primary inguinal hernia: it's simple, easily administered and mastered, well accepted by the patients, and with virtually no side effects.

For its characteristics of high tolerability, it is a formidable tool for the increasing number of elderly patients with concomitant morbidities: it represents a good solution to the problem of an aging population with high life expectancy, asking for an effective and low-risk treatment to their disability [7].

In our division, since the introduction of tension-free hernioplasty, local anesthesia has been used also in the setting of recurrent hernia, and we acknowledged that the technique becomes more challenging with this approach because of the suboptimal diffusion of the anesthetic solution in the tissues and more challenging in the presence of a previous mesh repair. However, we clearly showed its feasibility in the setting of a teaching hospital [6] with low morbidity and low recurrence. Some form of additive light sedation is asked from the anesthesiologist in cases in which patient's pain or anxiety becomes an obstacle for the surgeon.

We do not adopt regional anesthesia on a regular basis for its well-known risks and side effects (urinary retention, nausea and vomiting, headache) that can end in prolonged hospital stay. The indication to this procedure is represented mainly by difficult cases such as scrotal hernias regardless whether primary or recurrent.

On the opposite hand, when general anesthesia is needed, it is indicated mainly for a posterior laparoscopic approach. Its use in the setting of open anterior approach, in our practice, is considered as a "rescue procedure" for those patients not tolerating a local anesthesia or asking for a complete unconsciousness.

26.3.2 Local Anesthesia

26.3.2.1 Mixture

Even if very old, mepivacaine, a local anesthetic of the amide type, is the agent of choice in our practice. Its pharmacokinetic profile fits well our needs because the fair rapid onset helps us save time where no other drug is given outside of the operatory room; on the other hand, its medium duration of action allows us the completion of the procedure and analgesia during the minutes after the end of the procedure. We utilize a solution of mepivacaine 2% (20 mL) neutralized with sodium bicarbonate 8.4% (10 mL) and diluted with saline (30 mL).

We do not use adrenalin because the anesthetic mixture is adequate in the vast majority of cases; the protraction of the procedure beyond 2 h is very rare and in our opinion not advantageous for the patients. We consider this type of event precognizable, and usually we approach it with a general or spinal anesthesia.

26.3.3 Technique

We adopt a step-by-step approach in which the mixture is given in subsequent injections of local anesthetic during the procedure.

Before starting the intervention, a single injection with an insulin needle (25 G) is performed in order to obtain an intradermal wheal (Fig. 26.1). Afterward, using this wheal as an entry mark, we shift to a 22 G spinal needle; the superficial subcutaneous tissue is injected moving forward and backward the needle to obtain an area with 3–4 cm width around the site of the future incision. From the superficial layer, we then move to anesthetize the deep subcutaneous tissue to obtain a preliminary nerve block (Fig. 26.2).

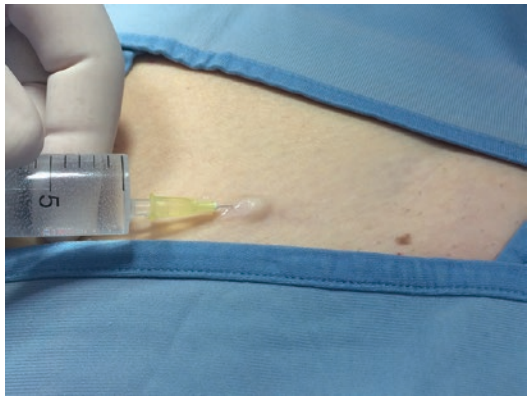

Fig. 26.1 Derma infiltration with a 25 G insulin needle

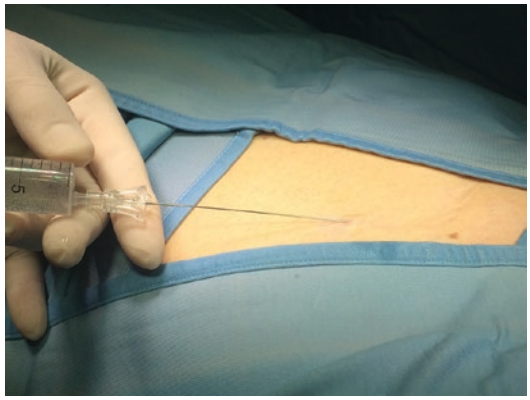

Fig. 26.2 Superficial subcutaneous layer infiltration with a 22 G spinal needle

Authors' Comment

1. The continuous movement of the tip off the needle prevents from inadvertent injection of anesthetic in a vessel.
2. The spinal needle is sufficiently long to avoid the complete withdrawal of the needle and reduce the number of punctures and possibly the risk of infection.
3. We are not in favor of truncal anesthesia since the search of the site for a correct entry is subject to failure due to the frequent anatomical variations of the nerve emergences; moreover, this maneuver can be complicated by hematomas or inadvertent lesion to visceral structures.

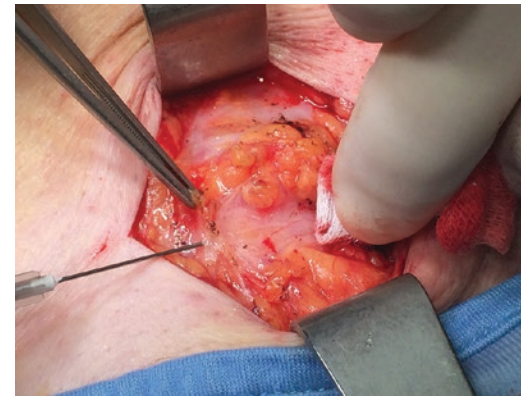

Fig. 26.3 Deep subcutaneous layer (below Scarpa's fascia) infiltration with a 21 G needle

26.4 Surgical Dissection

After the onset of anesthesia, an oblique 6–7 centimeters skin incision is made on the cutaneous projection of Poupart's ligament, in the inguinal fold, using the pubic tubercle (PT) and superior iliac spine (SIS) as landmarks. The line of section falls between the middle and medial third of the aforementioned line.

The dissection of the superficial subcutaneous tissue is carried with monopolar energy, and the epigastric superficial vessels when encountered are ligated and transected.

Scarpa's fascia represents the boundary between superficial and deep subcutaneous tissue. Before division of this thickened connectival structure, we usually perform injection of 2 mL of anesthetic in the deep subcutaneous layer (Fig. 26.3).

Authors' Comment

We adopt this type of strategy to block aberrant branches of the ilioinguinal nerve that several times can be encountered immediately coming out from the external inguinal ring [8].

Another 2 mL of local anesthesia is delivered under the external oblique aponeurosis (EOA) as soon as it is visualized in order to anesthetize the ilioinguinal and iliohypogastric nerves (Fig. 26.4).

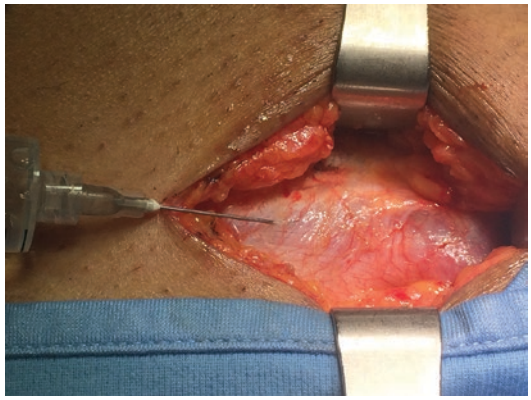

Fig. 26.4 Anesthesia of iliohypogastric and ilioinguinal nerves

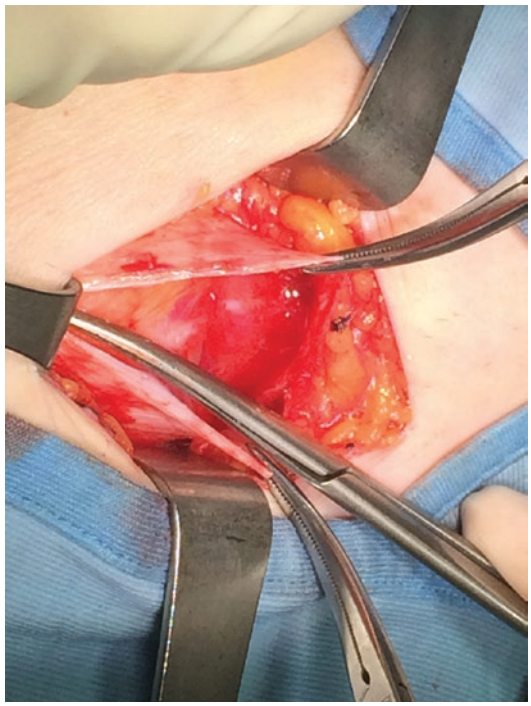

Fig. 26.5 External oblique aponeurosis opened and retracted with clamps

The EOA is dissected free to expose its lower part from which the inguinal ligament reflection and the superficial inguinal ring take origin. The aponeurosis is opened following its longitudinal fibers downward to the pubic tubercle and upward for 5 cm in direction of the SIS. The free edges of the aponeurosis are retracted with clamps (Fig. 26.5).

The internal oblique, conjoined tendon, and inguinal ligament or Poupart's ligament are gently dissected with scissors or fingertips from the EOA. During this step, it easily can be visualized the ilioinguinal nerve entering the inguinal canal and the iliohypogastric nerve that pierces the EOA. The spermatic cord is freed from the deep floor of the inguinal canal, underpassed at the level of the pubic tubercle, and suspended with a silastic tube.

Firstly 2–3 mL of anesthetic is injected in the space between the cremasteric muscle, the external spermatic fascia, and spermatic cord at the level of the genital branch of the genitofemoral nerve using the "blue line" as anatomical landmark and then some 2 mL on the upper part of the cremasteric fascia to obtain anesthesia of the entire cord (Fig. 26.6).

The suspended cord is retracted and completely freed from its posterior attachments to the inguinal floor.

The ilioinguinal nerve is identified at this level and gently isolated from the underlying muscle fibers. The cremasteric muscle is then divided longitudinally (Fig. 26.7) from the deep inguinal ring toward the pubic tubercle for 3–4 cm and dissected from the spermatic structure. The resulting medial leaf of the cremaster, usually very thin, is resected with monopolar cautery (Fig. 26.8). In the classic Lichtenstein's description, the lateral leaf which carries also vascular structures is preserved.

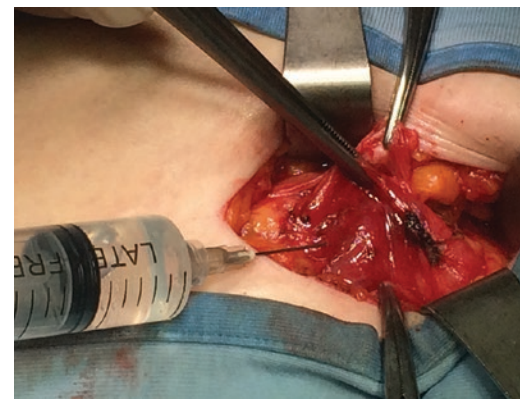

Fig. 26.6 Anesthesia of the spermatic cord and genital branch

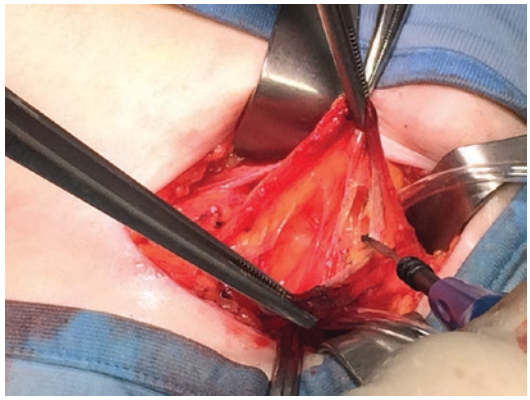

Fig. 26.7 Longitudinal incision of the cremaster muscle

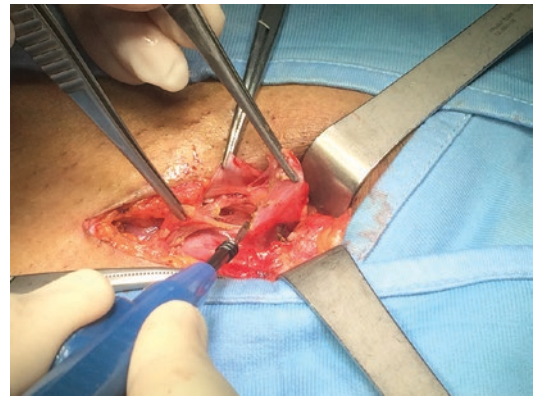

Fig. 26.8 Resection of the medial leaf of the cremaster muscle with electric scalpel

Authors' Comment

On principle, we prefer not to immediately underpass the spermatic cord, because mainly in the setting of local anesthesia, this maneuver can elicit some form of reaction from the patient due to discomfort or actual pain.

After anesthesia, the cremaster is divided along its longitudinal fibers from the deep inguinal ring downward for 3–4 cm. The two leaves of muscle (lateral and medial) are dissected from the cord and the sac and immediately interrupted between sutures (Fig. 26.9) or coagulated with monopolar energy.

Usually, the remnant of the lateral leaf of the cremaster is kept redundant and used during the reconstruction of the deep inguinal ring.

The cord structures are then easily underpassed and suspended with a silastic tube.

Possible advantages:

1. This maneuver eases underpassing the spermatic structures alone without undue traction on the nerves, which is a possible cause of pain.
2. Cutting off the muscle helps identifying small indirect defects and helps in the dissection of the sac.
3. Without cremaster, the spermatic cord can be surrounded effectively with the mesh,

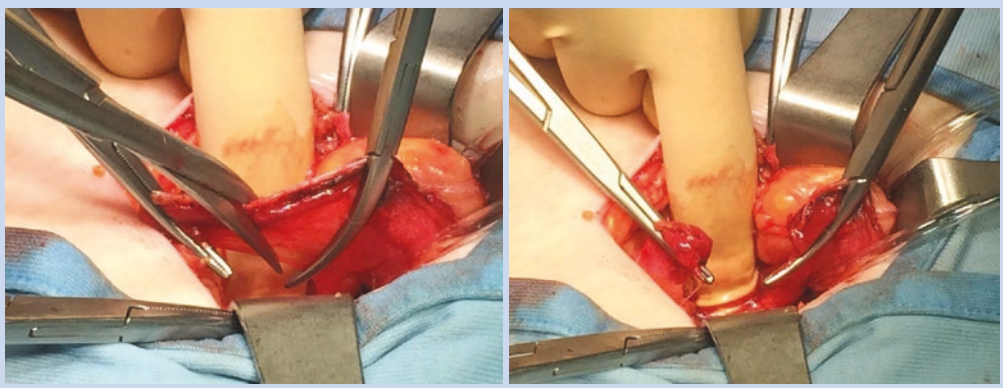

Fig. 26.9 The lateral leaf of the cremaster muscle is interrupted and ligated

and a lateral recurrence becomes less likely.

Possible disadvantages:

1. The function of the muscle is lost, and few patients complain of descending testis.
2. The direct contact of the mesh with spermatic structure could lead to undesired inflammatory reactions.
3. The ilioinguinal or genitofemoral nerves can be damaged while dividing the muscle in case of misidentification during dissection of the cord.

26.4.1 Hernia Sac Treatment

This step of the procedure can cause several problems to the operating surgeon depending on the grade of inflammation, the length of the sac, and the nature of the hernia (congenital vs. acquired). All these features determine tight adhesions of the cord structures to the peritoneal sac; thus, the dissection maneuvers can produce lesions to the vas deferens, nerve branches, and vascular structures which can turn in serious complications, namely, reproductive dysfunction, pain syndromes, and ischemic orchitis followed by testicle atrophy.

26.4.1.1 Medial Hernia Sac

For non-scrotal hernia, the so-called direct sac does not represent a surgical challenge, and it's easily visualized medially to the cord covered by the medial leaf of the cremaster muscle. It's dissected and inverted, and care must be taken when reducing the part near to the internal inguinal ring since several times the epigastric vessels can be dislocated and inadvertently injured during dissection or reconstruction of the inguinal floor.

26.4.1.2 Lateral Hernia Sac

To truly access the plane containing this type of hernia, it is very important to open the external spermatic fascia, a thin layer of unorganized connective tissue arising from the innominate fascia at the cord emergence from the internal ring.

We usually look first for the distal end of the sac and dissect it proximally to the neck. In case of a long sac or a particular type of sac, namely, those entering in the middle of the spermatic cord, we adopt the technique of dissecting circularly the sac halfway in the spermatic cord, in the place where it is most accessible, and subsequently the distal end is retrieved and the proximal dissection is finalized.

Authors' Comment

We adopt several tricks to treat a difficult hernia sac:

1. The injection of anesthetic in the contact surface between the sac and the structures to be preserved allows tissue divarication and a safer dissection (hydrodissection).
2. In case of big hernia sac, the peritoneal layer can be opened, entered with a finger, and retracted more efficiently.
3. The sac can be transected and the distal portion left opened (drained or everted to avoid a secondary hydrocele) in the case of encasement of important structures in the hernia sac, such as for the congenital hernia, to avoid lesion mainly to the vas and vessels.

During this step, the patient can feel pain originating from excessive traction on the peritoneal sac or inadvertent stimulation of the genital

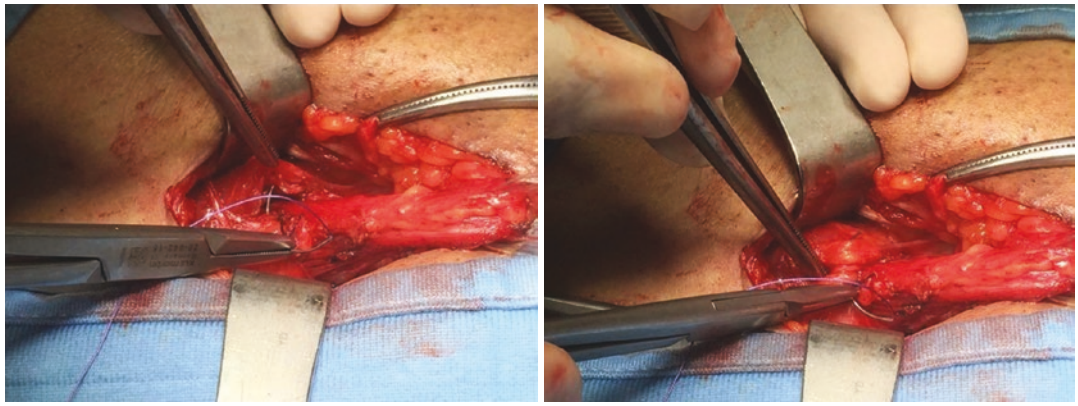

Fig. 26.10 Reconstruction of the internal ring with absorbable sutures

branch of the genitofemoral nerve with monopolar energy. We advise infiltration of the neck of the sac with 1–2 mL of anesthetic mixture when approaching the deep inguinal ring to reduce this occurrence particularly in presence of an inflamed field.

Except for some scrotal hernia and emergent cases to check the bowel for vitality, the sac, once dissected completely, is never opened or excised since it's well known that this maneuvers can cause postoperative pain.

According to Lichtenstein [1], we routinely reduce the hernia content in the abdominal cavity: in case of lateral hernias, few resorbable stitches are required to narrow the patent deep inguinal ring (Fig. 26.10), and for medial sac, we use inverting continuous resorbable suture (Fig. 26.11). These maneuvers of reconstruction of the anatomy have the only purpose of keeping in place the hernia content during placement of the mesh and do not represent a support for the repair.

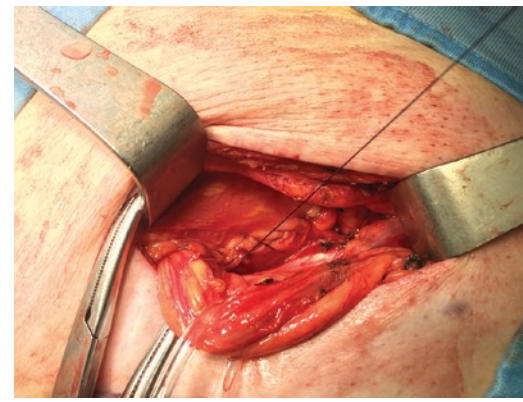

Fig. 26.11 The transversalis fascia is inverted with running absorbable suture

26.4.2 The Mesh: Material

Today, after several years have passed and study performed, the mainstay of every inguinal hernia repair is represented by the mesh [9] as recommended by current guidelines [4]. The material originally adopted was polypropylene, but also polyester and PVDF meshes have shown their efficacy in the treatment of this disease.

Authors' Comment

The choice of mesh material for Lichtenstein's technique is crucial and is influenced by the clinical scenario, patient's characteristics, costs, surgeon preferences, and hospital choices.

From standard polypropylene mesh, several innovations in materials have occurred, and the focus has changed from simply preventing recurrence to reducing postoperative pain and discomfort by improving biocompatibility and reducing foreign body reaction to the mesh. Clinical research has developed several types of meshes suitable for Lichtenstein's technique to meet these needs, in recent years:

Lightweight meshes were introduced at the beginning of 2000s and have less polypropylene volume; it is postulated that they encourage collagen production which integrates the mesh into the abdominal wall with less inflammation compared with heavier-weight meshes and that may reduce the complications after surgery [10]. They range from weight-reduced implants to partially absorbable to material-reduced and titanium-coated meshes [11]. Several trials and metanalises [11, 12] were performed on the use of this type of material in open Lichtenstein hernia repair, and their results, in comparison to traditional heavyweight meshes, showed that lightweight meshes offer less chronic pain and foreign body sensation without difference in recurrence.

Accordingly, their use is currently recommended from European Hernia Society guidelines [4] as a measure to prevent the occurrence of chronic postoperative pain. It is our preferred type of mesh, and its use in our practice is limited only to younger and active patients due to the costs of the device.

Biologic meshes derived from human or animal sources are degraded gradually, inducing neovascularization and colonization by host cells that progressively cause a site-specific remodelling process until reconstruction of a new and mature autologous fascia is completed.

The ability to be remodelled makes the new materials theoretically attractive to surgeons as a means to reduce post inguinal herniorrhaphy complications [10].

However, a recent Chinese meta-analysis showed that biologic mesh has no superiority to synthetic mesh in open inguinal hernia repair with similar recurrence rates and incidence of chronic groin pain but higher rate of seroma and longer operating time.

To date we reserve the use of this type of material as an alternative to synthetic mesh when the use of the latter becomes a risk for the growing patient or in contaminated and emergent scenarios to lower the risk of postoperative infection.

The mesh is tailored on table, not preshaped but trimmed according to the patient's inguinal floor, and the dimensions are 7 × 13 cm.

The mesh is tailored to look like the outline of a foot with the toe covering medially the angle between the inguinal ligament and the anterior rectus sheath. The mesh has a slit, along its major axis, at the level of the internal ring to allow the passage of the spermatic cord forming two tails of different dimension: the lateral thinner and the medial wider. These tails are crossed and solidarized with nonresorbable sutures behind the spermatic cord to avoid recurrence lateral to the internal ring. Suturing the tails together in a parallel position, without crossing, is a known cause of recurrence in the internal ring area [3].

How I Do It

We are used to shape the mesh in a different way from original Lichtenstein's description (Fig. 26.12). This type of tailoring helps us, in our intention, to follow more precisely the shape of the inguinal floor, to really protect it, and to make possible a safe suture to the surrounding structures. We usually cut a vertical slit (perpendicular to the main axis of the mesh) (Fig. 26.13) starting from the medial border of the mesh to the emergence of the spermatic cord. The reason for this choice lies in the analysis of the direction of the inferior edge of the internal oblique muscle: it forms an acute angle with the inguinal ligament cranially and laterally to the deep inguinal ring. In the original description, the slit lies just above this weak zone and could be challenged in case of a lateral hernia sac, leaving possibility to a lateral recurrence. In our modification, the slit is completely protected by the underlying muscle.

The most lateral part of the mesh lies flat in the space between EOA and oblique muscle without the need for further fixation.

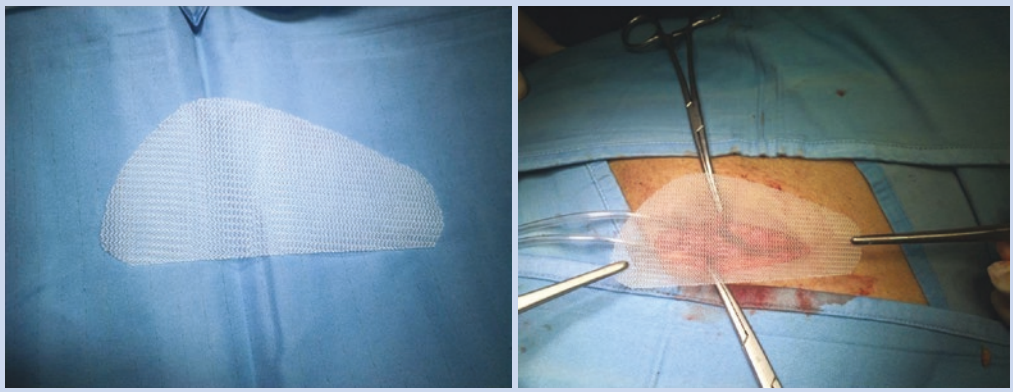

Fig. 26.12 The mesh reproduces the shape of patient's inguinal canal

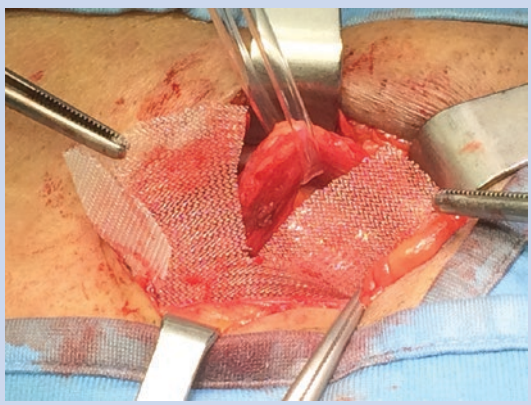

Fig. 26.13 The slit of the mesh

26.4.3 Mesh Fixation

In 2002 [3] after evaluation of their experience, the authors identified five features of the original technique responsible for suboptimal results and needing revision. These so-called flaws were thought to produce two main complications of hernia repair, recurrence and chronic postoperative pain, and considered as insufficient application of the tension-free principles, namely:

1. The mesh was not extended beyond the pubic tubercle to overlap the pubic bone.
2. The mesh was too narrow (only 5 cm) to provide enough mesh tissue contact above the inguinal floor.
3. The mesh was kept flat and, therefore, was subject to tension when the patient stood up from the supine position of the operation.
4. The upper edge of the mesh was fixed using a continuous suture, which potentially left the iliohypogastric nerve at risk.
5. Passing the genital nerve and external spermatic vessel through a gap along the suture line of the mesh with the inguinal ligament exposed the nerve to potential risk of entrapment.

Accordingly, modifications were introduced to reduce the occurrence of adverse events and adopted in this final form till now. The mesh is bigger to cover all the inguinal floor, with a 2 cm overlap over the pubic tubercle and 5–6 cm lateral to the internal inguinal ring. After fixation, it should be kept in a relaxing configuration, somewhat redundant to overcome the problem of polypropylene shrinkage possible, as known, as far as 25%. Using interrupted resorbable sutures and keeping the nerves together with all cord structures helped in reducing pain generated by suture entrapment.

The main principle of tension-free hernia repair relies on accurate mesh fixation: no tension must be introduced in the sutures while tying the knots and on the mesh. According to the original technique, the mesh is fixed with a running nonabsorbable suture (USP 2/0 polypropylene) to the inguinal ligament (Fig. 26.14) and with interrupted resorbable sutures (USP vicryl 2/0) on the aponeurotic layer of the transverse and internal oblique muscle (Fig. 26.15).

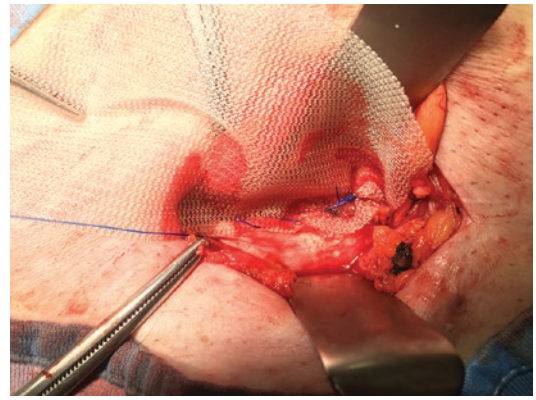

Fig. 26.14 Running nonabsorbable suture to fix the mesh to the inguinal ligament

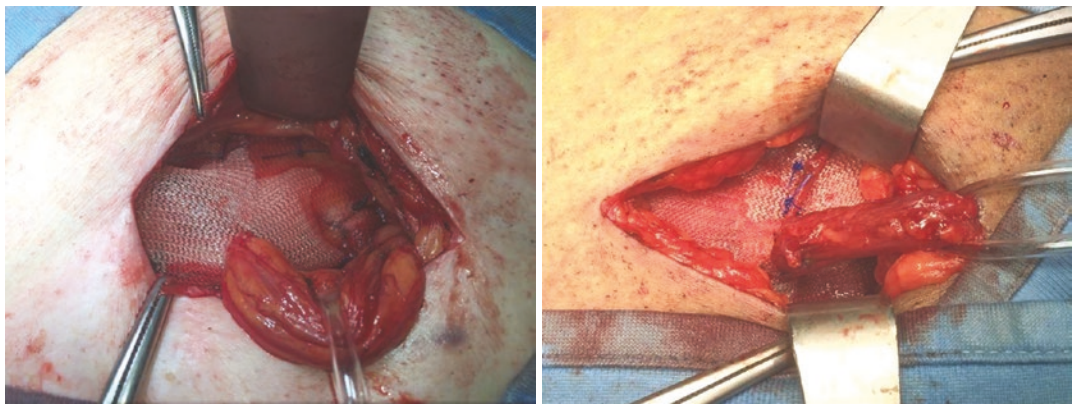

Fig. 26.15 Interrupted absorbable stitches to fix the mesh to the aponeurotic layer of the lateral muscles and nonabsorbable sutures to close the slit

Authors' Comment

- We do advise not to tie excessively the knots on the muscles in order to reduce the possibility of postoperative pain and nerve entrapment.
- According to several new modifications in the surgical technique aimed at reducing the total amount of implanted material, the fixation of the mesh can be achieved also by:
  Fibrin sealant: *we have experienced this material and appreciated the durable fixation characteristics along with its hemostatic power. The effect on pain, discomfort, and numbness and the reduction of postoperative bleeding in high-risk patients have been shown in several trials. For these reasons, it has become one of our favorite fixation techniques. When using fibrin sealant, we usually adopt two additional sutures, respectively, on the pubic tubercle and to solidarize the tail of the mesh, which represent the two weakest points of the hernioplasty.*
  Synthetic glue: *we have very few experiences of cyanoacrylate glue in Lichtenstein hernioplasty, and the application is very easy and, differently from fibrin sealant, made in the form of spots applied as common stitches. The results in the literature are good but not superior to traditional fixation with resorbable materials.*
  Self-gripping mesh: *in our experience, this type of mesh needs a little learning curve for its correct deployment, but after few cases, it eases and speeds the work of the surgeon. However, the current literature has still not found a clear advantage, except for reduced operative time, of this material when analyzing the effects on chronic postoperative pain* [13].

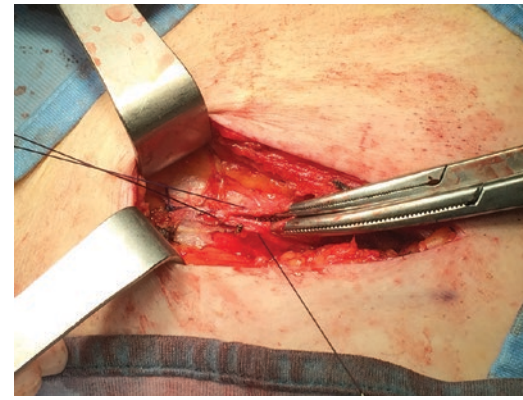

Fig. 26.16 The external oblique aponeurosis is closed above the cord with a continuous absorbable suture

26.4.4 Closure of the Surgical Wound

In the original, Lichtenstein advised the closure of the external oblique aponeurosis deep to the spermatic cord to offer some additive strength to the repair, but we do not adopt this technique nor the embrication described by Andrews; we simply close the aponeurosis over the cord not to introduce too much tension on the repair (Fig. 26.16). We acknowledge, however, that in this way the cord lies unprotected in direct contact to the prosthetic material possibly exposed to foreign body reaction, but as far as we can be sure, no such event has ever been observed in our series.

We usually perform a reapproximation of the deep subcutaneous tissue solidarizing with EOA. In our experience, this can help in reducing the occurrence of seroma.

The cutaneous incision is closed with intracuticular sutures. When used, stitches are removed at the first postoperative visit occurring 1 week after surgery.

26.4.5 Patient Discharge and Aftercare

The patient is discharged in the early afternoon after checking the surgical wound and testicle for

local complications. In our practice, causes of unplanned prolongation of hospital stay are pain not manageable with common painkillers, urinary retention, and fever. Postoperative painkillers are prescribed the night of the intervention and then on patient's request.

Lichtenstein stated that encouraging immediate postoperative ambulation "prevents muscle spasm that initiate the pain cycle," so at our center all patients are instructed to resume their normal activity as soon as possible, to walk immediately after the procedure without restriction. We adopt a "do what you feel you can do" [4] attitude, and we only prescribe no heavyweight lifting for 3 weeks. Postoperative bindings are not prescribed.

The first outpatient visit occurs 1 week after surgery to assess the surgical wound, and then patients are followed at 6 months and yearly up to the second postoperative year.

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Mesh Plug Repair

27

Francesco Gossetti, Linda D'Amore, Maria Romana Grimaldi, Francesca Ceci, and Paolo Negro

To Davide Fieschi (1869–1953), the pioneer of open plug repair [1].

27.1 Introduction

Besides the onlay prosthetic herniorrhaphy, of which the Lichtenstein technique represents the gold standard, mesh plug is one of the most common procedures for open tension-free groin hernia repair. The mesh plug repair (MPR) has been proposed in the late 1980s on the basis of the experience of Gilbert, Trabucco, and Rutkow [2–4], but it was only when a preformed plug (PerFix™, Bard Davol) began to be available on the market that this technique became widespread [5]. Since then, millions of plugs have been used worldwide, and many other new devices have been developed and continue to be produced by the medical industry, designed for those surgeons who prefer a three-dimensional (3D) technique for groin hernia repair.

MPR is actually a deep repair, as the device lies in the pre-peritoneal space. It requires a less complete dissection ensuring a tension-free hernioplasty. The plug prevents protrusion of the previously inverted peritoneal sac, so acting as a stopper [6]. Filling the pre-peritoneal space, the 3D configuration of the plug also provides a deeper area over which scarification takes place. In this way, the plug prevents the recurrence of lateral hernias following previous onlay repair, in which a peritoneal sac can be found protruding through the inguinal internal ring, between the posterior wall and the onlay patch [7].

Originally, mesh plug repair was proposed for all groin hernias, on the basis of the hernia classification described by Rutkow [4]. Today, MPR should be indicated for the treatment of lateral hernia, recurrent "internal" hernia, and femoral hernia, according to a tailored management of groin hernia.

27.2 Surgical Technique

The operation is performed under local anesthesia or sensory epidural block, as it allows the patient to cough or strain on command. In this way, it is possible to verify the correct positioning of the plug and to ascertain that the hernia sac remains safely reduced. The skin incision is less than 6 cm, and external oblique aponeurosis is slit from the external ring to just above its location over the internal ring. Tissue dissection, including that of the hernia sac, is minimal, and it is accomplished with electrocautery. The cremasteric muscle is removed to allow a proper placement of the mesh. The inguinal and genitofemoral nerves are preserved, if surgical steps allow it.

In lateral hernias, the sac is dissected off the spermatic cord structures to the level of the

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internal ring, along with any lipomas of the cord. The dissection of the sac should be high enough to visualize the pre-peritoneal fat pad at the level of the internal ring, in order to create a pocket for positioning the plug. The internal ring is the natural passage for the cord, so the space should be considered not virtual but real [8]. The hernia sac is opened only if strictly necessary. Once the freely dissected sac and any adjacent lipoma are inverted through the internal ring into the abdominal cavity, the plug is inserted with a clamp and placed into position beneath the crura. The plug must be secured to the internal ring with multiple interrupted sutures to fix the device in permanent position and prevent migration. Usually at the end of the repair, an onlay patch is placed on the anterior surface of the posterior wall of the inguinal canal to reinforce it inducing additional fibroplasia, thus preventing a medial hernia. In this way, MPR should rather be named "plug-and-patch" repair (Fig. 27.1).

In recurrent "internal" hernias, where the sac protrudes near the pubic tubercle, the sac is simply dissected down to its base on the inguinal floor and then circumscribed to permit full access to pre-peritoneal space. The plug is finally inserted into the defect and secured with multiple anchoring sutures between the device and the scarred margin of the floor defect and/or pubic tubercle.

In femoral hernias, the skin incision is located directly over the hernia impulse and the dissection is carried out on the hernia sac toward its base, at the orifice of the femoral canal. The sac is then reduced into the femoral canal and the plug is placed through the opening. After proper positioning, the external layer of the plug is secured with some sutures to the margins of the defect.

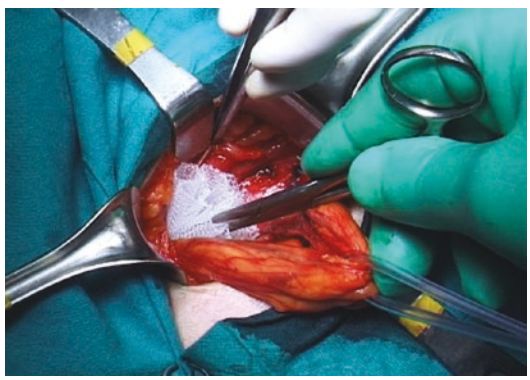

Fig. 27.1 Surgical technique: Placement of the plug

27.3 Comments

The above described procedure points out the surgical steps of MPR, referring to the original technique, proposed by Rutkow and Robbins for PerFix™ plug repair. Some modifications have been done during the years [9, 10], and a large number of new plugs or 3D devices have been introduced on the market, made of new materials and displaying new profiles, to meet the current requirements of hernia surgery (Fig. 27.2).

Following to the criticisms addressed to the plug, many new devices have been developed so to meet the emerging needs. Which are these criticisms?

In 2009, the European Hernia Society (EHS) guidelines on the treatment of inguinal hernia in adults concluded that the 3D mesh repair could be considered an alternative procedure to Lichtenstein technique (recommendation, grade B), although only short-term results were available at that moment [11]. In 2014, an update of the EHS guidelines, on the basis of a larger number of available data, confirmed that 3D mesh techniques were acceptable for hernia repair, with outcomes comparable to the Lichtenstein herniorrhaphy, except a shorter operative time [12]. However, the plug repair was somehow criticized: the excessive use of foreign material, the additional cost of the device, the chance of plug migration/erosion, the need to enter both the posterior and anterior plane of inguinal region, and the limited number of long-term follow-up studies. On the basis of these critics, more recently the HerniaSurge guidelines for groin hernia management have concluded that "the use of other meshes or gadgets to replace the standard flat mesh in the Lichtenstein technique is currently not recommended" [13].

Many trials compared MPR and Lichtenstein technique. We collected 15 RCTs in a systemic

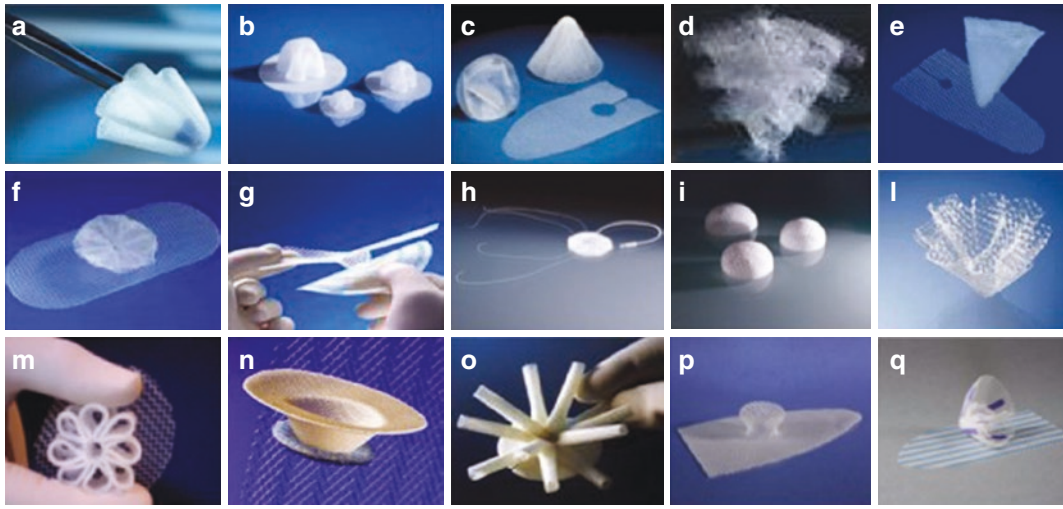

Fig. 27.2 Plugs and 3D devices available on the market

Table 27.1 MPR vs. Lichtenstein: RCTs

Lichtenstein vs. MPR
Kingsnorth AN (short-term) [14]
Kingsnorth AN (medium-term) [15]
Testini M [16]
Bringman S [17]
Adamonis W [18]
Bolognini S [19]
Horharin P [20]
Frey DN [21]
Sanders DL [22]
Droeser RA [23]
Ripetti V [24]
Lichtenstein vs. PHS vs. MPR
Nienhuijs SW [25]
Mayagoitia JC [26]
Dalenbäck J [27]
Nienhuijs SW [28]

review (Table 27.1) [14–28]. These showed comparable outcomes in the short and long period, in terms of return to normal activity, postoperative complications, chronic pain, and recurrence rate, with statistically significant shorter operative time in the plug repair group, even if the gap is less than 10 min. Two meta-analysis comparing different open techniques, including Lichtenstein and plug repair, confirmed that both procedures were equivalent in most of the analyzed outcomes, with the above demonstrated shorter surgical time associated with mesh plug technique [29, 30]. Interestingly, two trials showed, from the surgeon's point of view, that MPR was significantly superior to the Lichtenstein operation in terms of perceived difficulty and surgeon's satisfaction [25, 27]. Actually MPR had been proved to be the fastest to perform and the easiest to learn by 70 experts in hernia surgery [31]. Four RCTs reported long-term results, from 36 to 76 months [23, 26–28]. None of them showed relevant differences in recurrence, chronic pain, or other complications, as migrating mesh plug. In one RCT, the overall cumulative reoperation rate was fairly higher in the Lichtenstein group [23]. Nevertheless, the main criticism to plug repair continues to refer to the natural history of the mesh. The plug can shrink (*meshoma*), could migrate and erode the surrounding structures (cecum, sigmoid colon, ileum, bladder), or can be responsible for chronic pain. The cone tip of the device could act as a pivot, and any tilt or drift of the plug could play a role in the pathophysiology of the mesh migration [32]. Mesh migration might happen because of the movement toward the path of resistance, caused by a poor securement of the mesh, or might occur through surrounding structures conditioned by erosion caused by a foreign body reaction [33].

How common is the migration/erosion of the plug really? A previous review of the literature collected seven case reports published between

Table 27.2 Plug migration/erosion: visceral involvement

Reference	Time lapse	Clinical presentation	Site
Chuback JA [37]	2 years	Occlusion	Small bowel
Tokunaga Y [38]	7 years	Rectal bleeding (D like)	Sigmoid colon
Moorman ML [39]	15 years	Lower quadrant pain	Small bowel
Benedetti M [40]	2 years	Rectal bleeding (D like)	Sigmoid colon
Murphy JW [41]	2 years	Lower quadrant pain (D like)	Sigmoid colon
Ojo P [42]	8 years	Lower quadrant mass (C like)	Cecum
Zubaidi A [43]	2 years	Colocutaneous fistula (D)	Sigmoid colon
Stout CL [44]	nr	Occlusion	Small bowel
Liang X [45]	3 years	Occlusion	Small bowel
Ortiz JA [46]	nr	Necrosis (kidney Tx recipient)	Ureter
Ishiguro Y [47]	3 years	Colocutaneous fistula	Sigmoid colon
Chen MJ [48]	2 years	Perforation	Small bowel
Ratajczak A [49]	2 years	Obstruction (C like)	Sigmoid colon
Yilmaz I [50]	3 years	Occlusion	Sigmoid colon
Ishikawa S [51]	5 years	Bladder skin fistula	Bladder
Sekiguchi K [52]	13 years	Colocutaneous fistula	Cecum
Yamamoto S [53]	2 years	Occlusion	Small bowel
Scaringi S [54]	26 years	Colocutaneous fistula (D)	Sigmoid colon
Veroux M [55]	6 years	Hydronephrosis (kidney Tx recipient)	Ureter

1995 and 2006 [34], including two hernia recurrences, which should be excluded due to migration of the plug into the scrotum without any other clinical involvement [35, 36]. We extended the review over the last decade, collecting further 14 reports of plug-related visceral involvement (Table 27.2) [37–55]. In two other cases, the plug migration was revealed as an *incidentaloma* at CT scan, without any clinical sign [56, 57]. The sigmoid colon was the site more frequently involved, followed by the small bowel and cecum. The plug affected the urinary tract in three cases only. Symptoms related to plug migration or erosion apparently occur mainly in the first 3 years after the hernia repair, even if few reports suggest that the time interval might be longer. Clinical findings (occlusion, bleeding) mimicking carcinoma of lower gastrointestinal tract were frequently associated. The majority of the patients with sigmoid involvement suffered from diverticular disease.

Some surgeons suggest that migration may not be as uncommon as it seems to appear from the collection of anecdotal reports in the surgical literature [58]. Other cases of plug migration could not come to publication for medicolegal implications, indifference of the authors, or lack of recognition; the actual rate, therefore, could be underestimated. However, this opinion is in contrast with the results of population studies in which no case of mesh migration has ever been seen in the long run [23, 34, 59–61]. At the end of the 1990s, an Italian national inquiry, collecting 19,700 MPRs, showed only five cases of inner migration of the plug [62]. At the fifth International Hernia Congress of the American Hernia Society (AHS), we presented a search of the US Food and Drug Administration MAUDE for key word mesh plug (PerFix™) to find reports not published in the literature (from 1999 to 2011). We were able to collect only six cases of visceral involvement due to migration/erosion of the plug [63]. At the end of 2015, the total number reached 15 cases. In conclusion, visceral involvement following plug repair is a very rare complication, reported in literature as anecdotal clinical case, as it occurs for TAPP or TEP techniques [64].

Can the outcome of MPR be improved? Can the risk of migration/erosion be reduced? [65]. The answer is positive. The first suggestion consists in selecting proper indications, limiting plug repair to the treatment of lateral hernias, to femoral hernias, and to selected types of recurrences, and avoiding it in patients suffering from left groin hernia and colonic diverticular disease or in case of sliding hernias; secondly it is important to

pay attention to technical details, such as to avoid excision of the sac and lipoma, to identify and repair any tears of peritoneum, to avoid to place the plug too deep into the inguinal canal, and to secure the plug with a number of sutures; thirdly it is important to choose the proper plug. A new generation of plugs and 3D devices, made from lightweight or semi-absorbable or completely absorbable materials, and improved profiles are available today on the market. Some of these have proved to provide benefits [22, 66, 67]. Others seem to show favorable effects in selected cases [68–70]. Finally new "all-in-one" devices allow a plug-and-patch repair without any risk of migration [71].

We do not agree with those who consider MPR as *gadget surgery*, highlighting the *marketing* of the technique. The additional cost of the device doesn't justify this criticism, though other commended techniques, such as TAPP or TEP repair, are more expensive. Instead with the same outcome and comparable complication rate, other parameters should be considered when selecting the more effective repair, like the surgeon's satisfaction [72]. MPR offers the fastest learning curve and the shortest operative time [31]. The plug should be kept in the armamentarium of a general surgeon interested in a tailored approach to groin hernia surgery.

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28 Self-Gripping Mesh Repair in Primary Inguinal Hernia

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28.1 Introduction

Since the first description of Lichtenstein technique [1], open anterior prosthetic tension-free hernioplasty has become the most widely used and gold standard for the treatment of primary inguinal hernias as suggested by the guidelines issued by the European Hernia Society in 2009 [2]. The choice between a laparoscopic approach or open methods of unilateral hernia repair is mainly subject to the surgeons expertise and preference, since there are no significant differences in the recurrence rates and complications [3]. Hernia recurrence rates, the primary concern following pure tissue repair, is no longer a pressing clinical problem with an estimated incidence well below 5% [4]. Conversely, the incidence of chronic postoperative inguinal pain (CPIP), also referred as inguinodynia, defined as moderate to severe pain persisting for 3 months after surgery [5], is a growing concern in the field since it arises in up to 29% of cases, particularly following open repair procedures [6], although it must be noted that severe pain occurs rarely, in 3–4% of patients [7]. The main causes of CPIP are considered to be perioperative nerve damage, postoperative fibrosis, or mesh-related fibrosis [8]. Considering that 5–7% of patients with postherniorrhaphy groin pain will sue their surgeon [9], the updated European hernia guidelines suggest that atraumatic mesh fixation could be a key element in reducing this occurrence [10]. In order to avoid mesh fixation with potentially traumatic sutures, both fibrin glue and n-butyl-2-cyanoacrylate have been used with promising results [11, 12]. In this chapter we introduce the topic of self-gripping mesh in primary inguinal hernia repair; these are self-fixating devices covered by Velcro-like hooks that stick to the inguinal wall the moment they are applied, making fixation essentially unnecessary. We will start with a description of the product presently available on the market before passing on to a step-by-step guide on how to best perform this surgical procedure; this will be enriched by a tips and tricks paragraph with advice from our experience to help you in your everyday practice. Finally, since Chastan first report on the use of self-gripping meshes for tension-free open hernia repair in 2006 [13], numerous articles have been published and different conclusions have been drawn; we will overview and discuss the available literature highlighting advantages and limitations of self-gripping mesh repair.

28.2 Description of the Self-Gripping Mesh

ProGrip™ is the most used self-gripping mesh in inguinal hernia repair (Fig. 28.1).

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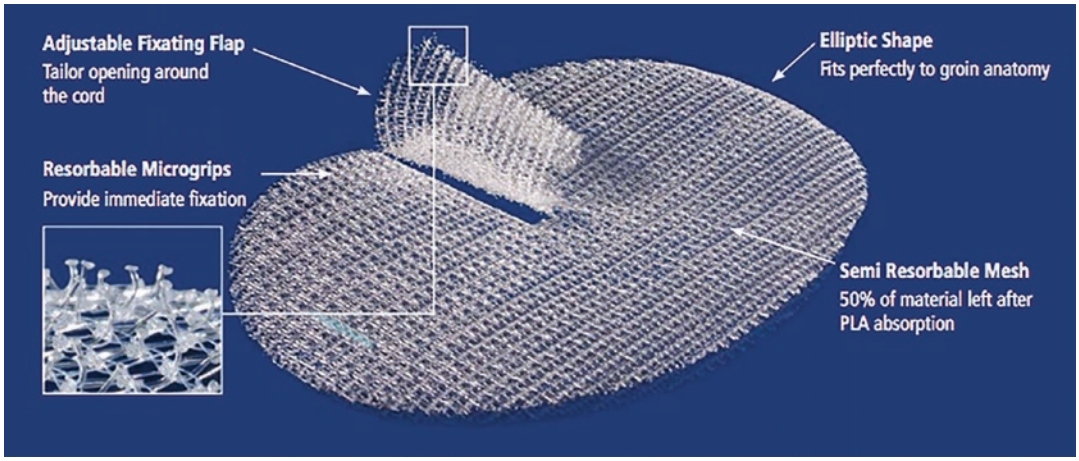

Fig. 28.1 Mesh overview (Reproduced from Medtronic)

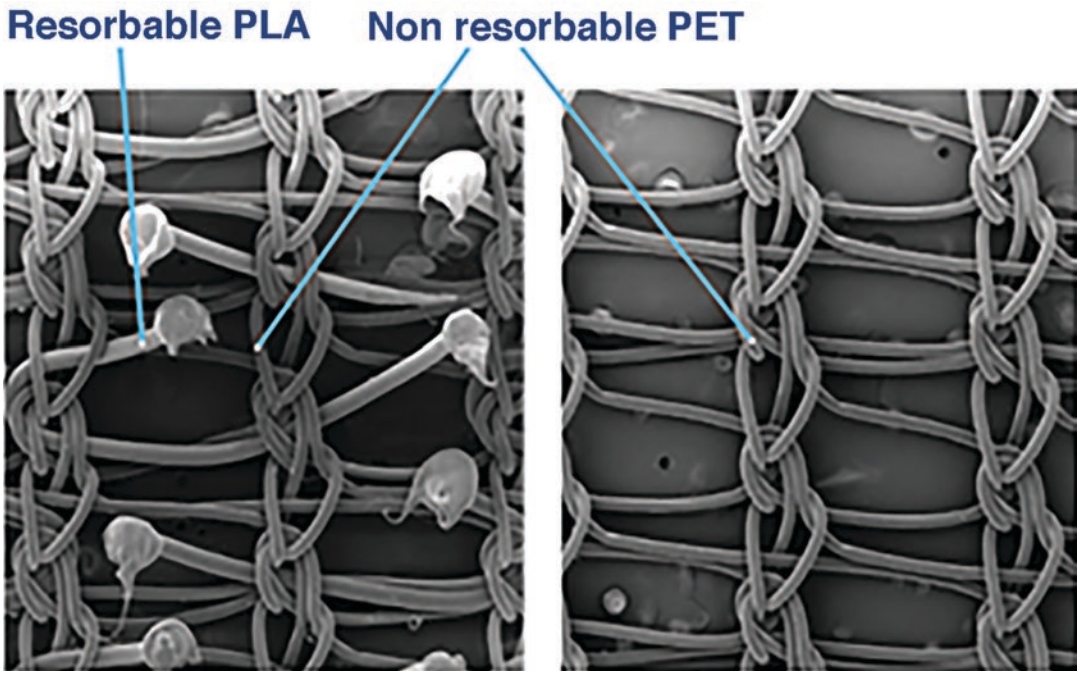

Fig. 28.2 Magnified mesh structure before and after PLA micro-hook resorption (Reproduced from Medtronic)

The Parietex ProGrip™ is a bicomponent self-fixating mesh made of hydrophilic monofilament polyester (PET) knit with resorbable polylactic acid (PLA) microgrips. The pore size of the mesh varies from 1.1 to 1.7 mm, and its weight decreases from 73 g/m^2 at insertion to 38 g/m^2 after the PLA hook resorption [14] (Fig. 28.2).

28.3 Surgical Procedure

28.3.1 Anesthesia

Inguinal hernias are mostly repaired under local anesthesia, with the possible addition of sedation. In case of recurrences or complicated hernias, it

is preferred to perform the surgery under general anesthesia.

28.3.2 Incision, Opening, and Exploration of the Inguinal Canal

Open inguinal hernia repair can be performed with two types of incisions (Fig. 28.3):

(A) a 7 cm oblique skin incision above the inguinal ligament, from an ideal point, located 2 cm medially to the anterior superior iliac spine, to the ipsilateral pubic tubercle;
(B) a 4 cm transverse skin incision in an ideal area corresponding to the lateral Pfannenstiel incision

Dissection is continued through the subcutaneous tissues and *Scarpa*'s fascia until the external oblique aponeurosis and the internal inguinal ring are identified (Fig. 28.4).

Using a *cold* scalpel, the external oblique aponeurosis is opened starting from the internal inguinal ring to expose the inguinal canal, paying attention to identify the ilioinguinal nerve and possible femoral hernias (Fig. 28.5).

The external oblique aponeurosis is then grasped with two *Kelly* forceps, and, with the help of a folded sponge, a space for mesh application is created up to the inguinal ligament (lateral). Paying particular attention to the iliohypogastric nerve, the space is extended medially with the use of curved scissor (Fig. 28.6).

The spermatic cord with his muscle, the cremaster, is identified and separated from the floor

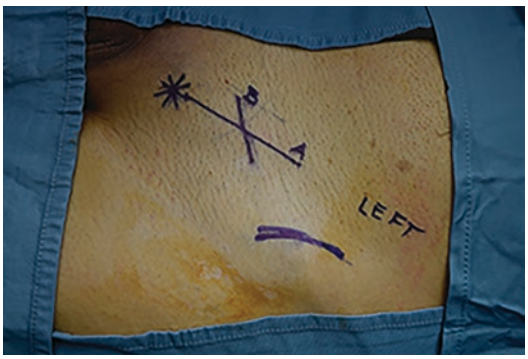

Fig. 28.3 Marked operating field: *A* = oblique incision, *B* = transverse incision

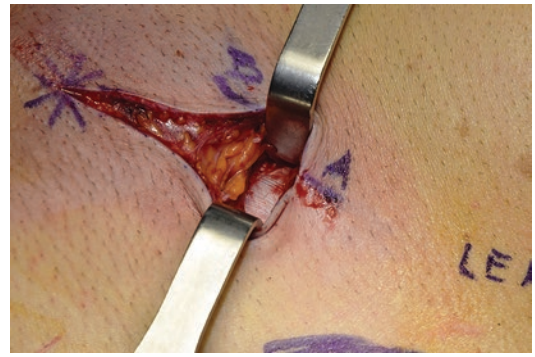

Fig. 28.4 The lateral cleft exposes the external oblique aponeurosis

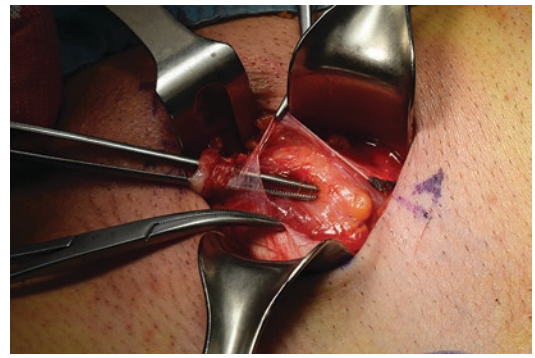

Fig. 28.5 Opening of the aponeurosis and of external inguinal ring

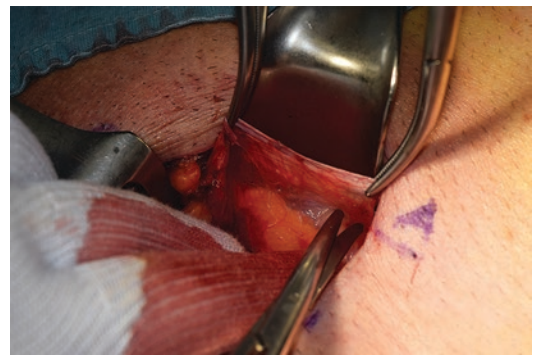

Fig. 28.6 Preparation of the medial portion of the inguinal canal

of the inguinal canal at the level of the pubic tubercle. Whenever possible, the ilioinguinal, iliohypogastric, and genital branches of the genitofemoral nerves have to be visualized and protected throughout the operation.

With the use of a vessel loop, the spermatic cord is gently suspended.

28.3.3 Hernioplasty and Mesh Application

The cremaster muscle is opened longitudinally and resected; a large and comprehensive dissection is necessary to detect a possible lateral hernia and allow a perfect allocation of the mesh around the cord.

In case of lateral (L) hernias, the hernial sac is identified and isolated from the muscle and the cord (Fig. 28.7). Without opening, when possible, the hernial sac is reduced into the internal inguinal ring (Fig. 28.8). A plastic of the inguinal ring is then performed with a 2-0 resorbable stitch.

In case of medial (M) hernias, a plastic of the *fascia transversalis* is obtained with a 2-0 continuously running resorbable suture (Fig. 28.9).

Before opening the mesh, gloves are changed.

A polypropylene self-gripping mesh is then opened paying attention in avoiding any unnecessary folding of the mesh.

A flap of the anatomically designed mesh is folded and attached on the lateral portion of the mesh itself.

The mesh is spread down to the pubic tubercle level with a 2 cm overlap on the symphysis (Fig. 28.10).

Particular attention is needed in this stage to avoid that any adipose tissue remains stranded between the mesh and the tubercle.

The mesh is slept down both medially and laterally above the inguinal ligament, and then the previously folded flap is closed around the spermatic cord.

Thanks to the Velcro-like hooks, mesh fixation is immediate and no additional sutures are usually required.

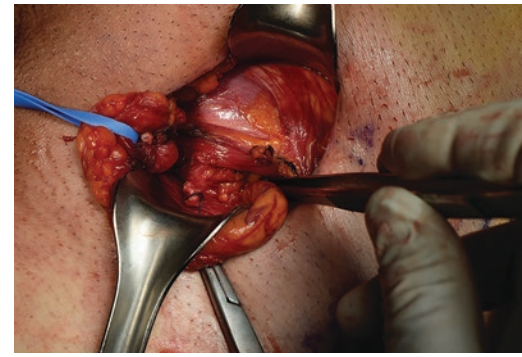

Fig. 28.8 Reduction of hernial sac

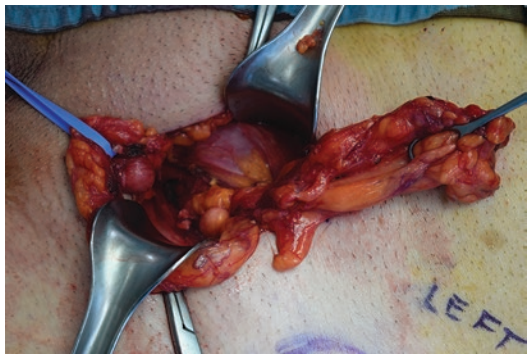

Fig. 28.7 The hernial sac (holded by Foerster forceps) isolated from spermatic cord

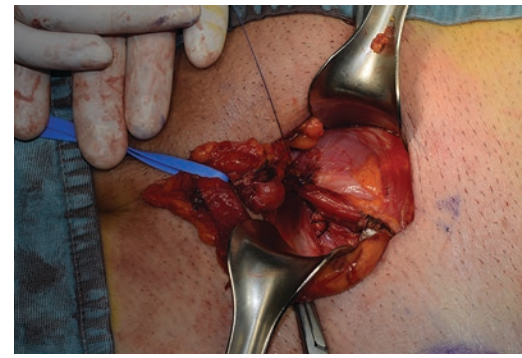

Fig. 28.9 Plastic of *fascia transversalis* helped by an antibacterial absorbable hemostat inserted in the defect

The external oblique aponeurosis is closed with two continuous sutures using slowly resorbable stitches (Fig. 28.11a, b). This type of suture is interrupted in the midline by the passage of the spermatic cord that is left in the subcutaneous tissue, just above the external oblique aponeurosis.

Scarpa's fascia is then approximated with a 3-0 absorbable interrupted suture, beginning from the inferior part of the incisional line to avoid a possible lesion of the spermatic cord. The skin is closed with 3-0 non resorbable stitches or staples.

The incision line is then covered with a compressive dressing.

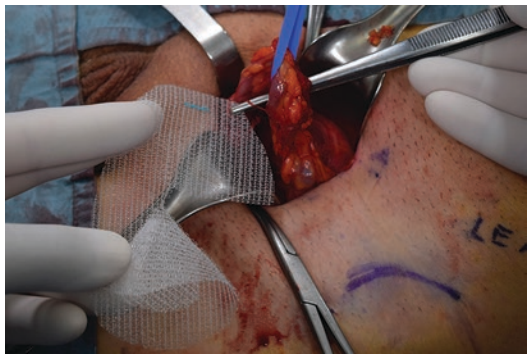

Fig. 28.10 Insertion of the folded self-gripping mesh

28.4 Tips and Tricks

28.4.1 Antibiotic Prophylaxis

- <40 years old, ASA class I: no prophylaxis
- >40 years old: a prophylactic preoperative single dose of second-generation cephalosporin
- Patients at risk (i.e., diabetes, cardiovascular comorbidities): 5 days of therapy with cephalosporin

28.4.2 Preoperative Landmarks

We use a dermographic pen to mark the anatomy.

Of the described skin incisions, we mostly use the oblique one reserving the partial Pfannenstiel to women, children, and underweight patients to ensure a better aesthetic result.

28.4.3 Anesthesia

We usually perform the procedure under local anesthesia, using the following preparations:

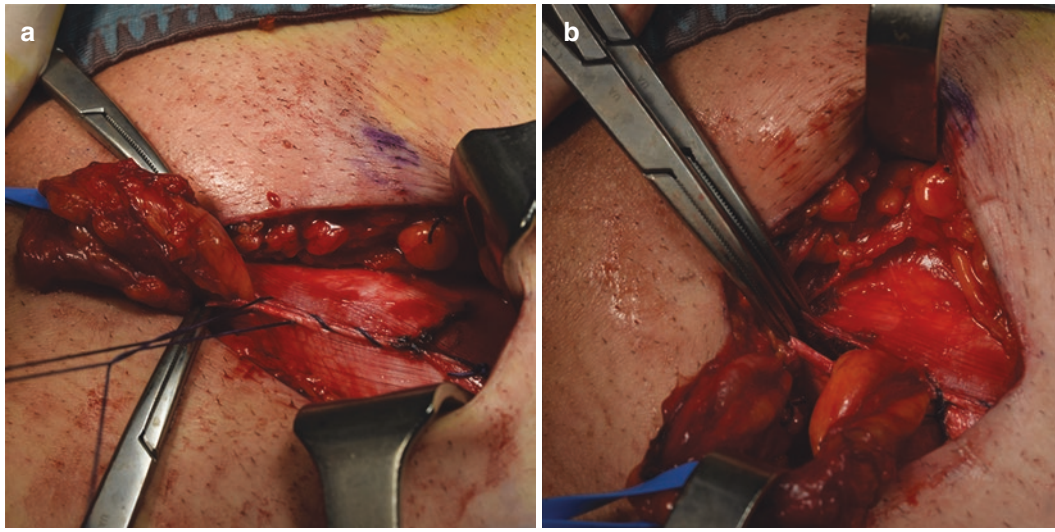

Fig. 28.11 Suture of external oblique aponeurosis interrupted by the passage of the spermatic cord

1. A mixture of 10 mL of 2% mepivacaine hydrochloride, 9 mL of saline solution, and 1 mL of sodium bicarbonate, in a 20 mL syringe
2. A mixture of 9 mL of 2% mepivacaine hydrochloride and 1 mL of sodium bicarbonate, in a 10 mL syringe
3. A mixture of 20 mL of 7.5% ropivacaine hydrochloride and 40 mL of saline, in a surgical basin

Before making the incision, we make a subcutaneous infiltration using the first of the three solutions. Mepivacaine is a local anesthetic of the amide type that has a reasonably rapid onset and medium duration of action. The solution is injected in the subcutaneous space (Fig. 28.12a) allowing a reversible block of nerve conduction that produces a temporary loss of sensations.

The second solution is then injected along the incision line into the subdermal space (Fig. 28.12b), placing the needle parallel to the skin. This infiltration is performed on a more superficial level in respect to the first injection.

During tissue dissection, we usually start by creating a cleft in the lateral third of the incisional line to easily identify the external oblique muscle aponeurosis and infiltrate the inguinal canal with 10 mL of the third solution (Fig. 28.13); this injection will block the ilioinguinal, iliohypogastric, and genital branch of the genitofemoral nerves. In doing that, we usually bend the needle of a syringe and pay special attention to avoid infiltrating the cremaster muscle that should remain on the posterior layer of the aforementioned aponeurosis. With another 10 mL of the third solution, we infiltrate the deepest subcutaneous tissue just before completing the surgical incision. We keep the remaining 40 mL of the ropivacaine solution in case this is needed for nerves or peritoneal infiltrations during surgery.

28.4.4 Nerve Management

Pain prevention is a primary goal in open inguinal hernia repair.

The EHS guidelines [2] suggest that surgeons routinely identify and protect the three nerves we encounter during this procedure, respectively, the ilioinguinal, the iliohypogastric, and genital

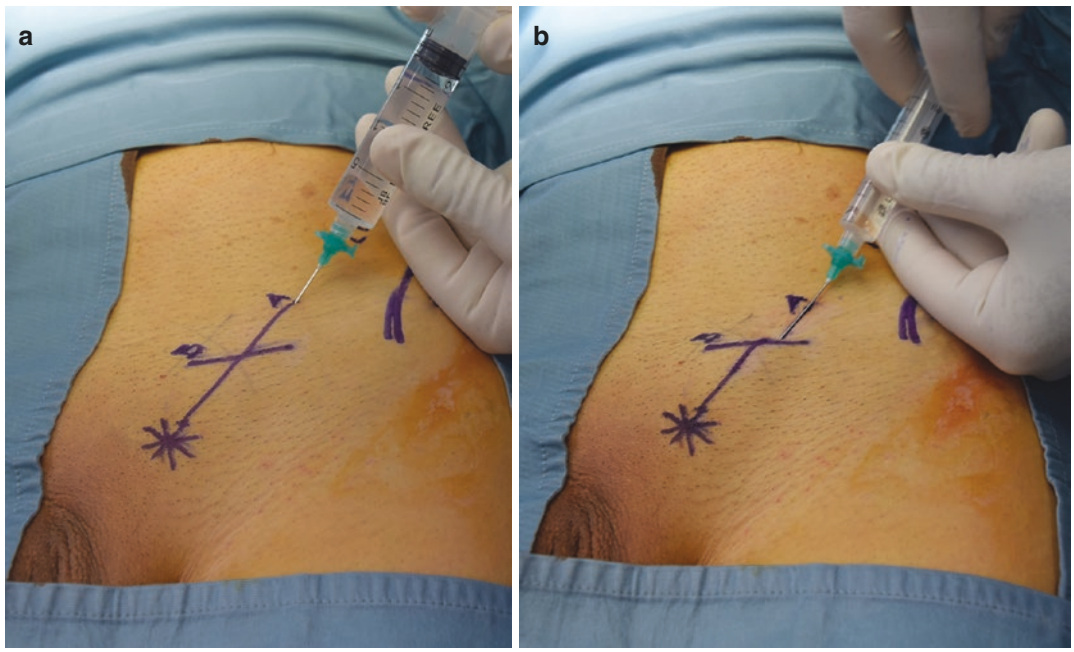

Fig. 28.12 Local anesthesia: (**a**) subcutaneous injection, (**b**) superficial infiltration

branch of the genitofemoral nerve. However, sometimes this is not safe.

We consider a nerve *at risk* when this is stressed during the dissection phase of the surgical procedure or when this will be placed in direct contact with the mesh during the reconstruction phase.

In case that any of the three nerves is considered *at risk*, this will be infiltrated using a 30 G needle with 20 mL of 7.5% ropivacaine hydrochloride diluted with 40 mL of saline and later resected (Fig. 28.14a, b). Ropivacaine is a safe long-acting local anesthetic belonging to the amino amides group. This drug permits differential nerve blocks, making it possible to anesthetize sensitive fiber without influencing the nerve's motor fiber. In addition, it has a vasoconstrictive effect, which prolongs the duration of the anesthesia.

28.4.5 Hernial Sac Management

If unnecessary, we usually don't open the hernial sac; we reduce it after a careful preparation up to its neck. In case of L2 and L3 hernias, to reduce the sac back in the abdomen, long tissue forceps are used to hold an antibacterial absorbable hemostat as a plug into the internal inguinal ring (Fig. 28.15). When the peritoneum that forms the hernia sac is stressed during the described

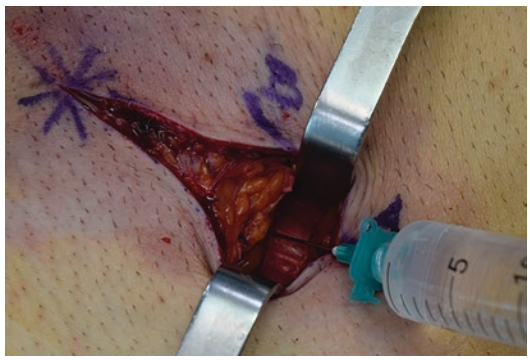

Fig. 28.13 Infiltration of the inguinal canal

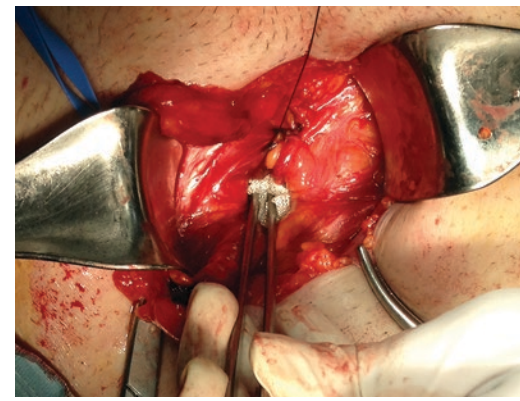

Fig. 28.15 Long tissue forceps are used to hold an antibacterial absorbable hemostat as a plug into the abdominal wall defect

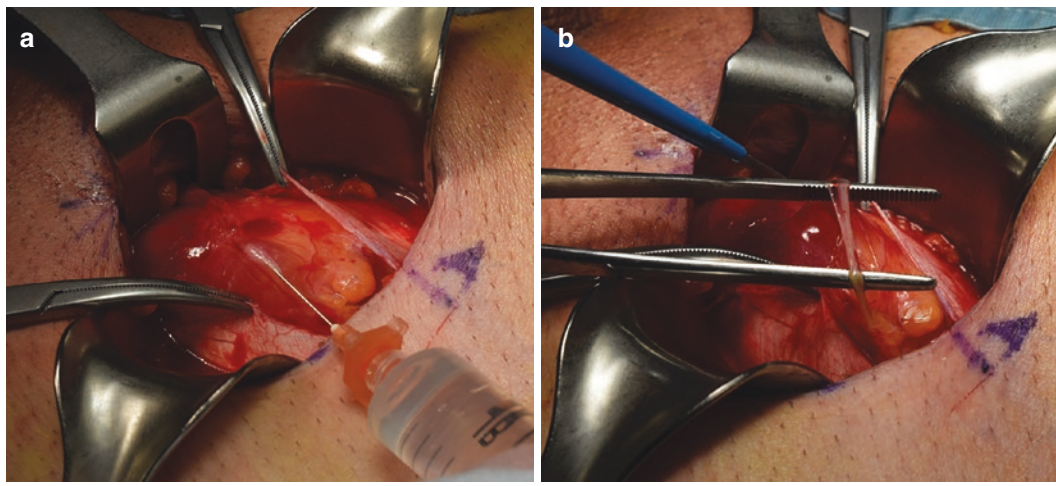

Fig. 28.14 Infiltration (**a**) and resection (**b**) of the nerve *at risk*

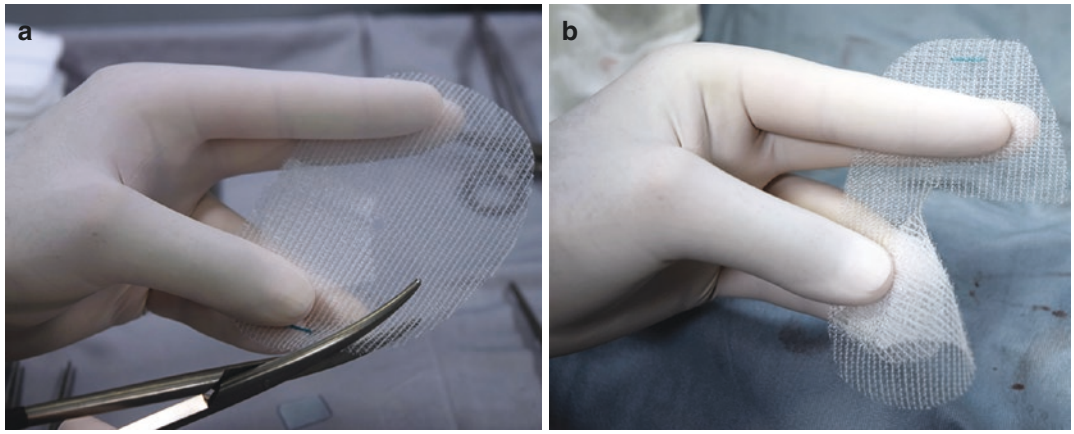

Fig. 28.16 Self-gripping mesh handle: (**a**) tailoring, (**b**) folded mesh

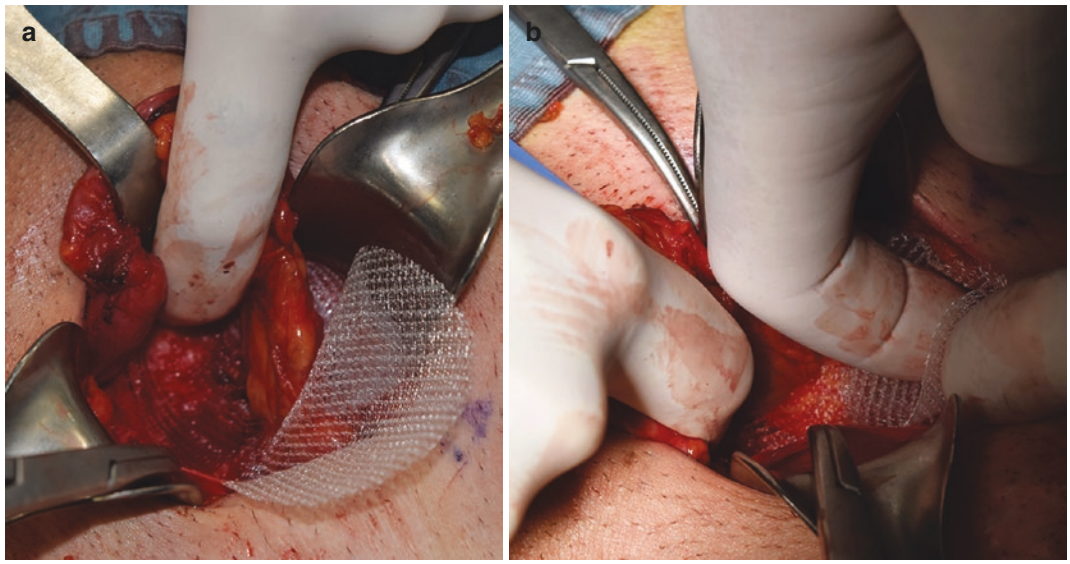

Fig. 28.17 Positioning of the mesh: (**a**) assistant's index finger holds the mesh on the pubic tubercule, (**b**) the operator slides the mesh in place

maneuvers, this should be infiltrated with the remaining ropivacaine solution.

28.4.6 Mesh Application

Even though we mostly use anatomically designed self-gripping meshes, we often tailor them according to the shape of the patient's posterior wall of the inguinal canal (Fig. 28.16a, b).

After positioning the prosthesis over the pubic tubercule, the operating surgeon gently pulls the portion of the oblique aponeurosis lateral to the spermatic cord with his left index in order to create space for the mesh to be slipped in with his right index finger (Fig. 28.17b). During this maneuver, the assistant should keep the medial portion of the mesh well in place over the symphysis to avoid any shrinkage (Fig. 28.17a). The first operator then smoothes out the mesh medially and laterally using both fingers.

Even though fixation sutures are mostly unnecessary, in case of M2 and M3 hernias, nonabsorbable suture stitches near the pubic tubercle

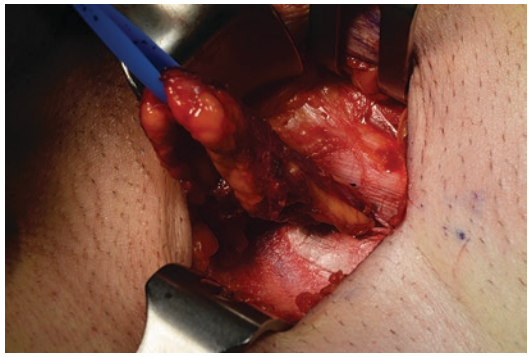

Fig. 28.18 The spermatic cord goes through the external oblique aponeurosis and remains in subcutaneous space (Trabucco)

are used to fix the mesh, one toward the rectus abdominis muscle and one toward the ligament. Important to notice, this suture should not be placed too deep right on the pubic tubercle to decrease the risk for chronic pubic pain.

Since the external oblique aponeurosis is approximated beneath the spermatic cord, the latter remains in the subcutaneous space, as in the *Trabucco* and the *Postempski* techniques (Fig. 28.18).

This strategy should be preferred over the classical *Lichtenstein* for three main reasons:

1. Having better fixation of the mesh, thanks to the creation of an *inguinal box*
2. Avoiding the mesh to get in direct contact with the spermatic cord
3. In case of recurrence, easier identification of the spermatic cord, thus less risk of lesion

28.4.7 In Females

In women, we usually implant a flat self-gripping mesh rather than an anatomically designed one. Since the genital branch of the genitofemoral nerve is contained in the round ligament of uterus, it is suggested to preserve the latter to avoid the small risk of hypersensitivity and ipsilateral labial numbness [2]. When this is the case, the self-gripping mesh is cut in its straight posterior side instead of the lateral cut visible on the anatomical design; the flaps are encompassed around the ligament and blocked placing a small piece of the self-gripping material over the mesh itself. In the case the round ligament of uterus cannot be preserved, the flat mesh is positioned as it is.

28.5 Discussion and Conclusions

After having described the surgical technique to perform an open anterior tension-free inguinal hernia repair using a macroporous semi-resorbable self-gripping mesh, we will now present and discuss an overview of the 27 papers published on the topic in the last decade (Table 28.1).

As stated previously, since the introduction of tension-free prosthetic mesh repair, the key issue regarding inguinal hernia repair has shifted from recurrence rates to incidence of patient discomfort following surgery, especially severe inguinodynia and the medicolegal consequences this occurrence implies.

The self-gripping mesh was originally designed to address this concern by eliminating the need for fixation points conferring an even distribution of tension across the repair and avoiding the stitches that are accountable for nerve entrapment and neuroma formations, the main causes of CPIP. Furthermore, the polylactic acid (PLA) microgrips that give Velcro-like properties to the device resorb naturally, leaving less material behind.

Professor Philippe Chastan in 2006 was the first to describe on a cohort of 52 patients that this sutureless mesh is easy to use, takes less than 60 seconds to be put in place, and is comparable to the Lichtenstein technique in terms of complication rates. This publication justifies the use of his eponym when referring to this surgical treatment of inguinal hernia.

Following, a number of clinical trials and meta-analysis have managed to demonstrate that this new atraumatic mesh is not inferior to the gold standard Lichtenstein technique in terms of recurrence rates and postoperative complications. The results concerning the pain and/or discomfort felt by the patients following surgery is far more controversial due to contrasting results and

Table 28.1 Overview of the conclusions of published papers (2006–present) about open anterior tension-free inguinal hernia repair using a self-gripping mesh

Publication	Journal and year	Type of study	Results
Chastan [13]	J Min Access Surg 2006	Report	Based on the first results of this clinical study, this unique concept of low-density self-gripping mesh should allow an efficient treatment of inguinal hernia. It should reduce postoperative complications and the extent of required suture fixation, making the procedure more reproducible
Chastan [15]	Hernia 2009	Report	Self-gripping mesh may be a satisfactory solution to the clinical problems of pain and recurrence following inguinal herniorrhaphy. It takes less than 60 s to place the mesh in site
Kapischke et al. [16]	Langenbecks Arch Surg 2009	Controlled prospective clinical trial	Less pain on the first postoperative day, less analgesic, and faster surgical procedures. No differences at 6 months
Bruna Esteban et al. [17]	Cir Esp 2010	Randomized clinical trial	The use of this type of mesh reduces the time of fixing the prosthesis and the total surgical time, with no effect on early postoperative pain or surgical complications
Anadol et al. [18]	Surg Today 2011	Prospective comparative study	Operating time was shorter, and early pain scores were lower in the self-adhesive mesh group
García Ureña et al. [19]	Hernia 2011	Multicentric observational study	Incidence of chronic pain at 6 months was 3% lower when using a self-gripping mesh
Kingsnorth et al. [20]	Hernia 2012	Randomized clinical trial	Surgery duration was significantly shorter, and early postoperative pain was significantly lower in the self-gripping group
Quyn [21]	Langenbecks Arch Surg 2012	Clinical trial	Self-griping mesh may lead to less chronic pain and less restriction of daily living activities
Pierides et al. [22]	BJS 2012	Randomized clinical trial	No differences regarding chronic postoperative pain
Jorgensen et al. (DANGRIP) [23]	BJS 2012	Randomized clinical trial	The use of self-gripping mesh was not accompanied by a reduction in chronic symptoms
Gys et al. [24]	Acta Chir Belg 2013	Prospective observational study	The open Lichtenstein hernia repair with the semi-resorbable self-gripping Parietex ProGrip mesh seems to offer a reliable alternative for the treatment of inguinal hernia with benefits on operating time as well as on postoperative pain
Sajid et al. [25]	Updates Surg 2013	Systematic review and meta-analysis	Chronic pain, recurrence, postoperative complications, and length of hospital stay were similar
Zhang et al. [26]	J Surg Res 2013	Systematic review and meta-analysis	No significant differences, except for the shorter mean operative duration recorded in the self-gripping mesh group
Pandanaboyana et al. [27]	The Surgeon 2013	Meta-analysis	The only significant difference found was the shorter duration of the operation
Li et al. [28]	Ann Surg 2014	Meta-analysis	No statistical difference, except for the shorter operating time
Fang et al. [29]	Am J Surg 2014	Systematic review and meta-analysis	No significant differences, except for the mean operating time that was significantly shorter in the self-gripping group
Sanders et al. [30]	BJS 2014	Randomized clinical trial	Self-gripping mesh was well tolerated and reduced early postoperative pain, without increasing the risk of early recurrence or reducing chronic pain

Table 28.1 (continued)

Publication	Journal and year	Type of study	Results
Rönkä et al. (FinnMesh) [31]	Ann Surg 2015	Randomized clinical trial	Mesh fixation without sutures does not cause less inguinodynia than suture fixation, but it is faster and easier and feasible without compromising postoperative outcome
Smeds et al. [32]	Hernia 2015	Secondary exploratory study	The use of self-gripping mesh was shown to reduce the level of postoperative pain when the iliohypogastric nerve was preserved. Resection of the nerve during Lichtenstein repair eliminates this difference
Nikkolo et al. [33]	J Surg Res 2015	Randomized clinical trial	Self-gripping mesh compared with standard Lichtenstein operation has no advantages in reducing chronic pain 6 months after surgery. The rate of foreign body feeling was higher in the self-gripping mesh group
Wang et al. [34]	Asian J Surg 2016	Retrospective study	No recurrences recorded
Fan et al. [35]	Hernia 2016	Randomized clinical trial	The use of self-gripping mesh effectively reduces the operating time with comparable long-term surgical outcome with traditional polypropylene mesh
Verhagen et al. [36]	BJS 2016	Randomized clinical trial	A self-gripping mesh for hernia repair may result in less pain in the early postoperative phase, but chronic postherniorrhaphy pain is not affected
Cadanová et al. [37]	Hernia 2016	Randomized clinical trial	No significant difference in chronic pain between the inguinal repairs with the use of a self-gripping mesh compared with a transinguinal preperitoneal (TIPP) repair at 1 year after surgery
Nikkolo et al. [38]	J Surg Res 2017	Randomized clinical trial	We failed to demonstrate the advantages of self-gripping mesh in terms of chronic pain and foreign body feeling. However, usage of self-gripping mesh does not increase hernia recurrence rate
Ismail et al. [39]	Surgery 2017	Systematic review	Data from our analysis did not favor either of the two fixation techniques over the other in terms of recurrence or postoperative chronic groin pain
Molegraaf et al. [40]	Ann Surg 2017	Randomized clinical trial	The self-gripping ProGrip mesh does not reduce CPIP rates. Outcomes of the ProGrip mesh are comparable to the Lichtenstein technique with the additional advantage of a reduced operation time

a poor definition of chronic postoperative inguinal pain. For the sake of brevity, most of the studies agree on a reduction of early postoperative pain and need of analgesic, but unfortunately there is no evidence of reduced CPIP, especially when the iliohypogastric nerve is not preserved. However, a common finding highlighted by most of the papers is the significantly shorter time needed to fix the prosthesis and an overall faster surgical procedure that would allow a more efficient utilization of the operating theater and staff; this makes the use of these devices feasible from a health economics point of view. Moreover, there is no major technical difference between the procedures apart from the fixation steps, and more than one author has stated that the sutureless technique is easy to use and learn; this is crucial since inguinal hernia repair is among the first procedures performed by general surgery residents.

In conclusion, a general surgeon dedicated to the treatment of abdominal wall defect should include in his armamentarium the ability to perform an open anterior tension-free inguinal hernia repair with a self-gripping mesh in order to tailor on the need of the patients his surgical approach.

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29 Gilbert Technique: PHS Bilayer Repair

Jerrold Young and Arthur I. Gilbert

29.1 Anatomy: Principles of Repair

Over the past 120 years, because of the complexity of the anatomy of the groin region, and the goal of simplifying the procedure so that all general surgeons can have acceptable outcomes, there have been many different techniques described for inguinal hernia repair. The ideal hernia repair would be performed as an outpatient procedure under local anesthesia, with a short operative time, at low cost, with low risk for other side effects and complications. There should be few recurrences and minimal post-op and long-term discomfort and disability. The technique should have a short learning curve, with excellent reproducible results when performed by all general surgeons as well as experts. Because there is no single repair which has all of these desired outcomes, there has been continued investigation and analysis of new concepts and techniques and rebirth of old techniques.

The underlying principle of all groin hernia repairs is to reduce the herniating intra-abdominal or preperitoneal contents behind the musculoaponeurotic plane of the abdominal wall and prevent them from coming out again. All groin hernias protrude through the myopectineal orifice (MPO), the opening in the lower abdominal wall surrounded by musculoaponeurotic structures as described by Henri Fruchaud in 1956 [1] (Fig. 29.1).

The boundaries of the MPO are:

Medial—the lateral edge of the rectus muscle and its fascia.

Superior—the transversus abdominis muscle.

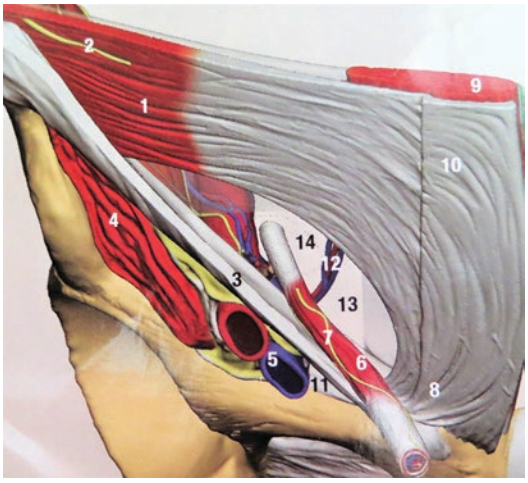

Fig. 29.1 Myopectineal orifice: Anterior view. KEY (1) transversus abdominis, (2) iliohypogastric n, (3) inguinal ligament, (4) iliopsoas, (5) femoral a and v, (6) spermatic cord, testicular a and v, (7) ilioinguinal n on spermatic cord, (8) rectus ap. attachment to pubic tubercle, (9) rectus abdominis, (10) anterior rectus sheath, (11) femoral canal, (12) inferior epigastric a and v, (13) transversalis fascia, (14) deep inguinal ring

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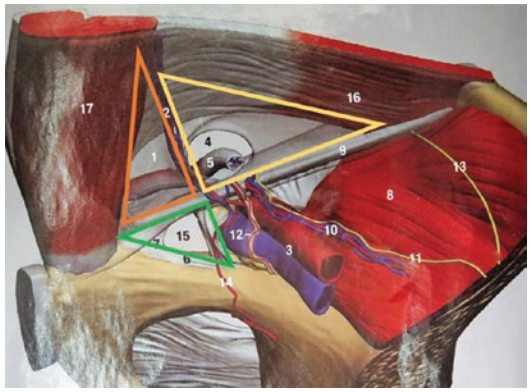

Fig. 29.2 MPO: Posterior view—triple triangles. KEY (1) transversalis fascia, (2) inferior epigastric a and v, (3) external iliac a and v, (4) deep inguinal ring, (5) spermatic cord, (6) Cooper's ligament, (7) lacunar ligament, (8) iliopsoas, (9) ilio-pubic tract, (10) testicular a and v, (11) genitofemoral n, (12) vas deferens, (13) lateral femoral cutaneous n, (14) corona mortis, (15) femoral canal, (16) transversus abdominis, (17) rectus abdominis Orange, medial triangle Yellow, lateral triangle Green, femoral triangle

Lateral—the iliopsoas muscle.
Inferior—the pectineal (Cooper's) ligament.

The MPO is further divided into the "triple triangles" of the groin (Fig. 29.2). The femoral triangle is below the inguinal ligament (IL). There are two inguinal triangles above the inguinal ligament: a medial triangle (direct) and a lateral triangle (indirect) separated by the deep epigastric vessels [2]. Ideally, groin hernia repairs should protect all three triangles to prevent recurrences. Appreciation of these factors is important to the long-term success of any repair in which a prosthetic device is used. Coverage of the MPO can be accomplished from an open approach with either sutures or an onlay prosthesis, by an open or laparoscopically placed posterior patch behind the MPO or by a combination of anterior and posterior coverage.

29.2 Background: Lessons from History

In 1979, Dr. Arthur Gilbert, a general surgeon in Miami, Florida, decided to devote his career to the discipline of "herniology," the study of abdominal wall hernias. By 1984, Dr. Gilbert's dedication to this single area of surgery allowed him to develop expertise and skills that led him to be a world leader in the field. He delved into the history of hernia surgery dating back many centuries, learning the importance of the anatomy and physiology of the abdominal wall. He traveled to Padua to see the workplace of Edoardo Bassini and at its university to see the Theatrum Anatomicum. In his quest to learn from known accomplished herniologists, he went to Toronto to meet with Nicholas Obney at the Shouldice Hospital, to Los Angeles to visit with Irving Lichtenstein, to New York City to operate with George Wantz, to Paris to operate with Jean Pallier, and to Amiens to operate with Rene Stoppa. He met with many other prominent surgeons including Campanelli, Chevrel, Flamant, Negrro, Kreuzer, and Schumpelick who were part of G.R.E.P.A. ("Groupe de Recherche et d'Etudes de la Paroi Abdominale"), which later became the European Hernia Society [3]. He embraced the camaraderie of other surgeons with an interest in hernia surgery, and in the 1980s, he invited many colleagues from the United States, the United Kingdom, South Africa, Israel, and Europe to participate in hernia surgery conferences in Miami. In 1997, at an organizational meeting in Miami hosted by Dr. Gilbert, the American Hernia Society was founded, and Dr. Gilbert became its first president. Dr. Gilbert's approach to hernia repair has mirrored that of general surgeons around the world, initially using suture repairs and then switching to mesh repairs as surgeons and patients became frustrated and dissatisfied with high recurrence rates requiring additional procedures. The concept of placing mesh behind the muscle led to the development of a bilayer repair with the PHS, a technique in which two layers of mesh attached by a "connector" are placed behind and in front of the muscles, requiring very few sutures [4].

29.3 Suture Repairs

Edoardo Bassini, of Padua, is credited with beginning the modern era of hernia surgery. Through an anterior open approach, he ligated the peritoneal sac, then opened the posterior wall of the inguinal canal, and constructed a sutured, three-layered tissue repair in 262 patients with a

failure rate of less than 3% [5]. A simplification of this technique was developed to avoid opening the posterior wall, with approximation of the transversus arch (conjoined tendon) to the shelving edge of the IL using interrupted sutures. This became known as the "modified Bassini repair," but recurrences were closer to 10–15% because of the modification. For direct and femoral hernias, Lotheissen, of Austria, and later Anson and McVay, in the United States, popularized an anatomic repair that required opening the floor and approximating the transversus arch to CL, but this also created significant tension. In 1946, Edward Earle Shouldice, of Toronto, used Bassini's original concept and developed the Shouldice operation [6]. This complex technique requires a "thinning" of the cord by dividing the lesser cord, including the genital branch of the genitofemoral nerve (GFN) and external spermatic vessels and a multilayered closure of the floor with stainless steel wire—the failure rate was reduced to less than 2% for primary hernias and to 8% for recurrent hernias. The problem with the Shouldice operation is the difficulty of the procedure and the lengthy "learning curve"—general surgeons could not learn the procedure and produce the same results as the experts.

Suturing the transversus arch to the inguinal ligament creates tension at the suture line, a feature of the Bassini operation and all other suture repairs that is disadvantageous. Even with relaxing incisions to reduce suture line tension, patients who had suture repairs still experienced a high level of postoperative pain and unacceptable failure rates as well as prolonged disability and chronic pain in up to 10% of patients [7]. Failures from suture repairs were common in both the medial and lateral triangles and often occurred years later as the muscles and fascia weakened with time, so short-term follow-up was not sufficient to detect many of the recurrences.

29.4 Anterior Mesh Repairs

In the early 1980s, surgeons, concerned about the unacceptably high incidence of hernia repair failures, began to evaluate the use of nylon mesh products for hernia repairs. Tension-free techniques were proposed to reduce recurrences and postoperative pain. In 1960, Usher, from Texas, had reported suturing a polyethylene mesh inlay patch deep to the transversalis fascia to do a "tension-eliminating" inguinal hernia repair [8]. Dr. Irving Lichtenstein popularized the tension-free Lichtenstein repair (LCHT) using a polypropylene patch on the outside of the internal oblique muscle, sutured with permanent sutures to the IL and absorbable sutures on the upper edge [9]. This is the most common hernia repair technique used worldwide, to which all other hernia techniques are compared. Surgeons have proposed modifications of the LCHT technique, mostly by using different fixation methods with glue or self-gripping mesh products, but the basic principles of the repair are sound [10, 11]. Failures following mesh repairs present more commonly in the lateral triangle where the internal ring opening is too large, or by blowout of the floor medially with the mesh detaching along with the weakened floor, or rarely under the mesh as interstitial hernias. These usually become clinically evident within 2 years. The reason for failure following mesh repair is that the mesh did not cover the entire MPO, including the femoral triangle, leaving the unprotected areas vulnerable. For larger hernias, fixation is critical for prevention of recurrence as the mesh can be pushed out with the floor as it weakens with repeated stress—it is clear that an anterior patch acts as a lid, not a "stopper."

29.5 Preperitoneal Retromuscular Repairs

Rene Stoppa described the repair of bilateral large groin hernias by widely wrapping the peritoneal base with large mesh netting (giant preperitoneal reinforcement of the visceral sac—GPRVS), thereby blocking the viscera from entering any defect in the MPO [12]. After visiting and operating with Stoppa in Amiens, Gilbert was convinced that the ideal place to position mesh is in the PP space, between the force of the hernia and the defect in the abdominal wall. In the 1980s, he borrowed Lichtenstein's idea of creating a rolled plug and used it to repair indirect inguinal hernias.

The intact indirect sac was dissected and pushed inward, and a hand-rolled mesh plug was placed into the internal ring to block the hernia opening. To complement this, a flat mesh patch was used to reinforce the rest of the floor of the inguinal canal—the "plug and patch" technique (P&P) which was popularized by Rutkow and Robbins. This worked well, but the plug was annoyingly palpable and painful in some patients. To avoid these problems, and to protect a wider area, Gilbert described his sutureless "umbrella" technique in 1989 [13]. Using the deep inguinal ring hernia opening as the window of entry to the preperitoneal space, he placed the mesh behind the muscle layers, unrolling it like opening an umbrella, allowing it to become seated on the inside of the anterior abdominal wall (Fig. 29.3). It literally blocked the peritoneal sac and its contents from protruding through the defect. When the patient's intra-abdominal force was applied against the mesh, it held the patch in place and fortified the area covered (Pascal's principle). This sutureless technique proved satisfactory, providing a lasting repair, but only for small- and medium-sized indirect hernias. However, it was sometimes difficult to fully deploy the mesh, and some failures resulted from incomplete coverage or lack of fixation of the mesh, especially for large hernias. This concept of placing mesh behind the muscles is the basis for other "posterior" repairs including those of Nyhus and Kugel, as well as laparoscopic (LAP) repairs. It is also the basis for the PHS repair, and the recently described "ONSTEP" technique [14].

Fig. 29.3 Umbrella PP technique

29.6 Bilayer Repair: The Prolene Hernia System® (PHS-UHS)

In 1997, Gilbert, with a personal experience of thousands of hernia repairs, accepted the task of designing a mesh product for Ethicon, Inc. (Johnson & Johnson) that was suitable to repair all types of groin hernia and would meet all the criteria for the ideal hernia repair: ease of use, reproducibility, low cost, few recurrences, and decreased post-op and chronic pain. He designed the Prolene Hernia System®—a polypropylene bilayer-connected mesh device used to repair all types of direct and indirect inguinal and femoral hernias through an open approach. The system has three components: a flat round underlay, an elongated oval-shaped overlay, and a 1.5 cm round connector that joins these in the center (Fig. 29.4). It is a standard weight polypropylene—80 g/cm. There are three sizes—medium, large, and extra large. The PHS is symmetrical in the longitudinal axis so can be used on either the right or left side. The mesh is designed so that the surgeon is able to modify it to suit the needs of the specific patient by trimming it according to the type and size of the hernia. In the early 2000s, there was some discussion of using lighter weight products for inguinal hernia repair, balancing the anticipated decreased inflammatory response from the mesh against the possible increased rate of recurrence because the mesh was not strong enough. A lighter weight offshoot of the PHS, the Ultrapro® Hernia System

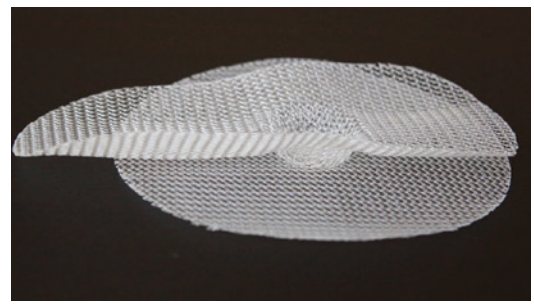

Fig. 29.4 Prolene Hernia System

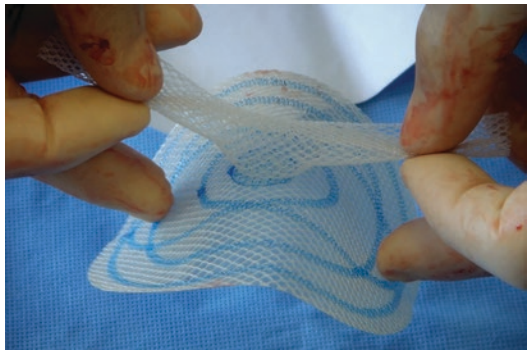

Fig. 29.5 Ultrapro Hernia System

(UHS) was developed, with an overlay of a soft lightweight partially absorbable product and an underlay that is "stiffened" by an absorbable element that dissolves over several days (Fig. 29.5). We found the stiff underlay difficult to deploy in comparison with the PHS, and there have been no studies with evidence that it improves outcomes compared to PHS.

29.7 Preoperative Evaluation and Planning

When the diagnosis is in question after the routine history and physical, a groin and testicular ultrasound examination is helpful for small or recurrent hernias, or patients with testicular complaints, to determine the location of the hernia, to check for multiple defects, and to document testicular anatomy and blood flow [15]. A "hernia-specific" informed consent is signed in the office and sent to the surgery center to become a part of the record, in addition to the blanket consent provided at the center. A medical evaluation and clearance is requested when indicated. All medications and supplements that may potentially affect coagulation are stopped 3–7 days before surgery. Some patients require a short-acting subcutaneous anticoagulant for the immediate pre-op and post-op period, depending on the reason for anticoagulation, as determined by the medical consultant. All other medications are continued up until midnight before surgery or taken with a sip of water the morning of surgery, except for diabetic medications. The patient is advised to shower the evening before and on the morning of surgery using a parachlorometaxylenol-impregnated sponge and not to shave the surgical site. In the pre-op suite, the patient is identified, and the surgical site is confirmed and marked by the surgeon prior to administration of any sedative. Any hair at the operative site is clipped just prior to the surgery. A single dose of 1–2 g of cefazolin (or 600 mg of clindamycin for penicillin or cephalosporin allergic patients) is administered within 30 min of incision time.

29.8 Operative Venue, Preparation, and Anesthesia

Most primary and recurrent inguinal hernia repairs are done as an outpatient in an ambulatory surgery center or in a hospital setting and are discharged the same day. Our preferred anesthesia is intravenous sedation with local—heavier patients or some patients with airway problems may require a laryngeal airway. General endotracheal anesthesia is rarely used, and we do not use an epidural or spinal. The goal is to avoid prolonged stay in the outpatient department and to reduce the incidence of post-op urinary retention. Versed® (Midazolam), propofol® (Diprivan), and Sublimaze® (fentanyl) are administered by an anesthesiologist as needed before and during the surgery. The skin of the lower abdomen is prepared with Betadine® (povidone iodine) or Hibiclens® (chlorhexidine gluconate). Prior to commencing, a "time-out" is initiated by the surgeon to identify all operating room personnel, the patient, date of birth, the marked operative site and procedure, and allergies.

Depending on the weight of the patient, we use up to 60 mL of 0.25% bupivacaine with 1/200,000 epinephrine injected as we proceed. Communication with the anesthesia personnel is helpful as they can increase sedation at different points during the procedure. The initial injection is in the sub-dermis and dermis and then the Scarpa's fascia. After identifying the external oblique aponeurosis, 20–25 mL more of the local anesthetic is injected by "flooding" the plane

below the external oblique—no attempt is made to "block" the nerves by direct injection as this may cause nerve injury that can lead to neuropathy. Additional local is injected in the deeper layers near the ilio-pubic tract and the pubic tubercle as needed. In some cases, if we need the patient to cough, anesthesia can lighten the sedation and temporarily allow us to communicate with the patient. This method of local anesthesia infiltration allows for reduced pain in the post-anesthesia care unit and for one or more hours after the surgery, so the patient does not awaken with severe pain and it is easier for the patient to void. If available, a long-acting local anesthetic, Exparel® (bupivacaine liposomal injectable solution), is injected prior to closure—this can reduce pain for 2–3 days after surgery.

29.9 Steps in Bilayer Repair

There are five parts to a hernia repair with the PHS: (1) incision and exposure, (2) preparation of the anterior space, (3) dissection of the posterior space, (4) deployment of the underlay, and (5) application and fixation of the overlay.

29.9.1 Incision and Exposure

A 3–5 cm transverse incision extending laterally from the pubic tubercle and 1–2 cm above the inguinal ligament is marked. Approximately 20 mL of the anesthetic solution is injected into the skin and subcutaneous tissue including the Scarpa's fascia. The skin is incised, and the subcutaneous layer is opened. The superficial epigastric vessels are retracted, or ligated and divided, and Scarpa's fascia opened. The subcutaneous tissues are cleared from the external oblique aponeurosis (EOA), exposing the external ring. Care is taken not to stretch or otherwise damage the ilioinguinal nerve as it exits the external ring with the cord structures. At this time, examination is performed to rule out the presence of a femoral hernia by incising the cribriform fascia at the junction of the thigh. As soon as the EOA is exposed, 20 to 25 mL of anesthetic solution is infiltrated just beneath it—we use two or three puncture sites to flood the area, avoiding direct injection into the nerves. This helps to separate the nerves from the undersurface of the EOA and aids in the dissection.

29.9.2 Preparation of the Anterior Space

The preparation of the anterior space and application of the overlay patch are similar to the technique that we use when we perform a LCHT procedure. The EOA is opened in the direction of its fibers through the external ring. Its medial flap is elevated and separated from the internal oblique (IO) muscle and aponeurosis, avoiding the iliohypogastric nerve (IHN). The IHN, ilioinguinal nerve (IIN), and genital branch of the genitofemoral nerve (GFN) are identified and left undisturbed within their investing fascia. The nerves are not dissected or retracted to "protect" them. If a nerve is involved with scarring from the hernia or prior surgery, or the location interferes with the repair, or will be under tension by the mesh, the nerve is removed by dividing it, dissecting it proximally, and ligating with a Vicryl tie. It is allowed to retract or implanted into the muscle, not unlike when doing a neurectomy. This "pragmatic" neurectomy is done to avoid neuroma formation and minimize development of neuropathic pain. The anterior space dissection is carried out laterally 3–5 cm beyond the internal ring. The lateral flap of the EOA is then elevated with careful dissection inferomedially toward Gimbernat's ligament and the pubic tubercle (PT).

The cord structures, including the cremaster muscles and the lesser cord, are elevated from the floor of the inguinal canal beginning near the PT—this is done medial to any direct hernia. They are encircled with a Penrose drain, and an arch-shaped opening is created for the overlay of the mesh. In patients with large hernias, reduction of the hernia contents at this juncture may facilitate elevation of the cord structures. The arch is created by careful dissection elevating the lateral cremaster muscles and the "lesser cord"

from the floor and the shelving edge of the IL, limiting trauma to the GFN and the lateral cremaster vessels, which are left undisturbed. This method of elevating the cord structures favors limiting dissection of the vas deferens within the internal spermatic fascia. We prefer this method as opposed to elevating the spermatic cord and testicular vessels and leaving the lateral cremaster muscles and vessels and the GFN attached to the floor.

29.9.3 Management of Indirect Hernia Sac and Lipoma

After the cord contents are elevated, the cremaster muscle is opened 1–2 cm from the internal ring to check for an indirect sac, which is usually on the anterior medial side of the cord. If a sac is identified, after confirming that there is no bowel present, a small opening can be made to examine and reduce the contents, to check for a sliding component where the bowel or mesentery forms the wall of the sac, and to see if the sac extends into the scrotum. If the sac does not extend beyond the external ring, it can be removed with care dissecting it away from the spermatic cord to which it can be intimately attached. If the sac extends into the scrotum, our approach is to divide the sac by transecting it 2 cm above the transversus abdominis (TA) muscle, where it is suture ligated and reduced into the PP space. If the lateral hernia is small, we do not make the opening larger in order to place the PHS through it, avoiding further dissection along the cord and GFN internally. Instead, we prefer to insert it through an opening made in the medial triangle.

If there is a sliding component, the mesentery and outside portion of the hernia is dissected away from the spermatic cord and vessels which lay inferior to it. The PP "true yellow fat" which is a deep yellow color can be identified inferior to the TA just lateral to the deep epigastric vessels. The opening in the sac is closed with a purse-string suture, and the entire hernia contents with the sliding component are reduced into the PP space. Cord lipomas can be dissected from the surrounding structures and suture ligated at the neck near the deep inguinal ring and resected. In some cases, larger masses of PP fat can be reduced and kept behind the underlay of the mesh. Interstitial fat in close continuity with the testicular vessels is left intact because of the risk of cord edema and inflammation along the cord which could restrict venous return from the testicle and lead to cord or testicular edema.

29.9.4 Dissection of the Posterior Space

The PP space of Bogros must be generously opened to allow the mesh to be fully deployed, no different than is done for other open or LAP repairs. This space behind the MPO is in fact more conical than flat in nature, so the underlay should not be expected to lie flat but more like a cone (Fig. 29.6). The space is relatively flat behind the TA in the upper portion. However, inferiorly, below the inguinal ligament, it goes posteriorly to pass behind the ilio-pubic tract and CL on the medial side; behind the femoral lymphatics, femoral vein, and artery in the center portion; and behind the spermatic cord and testicular vessels laterally.

29.9.4.1 Medial (Direct) Hernias

The floor of the medial triangle is opened making sure to go through both layers of the transversalis fascia (TF) until the "true yellow fat" is seen as it bulges out (Fig. 29.7). The edges of the TF are

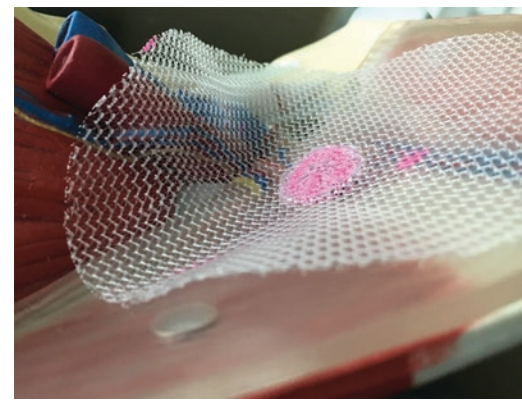

Fig. 29.6 Conical shape of MPO

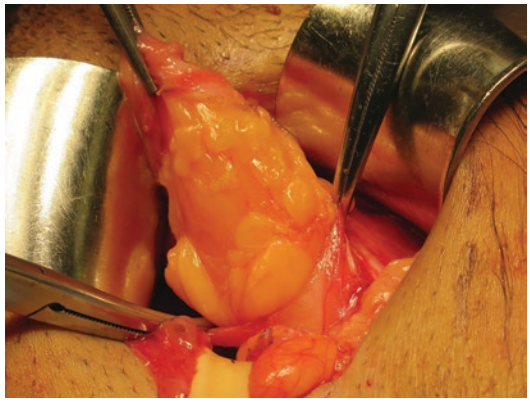

Fig. 29.7 PP "true yellow fat"

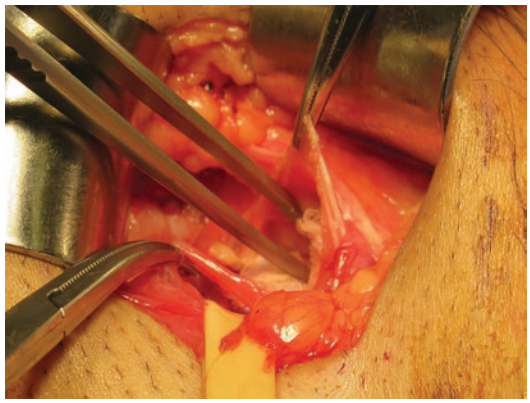

Fig. 29.8 Sponge dissection of PP space

grasped with hemostats, and the protruding contents are dissected from behind the fascia with an opened dry 4 × 4 gauze sponge, to actuate the PP space. The sponge's traction on the PP fat helps to separate it from the TF superficial to it (Fig. 29.8) . This can also be done by sweeping the index finger or with forceps and cautery. The dissection goes medially behind the PT, inferiorly behind CL, superiorly behind the TA, and laterally behind the deep epigastric vessels. The space is essentially avascular, except for small branches of the ilio-pubic vein which runs transversely along the ilio-pubic tract and CL. If the patient has no lateral defect, we limit the lateral dissection behind the epigastrics at this point, preferring not to place mesh along the spermatic cord internally, potentially avoiding scarring in that area. We rely on the overlay to protect the floor lateral to the internal ring.

29.9.4.2 Lateral (Indirect) Hernias

Once the entire sac or ligated sac has been fully dissected, it is grasped with forceps and invaginated through the internal ring. The surgeon's forefinger is inserted through the internal ring adjacent to the forceps and palpates the iliac artery, pulsating lateral to it. The forceps are extracted, leaving the forefinger in place, hooking it under the TA laterally. An opened dry 4 × 4 sponge is passed on the medial side of the forefinger to develop the PP space and separate the hernia contents from the elements of the cord. We prefer creating this space with the sponge, but it is also possible to do it with the index finger alone or forceps and cautery. The sponge is temporarily left in place to maintain the passageway and facilitate continuing the insertion maneuver. Medially, we dissect behind the deep epigastric vessels and under the floor of the medial triangle—an army-navy retractor placed behind the epigastric vessels facilitates this dissection. The dissection is extended further medially behind the PT, inferiorly behind CL, and superiorly behind the TA. Superiorly and laterally to the internal ring, the dissection is behind the TA, and inferiorly between the hernia contents and the cord contents. This result is that the lateral and medial PP space is connected as one. For small lateral hernias, we prefer not to enlarge the internal ring opening. The mesh can be inserted through an opening in the medial triangle, and the indirect space can be covered by the overlay.

In some cases of pantaloon hernias with large openings in both the medial and lateral triangle, the TF is opened both medial and lateral to the epigastrics, a Penrose drain is placed around the epigastric vessels, (or the vessels can be ligated and divided) and the two spaces are joined. This facilitates insertion and deployment of the underlay.

29.9.5 Deployment of Underlay

The PHS overlay tails are pulled up and "triple-folded" longitudinally and then grasped with a sponge stick near the connector, creating an appearance of a "taco" in the underlay (Fig. 29.9). This allows easy visualization and deployment of

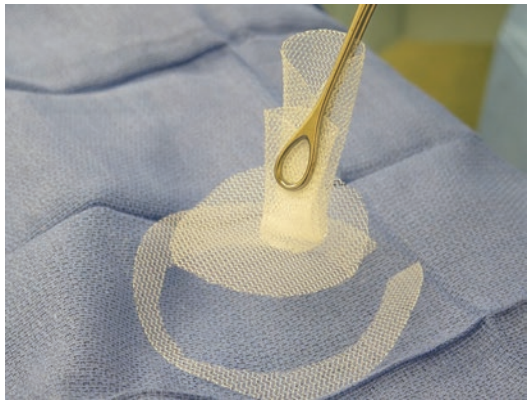

Fig. 29.9 Triple fold with trimmed underlay

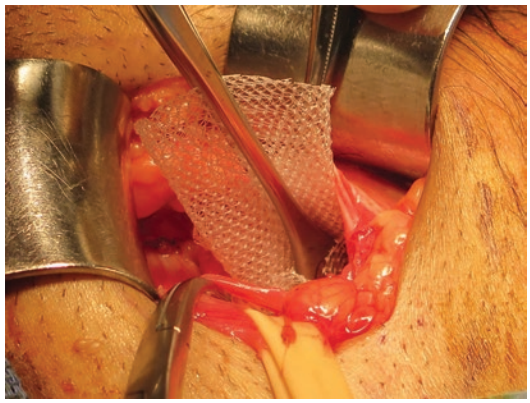

Fig. 29.10 Insertion of PHS

the underlay after insertion. The underlay is trimmed to fit into the space created by the dissection allowing it to lay close to the undersurface of the floor without folding and penetrating deeper like a plug (Fig. 29.9). The sponge stick is rotated before insertion to line up the overlay with the inguinal ligament. The device is inserted until the perimeter of the underlay is beneath the floor (Fig. 29.10). For inguinal hernias, sutures are not necessary in the underlay—the intra-abdominal pressure pushes the mesh against the floor and holds it in place.

For medial hernias, the device is inserted straight down, at a right angle to the opening. The edge of the underlay patch is deployed by unrolling the perimeter of the mesh from its connector using the forefinger, as the overlay component is gently extracted (Fig. 29.11). The edges of the underlay are placed behind the previously dissected structures—medially behind the PT, inferiorly behind CL, superiorly behind the TA, and laterally behind the deep epigastric vessels. Successful deployment can be confirmed by the tip of the finger. The underlay will have some radial folds to accommodate the conical shape of the space—it will not be flat, but trimming will reduce these folds and prevent it from having the effect of a plug. If there is no significant indirect hernia, the underlay can be trimmed laterally where it will be placed behind the epigastric vessels, thereby avoiding dissection along the cord and vessels and having the cord lay against the mesh. The floor lateral to the epigastrics will be protected by the overlay. The opening in the TF of the medial triangle is closed snugly around the connector with one or two figure-of-eight absorbable sutures, leaving it comfortably seated (Fig. 29.12). If there is a femoral hernia, prior to

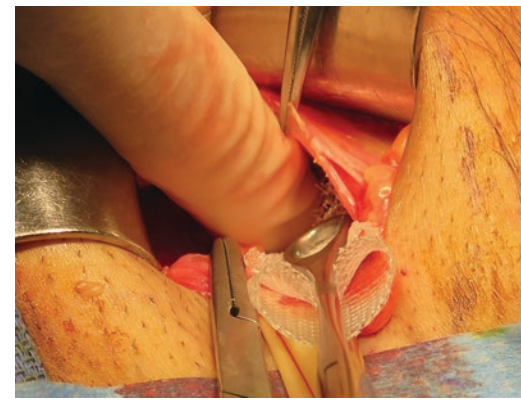

Fig. 29.11 Deployment of underlay

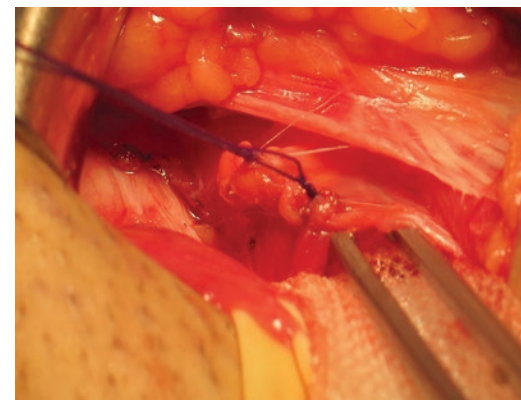

Fig. 29.12 Closure of TF

inserting the device, a single 2–0 Prolene suture can be placed to secure the underlay to CL.

For lateral hernias, we usually trim the underlay on the inferior and superior side prior to insertion, to make an oval shape that will fit into the dissected space. The surgeon's forefinger is placed under the lateral aspect of TA through the opened internal ring, and the device is slid down the medial side of the finger into the PP space—the direction of insertion is superior and lateral, aiming toward the shoulder. The perimeter of the underlay is placed behind the TA superiorly and laterally, while medially it is deployed behind the epigastric vessels and the PT. Inferiorly the perimeter is directed more posterior, covering the femoral canal and the tissues behind CL, and it separates the hernia contents from the cord contents. Typically, when repairing a lateral hernia, unless it is a three-finger defect or larger, the internal oblique is not tightened around the connector—the obliqueness of the internal ring offers additional protection to the underlay patch. Effectiveness of the underlay patch alone can be evaluated by having the patient cough and perform the Valsalva maneuver before the overlay is deployed. After the operation, when the patient stands, intra-abdominal pressure that flattens the underlay is against the abdominal wall between the peritoneum and the TF.

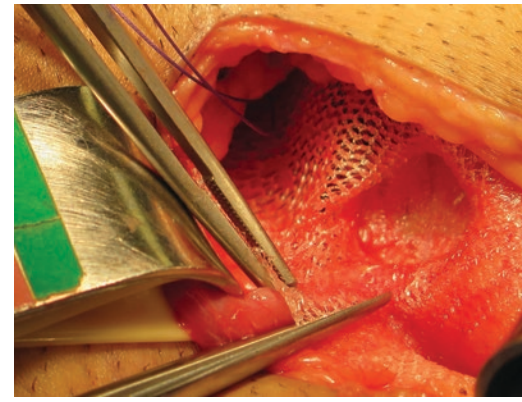

Fig. 29.13 Medial fixation suture

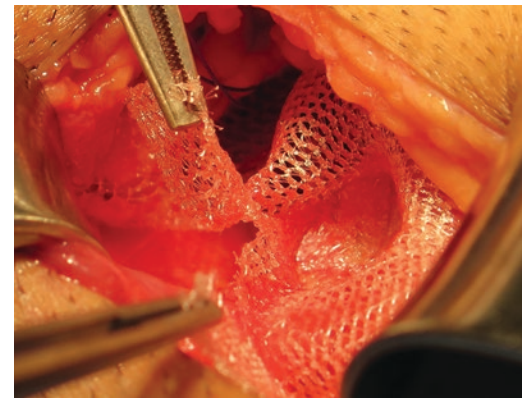

Fig. 29.14 Slit with "T" for cord

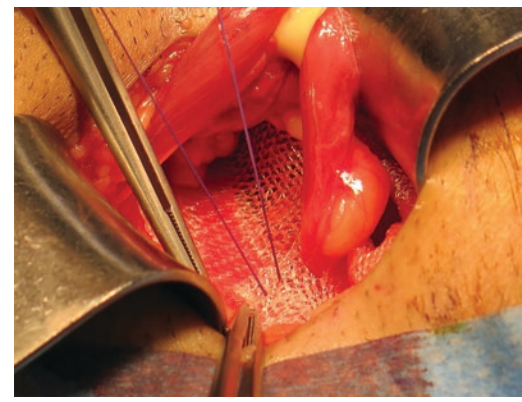

Fig. 29.15 Slit suture to shelving edge of IL

29.9.6 PHS Overlay Placement and Fixation

Using the sponge stick, the overlay is extracted to the level of the internal oblique (IO) and released, and the tips are pulled apart to a flat shape. The overlay is laid flat over the transversus arch with the medial end positioned 1–2 cm over the PT where it is sutured above and medial to the PT to the rectus aponeurosis with a 2–0 Vicryl (Fig. 29.13). A slit must be cut in the overlay to allow the cord contents to pass through. One option is in the inferior edge of the overlay at the internal ring, near the connector, adjacent to the midportion of the internal ring, with a "T" to make it larger (Fig. 29.14). The cord structures are passed through the slit, and the edges of the slit are sutured to the shelving edge of the inguinal ligament (Fig. 29.15). Another option is an overlay slit from the lateral edge toward the

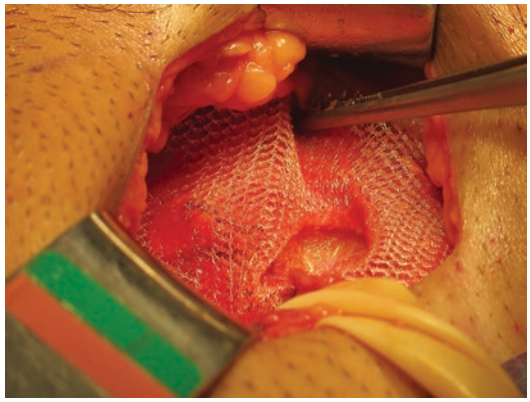

Fig. 29.16 Overlay application

connector favoring the inferior edge and adding a small keyhole near the connector. The tails are then wrapped around the cord contents, not unlike a LCHT patch, and sutured together with a Vicryl suture—it is not necessary to suture these to the inguinal ligament. The opening should be large enough to comfortably accommodate the spermatic cord and its contents without compression. An absorbable suture can be placed to secure the upper edge of the overlay to the IO at the middle of the transversus arch (using an air knot and avoiding the IH-N) and one at the middle of the inguinal ligament if the surgeon feels it is necessary. It is not necessary to suture the lateral part of the overlay that lies flat in the anterior space where it is covered by the EOA. The overlay should be trimmed on the inferior edges laterally and medially if any excess is noted where the mesh might fold on itself, especially in thin patients (Fig. 29.16).

For large hernias and recurrent hernias, 2–0 Prolene sutures can be used to secure the mesh medially and to anchor the slits to the shelving edge of the inguinal ligament. Additional sutures can be placed at the surgeon's discretion, but we do not recommend nonabsorbable sutures on the upper edge of the mesh. On occasion, for very large hernias with a complete blowout of the floor, bilayer sutures are placed that go through both layers with the floor in between.

The cord contents with the II-N are replaced on top of the overlay medially in the inguinal canal. All layers are irrigated with Bacitracin®-Polymyxin® solution. The EOA is closed with a 2–0 Vicryl® running suture, beginning at the internal ring, being careful not to make it too tight, anticipating that some swelling of the cord structures will occur. It is not necessary to re-create the external ring. The subcutaneous layer is closed with 3-0 Vicryl® sutures, and the skin with a subcuticular 3-0 Vicryl Rapide® suture. The skin is covered with Dermabond® or Steristrips®.

29.9.7 Post-op Care

Most patients go directly to the outpatient discharge area or to the recovery room if they are too sleepy or need monitoring. An ice bag is applied immediately and is used for 2 days. After voiding, the patient leaves the ambulatory center, usually 45–90 min after the operation. The patient is encouraged to ambulate often (if not lightheaded) on the day of surgery and to resume all activities that are not uncomfortable. Milk of magnesia is recommended if the patient has not had a bowel movement by the second day. Patients are told that they will have some ecchymosis around the incision and into the scrotum and often some testicular swelling that will last for several days. Swelling in the wound forms a firm wound healing ridge that lasts 6–8 weeks. As the healing ridge becomes more prominent, it narrows and rises before it flattens. Patients are told to expect mild to moderate pain, sometimes going down to the testicle, for 1–2 days, after which the pain diminishes significantly. All patients are given a prescription for an NSAID such as naproxen (if there is no history of GERD) and a narcotic analgesic such as oxycodone and acetaminophen. Patients who live locally are seen in 1–2 weeks for follow-up. Out-of-town patients are seen on the day after surgery and are followed by telephone in 1 week regarding their progress.

29.10 Results

April 1998 through December 2016, five surgeons doing only hernia surgery used the PHS to repair over 12,000 groin hernias in over 11,000

patients at the Hernia Institute of Florida. Male patients outnumbered female patients 15:1. Simultaneous bilateral repairs were done in 10%. One in eight repairs was for recurrences of one to six times. Femoral hernias accounted for 1.5% and were more common in women. Our PHS size preference is 60% extended, 35% large, and 5% medium—mostly in women. Follow-up for all hernia patients is very difficult as there is no national registry. Most patients who are doing well do not want to take time to come in for a checkup. All patients are given the surgeon's cell phone number. Our telephone and email follow-up showed a 30% compliance. All patients, including those covered under workers' compensation, were emphatically instructed to call or return if they suspected a recurrence or were bothered by unrelenting discomfort. Most of our patients call if they have a problem.

To the best of our knowledge, the total number of known recurrences in our series since April 1998 is 34. In our office, where we have done between 400 and 800 PHS repairs per year, we see 1–2 patients of our own per year who have a recurrence. If we assume there are two or three times as many recurrences that we are not aware of, our percentage is well below one half percent, a figure that we use in the pre-op discussion. Other surgeons using PHS have reported similar low recurrence rates [16].

Superficial infection, hematoma, or serous drainage, which required opening the wound, occurred in 40 patients—these were managed with topical and oral antibiotics—the patients were instructed to shower and change dressings twice daily, and most of these healed within 10–14 days. Infection requiring mesh removal occurred in four patients—the mesh was removed, and a suture repair was done with a monofilament absorbable suture. Two patients had MRSA—one with a prior history in another location and one who was an unidentified carrier. We currently ask patients about MRSA history prior to all hernia repairs. In all other cases, infections were superficial, and the mesh did not have to be removed to get complete wound healing. There were 8 hematomas that required drainage—2 in the OR, and 60 documented seromas, of which 10 persisted and required aspiration.

Thirty percent of patients used only acetaminophen for pain. The remainder used the prescribed NSAID or narcotic, on the average taking four narcotic tablets over 2 days. Ninety-five percent used no analgesics after the first 2 days. Most patients with ongoing discomfort were given naproxen. Ten percent of workers had ongoing pain that lasted between 3 and 6 months. One hundred twenty patients had chronic pain, i.e., pain more than 6 months after surgery. Twelve patients, including eight workers, had significant chronic postoperative pain lasting longer than 6 months and were referred for pain management. Two patients had the mesh removed for pain by us, and a third had the mesh removed by a surgeon elsewhere. Patients who experienced some degree of testicular pain from epididymitis were treated with sitz baths, naproxen, and Cipro®—all reported that the pain subsided in 3 to 8 weeks.

29.11 Quality of Life Issues

As recurrence rates after hernia surgery have been reduced with the use of mesh techniques, increased attention has been directed to quality of life (QOL) issues, particularly the problem of chronic post-herniorrhaphy inguinal pain (CPIP), a consequence occurring in many patients after hernia surgery. Symptoms of somatic, visceral, and neuropathic pain, as well as testicular pain, dysejaculation, and claims of sterility, have stimulated considerable evaluation and discussion at surgical meetings and in the literature, and discussions on the Internet are readily available to patients—these are often confusing and misleading. Almost all patients who present to the office in the past 5 years come with questions related to CPIP and the use of mesh. It is important to discuss these with the patient to make sure they understand the risks and benefits of mesh placement as part of the informed consent process.

We explain that post-op pain problems are a known consequence of hernia surgery, in part related to the scarring which occurs in both non-

mesh and mesh repair. The percentage of patients complaining of CPIP varies according to the methodology and definition of chronic pain—it ranges from 0.6 to 30% in different studies, but for severe chronic pain affecting the activities of daily living, it is 0.5–6% [17]. However, Cunningham had reported that the incidence of significant CPIP in patients after suture repairs without mesh is around 10% [7].

The use of mesh results in immediate strength of the repair. In addition, the mesh induces an inflammatory reaction and scarring, making the repair stronger as the scar creates a plate of tissue. This inflammatory reaction may affect structures which are in direct apposition to the mesh, a situation that is present in all types of hernia repairs. Lateral to the internal ring, the mesh is placed on top of the IO, and unavoidably comes into contact with the IIN and IHN, which may result in inflammation and scarring involving these structures. In routine hernia repairs, nerves, muscle, the spermatic cord, and all structures in the inguinal canal may come in contact with the mesh. This is true in open anterior repairs or open PP or LAP repairs.

There have been suggestions that the incidence of CPIP can be reduced by following recommended surgical technique. These include avoiding nerve trauma by blunt dissection, traction, and electrocautery; limiting dissection close to the spermatic cord to reduce scarring that may result in cord dysfunction, obstruction, and possible injury to the nerves and vessels that are present in the adventitia of the vas; avoiding placement of mesh in direct opposition to the vas when possible; using absorbable sutures with air knots and placing sutures in the IO away from visible nerves; dividing a long indirect sac near the internal ring and avoid dissecting near the spermatic cord distally; and avoiding placement of sutures into the periosteum of the PT [18]. Over the years, we have modified our surgical technique to limit dissection in the area of the nerves and the spermatic cord to attempt to reduce the incidence of these problems. In addition, "watchful waiting"—conservative management of asymptomatic hernias—is an acceptable course of management in the appropriate patient [19].

29.12 Selection of Technique: Tailored Repair

To perform lasting groin hernia repairs, surgeons must have a stronger appreciation for the techniques available to protect the entire MPO. Patients have different anatomy, and their hernia problems differ by size and location. Some patients may be more susceptible to recurrence because of age, occupation, activities, body habitus, collagen disorders, and smoking. Although a single technique can be used to repair all different types and sizes of inguinal hernias, the choice of procedure for an individual patient should be based on the anatomical findings and the type of defect, the needs of the patient, and the expertise of the surgeon with the technique being used. Some techniques are easier to perform, but may not offer as good results. The success of the procedure will ultimately depend on the skill of the surgeon—both in choosing the correct procedure and performing it.

Since its inception in 1985, over 30,000 inguinal hernias have been repaired by surgeons at the Hernia Institute of Florida. Our selection and modification of technique has evolved over the years based on technological advances and results. Initial procedures were classical Bassini or McVay suture repairs. The major change occurred in the 1980s with the popularization of mesh techniques, including the umbrella plug, plug and patch, and LCHT repairs. In 1998, the PHS was designed and became our primary hernia repair technique, with over 8000 repairs done between 1998 and 2008 with a recurrence rate of less than 0.5%. With the success in prevention of recurrences achieved, and more attention given to patient satisfaction and CPIP, our focus has been to modify our technique selection according to the needs of the patient. Since 2006, the LCHT technique using middle weight mesh has been used in 10–15% of our cases, with equivalent recurrence rates, but there has been no decrease in the incidence of post-op pain. We do not use ultralight-weight mesh products because we feel they are not strong enough for many of our patients. In patients with a high risk for recurrence, we use a sandwich technique with

"bilayer" Prolene sutures passed through both mesh layers and the fascia in between. Some new products and fixation techniques have been tried for LCHT where suture fixation of the mesh to the inguinal ligament is necessary, but this is irrelevant for PHS which is held in place by the synergy of the bilayer design, without any permanent sutures.

Not all surgeons have the benefit of the experience with large numbers of repairs with different techniques. The surgeon's choice of technique should depend on their personal experience and ability as well as the needs of the patient.

29.13 Discussion

There have been several studies reporting results of PHS repairs compared to other mesh techniques. Recurrence rates for PHS are equal to or lower than any other hernia repair technique, and QOL outcomes are favorable when compared to other mesh or suture techniques. Kingsnorth compared PHS to the Lichtenstein technique and reported less postoperative pain, earlier return to normal activities and work, shorter duration of operation, and fewer recurrences in the PHS group [20]. General surgeons trained in the PHS technique by Hernia Institute instructors have been able to reproduce our own results. In 2006, in a report of 21,791 PHS repairs by 42 trained general surgeons, there were only 28 recurrences, for a failure rate of 0.0013 [21]. Some RCT and meta-analyses included in the 2014 update of the EHS guideline compare the efficacy and safety of PHS and LCHT and P&P techniques. With follow-up in the range of 1–4 years, there was no difference between PHS and LCHT with regard to recurrence, CPIP, or other complications [22]. While PHS requires entry to the PP space, LCHT requires permanent sutures which may contribute to pain.

However, in 2015, Cox and Heniford et al. reported on an international, prospective, multicenter study of 1341 patients comparing recurrence and QOL outcomes of PHS, LCHT, and P&P repairs. The techniques had equal recurrence rates, while the variance between the most common techniques appears to be QOL [23]. LCHT and P&P demonstrated equal short- and long-term QOL. The PHS repair showed superior 1 month and 2 year QOL outcomes compared to LCHT and P&P. At 1 month and 2 years, PHS patients had less pain, less mesh sensation, and activity limitation, compared to LCHT and P&P.

Although there are many different hernia repair techniques available, we preferentially use PHS for our repairs unless the patient's needs direct us to other techniques. The PHS repair satisfies all of the desired qualities of the ideal hernia repair. Results are reproducible by all surgeons after a very short learning curve. Surgeons inexperienced with dissection of the PP space learn very quickly to become comfortable working in this relatively avascular space and can achieve high success rates equivalent to our outcomes.

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30 Open New Simplified Totally Extraperitoneal (ONSTEP) Technique for Inguinal Hernia Repair

Jacob Rosenberg and Kristoffer Andresen

30.1 Introduction

The ONSTEP technique for inguinal hernia repair was developed by two surgeons from Portugal, Lorenzo and da Costa [1]. For several years there has been a trend toward placing the mesh in the preperitoneal space rather than below the external aponeurosis as in the Lichtenstein repair. The reason for this has been reports of reduced pain after surgery, especially levels of chronic pain, with the preperitoneal mesh replacement as in laparoscopic repair [2].

There are several different operative techniques available for preperitoneal mesh replacement including the transinguinal preperitoneal (TIPP) approach [3] and transrectus sheath extraperitoneal procedure (TREPP) [4] and others, but these techniques may be difficult to approach for the novice surgeon. Thus, Lorenzo and da Costa thought that there was a need for a new method with a technically easier approach and therefore a shorter learning curve for the young surgeons.

The present status for the ONSTEP technique is that it is currently used in several surgical departments, and there are also a few ongoing research projects evaluating the technique [5, 6]. Currently, the technique has only been spread to some countries in Europe, mainly because the mesh has not been available in the United States until recently. Surgeons in the United States and Asia will soon be exposed to this new technique, hopefully resulting in more scientific trials evaluating the pros and cons.

The aim of the present chapter is to introduce the ONSTEP technique and give an overview of the current available clinical data. Furthermore, we discuss the technique's perspectives and the possible future role of ONSTEP in inguinal hernia repair in adults.

30.2 The ONSTEP Technique

The ONSTEP technique is special because it involves both the preperitoneal space as well as the space between the external and internal aponeurosis. Thus, it can be seen as a mixture of a preperitoneal technique and a fully external approach [1]. Because of space limitations, the reader is kindly referred to a detailed description of the operative technique published previously [1].

30.2.1 Why a Technique Involves Two Different Planes

An intriguing part of this surgical technique is that it involves two different planes. The medial part of the mesh is placed in the preperitoneal space, the space of Retzius, and the lateral part of the mesh is placed between the internal and external

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aponeurosis, i.e., the same place as we place the mesh in the conventional Lichtenstein repair. The mesh is not sutured to tissue, and this special mesh placement will ensure that it stays in place even though it is not fixated to the body structures. This special mesh placement also has the special effect that it will grab the abdominal wall, especially when the patient is standing up, where gravity will put force on a flat mesh placed simultaneously between the external and internal aponeurosis (lateral part) as well as a mesh placed in the preperitoneal space (medial part). In the ONSTEP technique, the mesh has a kind of a handgrip shape holding the abdominal wall and thereby keeping the hernias in place. This may be the mechanism of action of the ONSTEP technique and could explain the low-recurrence rates and, together with the lack of mesh fixation and the very gentle dissection technique, probably explain the extremely low risk of chronic pain [7].

30.2.2 The Onflex Mesh

A special mesh has been designed for the ONSTEP operation (Fig. 30.1). This mesh is called the Onflex mesh. It has a stiff ring along the border of the mesh in order to keep it deployed in the preperitoneal space. The ring is made of absorbable material so that it will not cause concern for the patient. Before the Onflex mesh was available, we used the Polysoft mesh for the ONSTEP operation. This mesh has a nonabsorbable ring, so that skinny patients could sometimes feel it and had pain from especially the lateral part of the mesh which lies between the external and internal oblique aponeurosis. If the patient is skinny and has the Onflex mesh in the correct position, then even though he or she may feel the lateral part of the ring in the beginning, these complaints will disappear when the ring is absorbed. The mesh is made of polypropylene and is low-weight, with large pore sizes. This should enable better ingrowth in the healing period after mesh placement. Furthermore, it has a pocket which will make it easier to position the mesh in the preperitoneal space. When the mesh is positioned, the pocket is meant for the index finger of the surgeon.

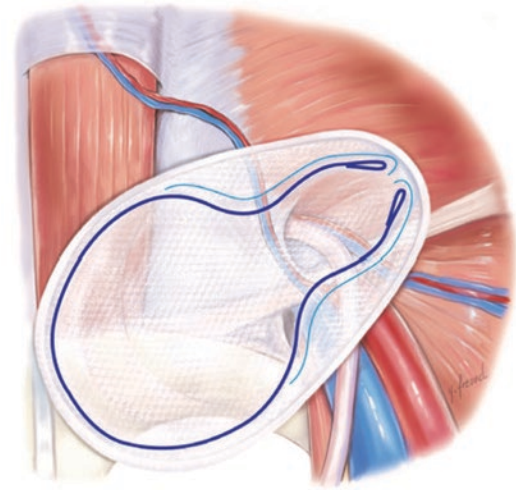

Fig. 30.1 The Onflex mesh for ONSTEP inguinal hernia repair. Reproduced with permission from Bard-Davol Inc

30.2.3 Pain from the Recoil Ring

There are thousands of patients who have had the ONSTEP procedure with the Polysoft mesh. In the Polysoft mesh, the ring is nonabsorbable, and if the patient is skinny, there may be complaints from the lateral part of the mesh where the ring will lie close to the skin. In such a case, we usually recommend that the patients should wait for 6 months in order for the mesh to be fully integrated into the tissue, especially in the preperitoneal position and on the muscle plate between the two aponeuroses. Then the patient is offered a small reoperation where an incision of about 1 cm is performed on top of the palpable part of the ring corresponding to the lateral part of the mesh. Then the two ends of the ring are dissected and cut, and the ring can be withdrawn in full. We have made a video clip of this procedure [8]. Usually after ring removal, the patient will have no complaints.

30.2.4 Recurrence Repair After Previous ONSTEP

Some surgeons may have concern about how to repair a recurrence after previous ONSTEP

repair, because the mesh will be present both preperitoneally and between the two aponeuroses laterally. It is, however, no problem at all to do a recurrence repair after a previous ONSTEP. It may preferably be done by two different approaches, one being a simple re-ONSTEP procedure and the other by laparoscopic operation. If doing a re-ONSTEP, then you dissect on top of the previously placed mesh, with dissection between the mesh and the pubic bone making a new space for a new Onflex mesh. A mesh is then placed between the old mesh and the pubic bone without removing any part of the old mesh. With a laparoscopic repair, we use the transabdominal preperitoneal (TAPP) approach; it has been easy to take down the peritoneum from the inside, and then simply put a standard flat mesh in the preperitoneal space as a standard TAPP procedure.

30.3 Clinical Data

The first clinical data regarding the ONSTEP technique is a large and impressive series of patients from two centers. The inventors presented 693 patients operated with the technique and followed up for one year [1]. Several findings from this paper showed a promise of a better open technique. Firstly, the degree of pain was very low, and none of the patients had chronic pain at 1-year follow-up. Secondly, only four recurrences (0.6%) were found with three of them being in women. This has led the inventors to slightly modify the technique for female patients. Thirdly, a very short duration of surgery—mean (SD), 17 (6) minutes—was found, which can be cost-saving for a department since it will allow for more patients to be operated in one day. Such a large series with promising results called for further scientific exploration of the technique and also justified the conduction of randomized controlled trials. Surgeons from other countries in Europe visited the inventors, learned the technique, and started operating at their own centers.

The first published results from outside Portugal were from Denmark and included 80 patients, with follow-up by standardized questionnaires [9]. Results were good, albeit with the use of questionnaires and not a dichotomous pain registration some patients were found to have pain, but at very low levels. Later, results were presented from a series from Greece [10]. Results were still similar, with low levels of postoperative pain and no patients with chronic pain. A similar report was published from the Czech Republic [11], still with promising results (Table 30.1).

The non-controlled series outside the departments of the inventors supported the promising results but are all at risk of bias since no randomization and/or control group was added to any of the studies. Furthermore, follow-up time and methods were not standardized. Therefore, there was a need for randomized clinical trials. As of December 2015, two prospective trials can be found on the WHO trial search portal [12]. Both studies are from Denmark. One is the ONSTEP versus Lichtenstein (ONLi) study, with 290 included patients and 1-year follow-up [5]. The other, ONSTEP versus Laparoscopy (ONLap), is finished but not published yet [6]. Both studies are being conducted as multicenter studies with general surgical departments, i.e., not specialized hernia centers.

The early results from the ONLi trial demonstrated a safe implementation of the technique, with results similar to the Lichtenstein technique [13]. The only significant difference found in the early results was the duration of surgery. Patients were followed up with several questionnaires and at 6-month follow-up, a significant difference was found, favoring the ONSTEP technique in the number of patients experiencing pain during sexual activity [14]. Follow-up for pain at 6 and

Table 30.1 Case series

Country	No	Study type	Persistent pain (%)	Recurrence	Minutes
Portugal [1]	693	Case series	0	4 (0.6)	17 (+6)
Denmark [9]	80	Case series	4.5	0	24 (13–53)
Greece [10]	33	Case series	0	0	33.28 (+11.69)
Czech [11]	72+25	Case series	0	2	18–35

12 months showed that the number of patients with nonsexual pain and the intensity of pain were similar in the two groups. A noteworthy finding was that two patients in the Lichtenstein group experienced disabling chronic pain after surgery. Both had the mesh surgically removed as well as neurectomy conducted around 6 months postoperatively with complete resolving of pain for one patient but persisting pain for the other. No patients in the ONSTEP group experienced these disabling symptoms.

The ONLap study is designed to show non-inferiority between the ONSTEP and the laparoscopic technique (TAPP), i.e., similar levels of postoperative pain. The rationale is that the ONSTEP technique has some advantages compared to laparoscopy, and therefore, if non-inferiority can be demonstrated regarding pain, other advantages will justify it as a valid alternative. The advantages are that the ONSTEP technique has a shorter duration of surgery, it does not require the same expensive equipment as laparoscopic repair, and it is likely to have a much shorter learning curve.

30.4 Learning, Training, and Implementation

The ONSTEP procedure has a shorter duration of surgery than a standard Lichtenstein or laparoscopic repair, and surgeons learning the technique find it easy to learn. To our knowledge, it has primarily been learned by surgeons already familiar with hernia repair, and therefore, experience is lacking as to how well younger surgeons in training can pick up the technique. We believe that it will be easier to learn than the Lichtenstein repair, but solid data are missing to support this. It is very likely easier to learn the ONSTEP technique compared to the laparoscopic techniques (TEP or TAPP), since no endoscopic skills are needed.

Implementation of the ONSTEP technique can be done if surgeons with experience are willing to learn the technique. It has been suggested that the optimal way of learning the technique and subsequent implementation is when the training is done as proctoring [15]. When training surgeons in the ONSTEP technique, some concerns and difficulties need to be addressed, such as fear of the preperitoneal space [16].

30.5 Health Economics

A formal health economics analysis comparing the ONSTEP method with laparoscopic and Lichtenstein repair has not been conducted yet, but it is planned to use the data from the ONLi and ONLap randomized trials [5, 13] for such an analysis. It is expected that the ONSTEP method will prove to be cost-saving compared to the laparoscopic techniques and comparable or maybe even cost-saving compared to the Lichtenstein technique.

Compared to the laparoscopic technique, the Lichtenstein technique has been demonstrated to result in lower costs [17], mainly due to the cost of equipment, sterilization, and time in the operating room. The level of pain, minor complications, and sick leave are expected to be similar between the laparoscopic and the ONSTEP technique, so the cost from sick leave will probably be equal in the two groups. The laparoscopic technique results in a low, albeit increased risk of serious complications that can result in increased costs.

Compared to Lichtenstein, the costs of conducting the ONSTEP are more or less comparable but with a more expensive mesh. However, the price of the mesh might be justified by the shorter duration of surgery, which in some healthcare systems is an important economic factor. However, it is well known that the Lichtenstein technique carries a risk of serious disabling chronic pain that results in a tremendous cost for the society because of resulting unemployment, for the employer because of long sick leave, and for the insurance, be it public or private, because of unemployment benefits. The development of disabling chronic pain seems so far to be avoided with the use of the ONSTEP technique.

Furthermore, if the assumptions regarding a shorter learning curve are true, younger surgeons will not need the same amount of supervision, which can free hands in the surgical department

and thereby be cost-saving, compared to training surgeons for the Lichtenstein or laparoscopic repairs.

Firm conclusions regarding the health economics aspect of the ONSTEP technique can only be made when results from the ongoing trials are combined and analyzed.

30.6 Perspectives

If data with the ONSTEP procedure continue to be robust and shown by different research groups to produce distinctly low levels of severe disabling chronic pain and comparable levels of acute pain and recurrences, then there may be a place for the ONSTEP procedure in the routine surgical armamentarium for repair of inguinal hernias. The procedure is fast and easy to learn, as well as advantageous compared with both the Lichtenstein and the laparoscopic procedure. Thus, ONSTEP may be first choice for primary inguinal hernias in men. In women it may be different since the operative procedure is different and technically more difficult than in men.

It could therefore be argued, that the laparoscopic procedure should still be first choice for women, as recommended in previous guidelines [18, 19].

If the patient has a recurrent hernia, then an ONSTEP procedure may be used after previous ONSTEP or after previous laparoscopic repair. If the patient has a previous Lichtenstein repair, then a laparoscopic approach will probably be the easiest technically to perform. The main goal of changing strategy for choice of operation for inguinal hernia repair will be to avoid the Lichtenstein procedure because of the well-known production of severe disabling chronic pain in some patients. A new strategy could therefore be as shown in Table 30.2. This, however, has to be supported by trial data from other research groups confirming the current available results, as well as a health economics analysis showing advantages for the ONSTEP procedure compared to the Lichtenstein as well the laparoscopic approach.

Table 30.2 Suggested treatment strategies of inguinal hernias

Current hernia	Previous operation	Recommended procedure
Male primary hernia	–	ONSTEP
Male, recurrent hernia	Lichtenstein Laparoscopic repair ONSTEP	Laparoscopic repair ONSTEP Laparoscopic repair or ONSTEP
Female, primary hernia	–	Laparoscopic repair
Female, recurrent hernia	Open procedure laparoscopic repair	Laparoscopic repair Lichtenstein
Male, special cases (prostate cancer, extensive surgery, etc.)	–	ONSTEP or Lichtenstein

This could become effective if other research groups can reproduce the findings, and the health economics analysis supports use of the ONSTEP technique

Conclusion

The ONSTEP procedure was introduced by two surgeons from Portugal and has been used in the inventors' clinics with great success. It thereafter spread to several European countries by proctoring initially at the clinic in Porto and after that also through local training in other countries. Randomized trials have been performed, and until now they have shown advantages for the ONSTEP procedure compared with Lichtenstein regarding sexual dysfunction after operation. Another very interesting feature of the ONSTEP procedure is that until now, after thousands of procedures, not a single patient with severe disabling chronic pain has been produced. This is in contrast to the Lichtenstein procedure where it is well-known that some patients will develop severe disabling chronic pain. Overall, the ONSTEP procedure seems to be very promising and will probably find its place in routine inguinal hernia repair in the near future.

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31 Transinguinal Preperitoneal (TIPP) Inguinal Hernia Repair Using a Totally Extraperitoneal, Parietalized, Memory-Ring Patch

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31.1 Introduction

Since introduction of the prosthetic repair of inguinal hernia reduced the recurrence rate to 1–2%, nowadays, chronic pain is the principal concern for hernia surgeons. This complication is indeed very common (10–12%) and can be debilitating in 0.5–6% of the cases [1]. The principal causes of chronic pain related to the surgical technique are nerve injury, chronic irritation by the fibrotic reaction induced by the patch, and damage to the spermatic cord or testicular vessels.

The Lichtenstein technique is the most commonly used because it is technically simple and easy to reproduce, but it entails some of the risk factors of chronic pain, namely, (1) extended dissection of the inguinal canal required to deploy the patch on the inguinal wall; (2) mesh fixation to prevent the patch breaking away, by the effect of intra-abdominal pressure; and (3) chronic irritation of the nerves by the fibroplastic reaction induced by the patch.

Most of the technical attempts to minimize these drawbacks failed to solve the problem. Identification of the three nerves is not always possible, and it is not associated with a reduced risk of chronic pain [2], which can even be increased by neurolysis [3]. Nerve resection can contribute to reduce the incidence of chronic pain according to a meta-analysis [4], but it failed to induce significant effect according to another one [5], and in both instances it resulted in sensory trouble. Fibrin sealant and synthetic glue were tried to minimize the risk of nerve entrapment by sutures, but on five meta-analyses, only two showed a reduction of chronic pain [6, 7], though one of them underlined the poor quality of the trials [6] and three concluded negatively [8–10]. Self-adhesive patches did not do better. Indeed, a recent large RCT as well as meta-analyses concluded that the self-gripping mesh could reduce early postoperative pain, but not chronic pain [11–13].

On the contrary, the preperitoneal patch does not involve these drawbacks: (1) the patch applied to the abdominal wall by intra-abdominal pressure requires minimal or no fixation at all; (2) the patch does not contact the nerves in the inguinal canal; (3) it is no more in contact with the nerves in the preperitoneal space, since before they reach the inguinal canal, the ilioinguinal and iliohypogastric nerves run between the internal oblique and transverse muscles (thus they are separated from the patch by the transverse muscle) and the genitofemoral nerve runs on the psoas muscle covered by the fascia iliaca [14].

Meta-analyses have shown that laparoscopic techniques provide less postoperative pain, shorter time to resume activity and work, less numbness, and less chronic pain than open techniques [15–17]. By contrast, a recent meta-analysis by Koning et al. comparing TEP to Lichtenstein concluded that the advantage of TEP is not really established, due to the huge heterogeneity and

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insufficient quality of some RCTs [18]. Nevertheless, three RCTs with low risk of bias [19–22] showed that the TEP provided less postoperative pain, earlier return to activity and to work, and less chronic pain than the Lichtenstein. Westin et al. concluded that TEP is the procedure of choice in the surgical treatment of primary inguinal hernias [22], and Langeveld et al. concluded that TEP could be recommended as the optimal technique in experienced hands [19]. Reference to the surgeon's skills is important, because of the limitations and drawbacks of laparoscopic techniques. Laparoscopy is indeed more demanding than the Lichtenstein technique, the learning curve is longer [23], and it can result in rare but severe complications [15].

The limits of laparoscopic repair justify the introduction of minimally invasive open techniques. The trans-inguinal preperitoneal (TIPP) repair consists of placing the patch in the preperitoneal space by inguinal approach. It was originally introduced by Rives in France [24] and by Schumpelick in Germany who coined the term TIPP [25]. These techniques were not simple and involved long opening of the transversalis fascia, extended preperitoneal dissection, and transmuscular sutures to fix the patch.

The modern TIPP concept consists of a short inguinal incision; limited dissection; introduction and deployment of the patch through the hernia orifice, without any other damage to the abdominal wall; and no fixation. This is enabled by the use of the special memory-ring patch Polysoft.

In his initial experience, Pelissier [26] used to split the patch in most cases of indirect hernias, to accommodate the spermatic cord, but he soon switched to parietalizing the cord and not splitting the patch [27]. We describe the current technique based on cord parietalization, without splitting the patch.

31.2 Anesthesia

Contrary to TEP, TIPP does not require a deep general anesthesia with myorelaxants. TIPP can be achieved either under local anesthesia [27] or under a "light" general anesthesia with a laryngeal mask, completed with a TAP block performed under ultrasound control [28]. The complete recovery is very fast allowing a quick return home, which is especially interesting for those patients operated on even late in the afternoon. This way TIPP is perfectly fitted with the D case surgery.

31.3 Operative Technique: Lateral Hernia

31.3.1 First Step: Skin Incision

Contrary to some other open preperitoneal repairs, TIPP uses the inguinal route well known by every surgeon. A short skin crease incision (3–5 cm depending on the panniculus adiposus thickness) is carried out at the level of the deep inguinal orifice (Fig. 31.1).

31.3.2 Second Step: Nerve Preservation

1. Ilioinguinal Nerve.

   The external oblique aponeurosis is incised. A careful attempt to identify and preserve the ilioinguinal nerve (II), running just behind this aponeurosis, is carried out. It is easier when done at the beginning of the procedure (Fig. 31.2).
2. Ilio-hypogastric Nerve.

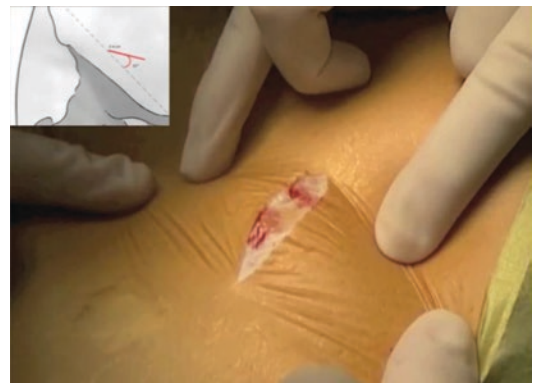

Fig. 31.1 Short inguinal incision (right inguinal hernia)

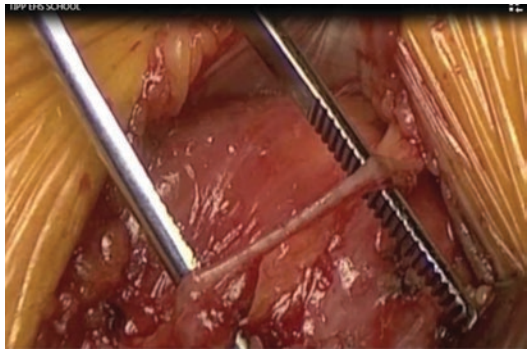

Fig. 31.2 Identification and preservation of the ilioinguinal nerve

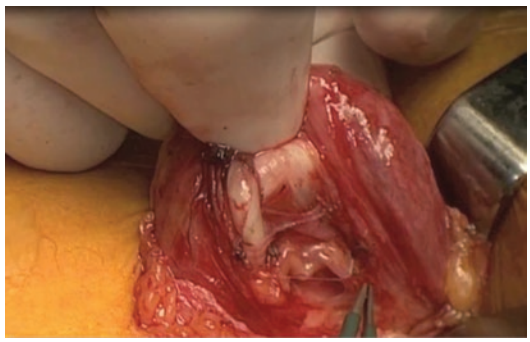

Fig. 31.3 Dissection between the proper cord and the lesser cord avoid any further traction on the genital branch of the genitofemoral nerve

Contrary to what is required in the Lichtenstein repair, no extensive dissection between the external oblique aponeurosis and the internal oblique muscle is necessary; therefore, the ilio-hypogastric nerve (IH) is protected, left in its bed far from the TIPP dissection.

3. Genital Branch of the Genitofemoral Nerve.

   Unlike in the Lichtenstein procedure, the inguinal floor (anterior aspect of the transversalis fascia) has not to be cleaned up.

   The genital branch of the genitofemoral nerve (GBGF) is left in place alongside the external spermatic vein, called the Amid's "blue line" [29] which helps to find the nerve.

   If the cord is lifted, in order to facilitate the parietalization of the cord constituents, attention is paid to avoid any direct or indirect traction on the GBGF leaving in place the external spermatic vessels. This is achieved (Fig. 31.3) by passing through the window between these vessels (lesser cord) and both the internal spermatic vessel and the vas deferens (proper cord) [29].

4. Femoral Branch of the Genitofemoral Nerve.

   As we will see further, the preperitoneal dissection is done in the visceral compartment close to the peritoneum and not in the lateral compartment where runs the genitofemoral nerve (GF) and caudally its femoral branch (FBGF).

31.3.3 Third Step: Treatment of the Hernia Sac

In lateral (indirect) hernia, the cremaster muscle is not resected, just longitudinally incised; the sac is dissected free, not resected and will be further reduced in the preperitoneal space through the internal orifice. Should you want to resect the sac, it is useful to postpone that because tensioning the sac helps both the dissection and the parietalization.

31.3.4 Fourth Step: Dissecting the Preperitoneal Space

Completely different from the Lichtenstein repair, the prosthesis will be inserted posteriorly to the transversalis fascia.

Completely different from the on-step technique, the prosthesis will be totally inserted in the preperitoneal space, exactly as in TEP.

The preperitoneal space is entered through the herniated inguinal ring following the inner aspect of the deferens, laterally and cranially to the epigastric vessels (Fig. 31.4). These vessels are a landmark to properly enter the preperitoneal space. They are preserved and gently retracted. The dissection starts just behind the transversalis fascia (Fig. 31.5), goes to the Cooper ligament (Fig. 31.6) and the posterior aspect of the pubicum, and comes back posteriorly to the rectus muscle and to the conjoint tendon. Provided the dissection keeps contact with the inner part of the abdominal wall, the plane is totally avascular.

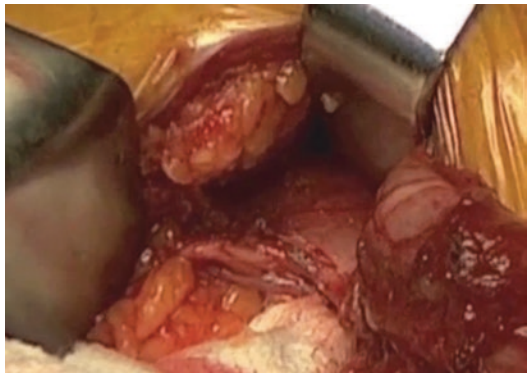

Fig. 31.4 Epigastric vessels, the door for the preperitoneal space

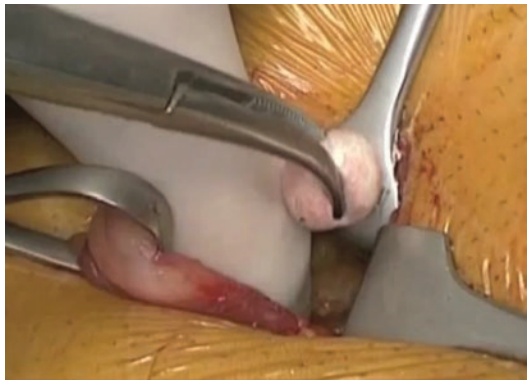

Fig. 31.5 Dissection of the Bogros space and right part of the Retzius space

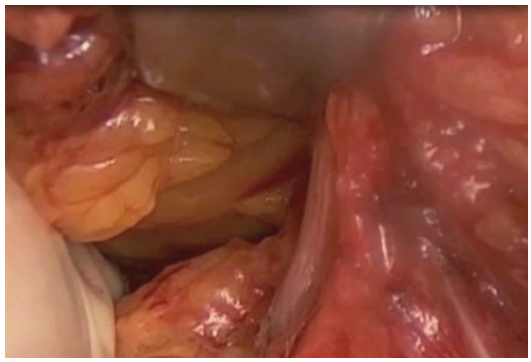

Fig. 31.6. Cooper's ligament

A first large gauze is inserted in the Bogros space, acting as an auto-static retractor.

31.3.5 Fifth Step: Parietalization of the Cord Elements

The inguinal ring, muscular, can be easily enlarged. Two Langenbeck's retractors are introduced. The second gauze is then introduced and kept in place with the retractor. That helps to expose the peritoneum being separated from the vas deferens and the spermatic vessels.

It is actually difficult to imagine how much this minimal approach can provide a sufficient exposure onto the preperitoneal structures (Fig. 31.7). This approach allows a complete dissection, under a permanent visual control (blunt but not blind dissection) of the peritoneum, the vas deferens, and the anterior aspect of the internal spermatic vessels (Fig. 31.8).

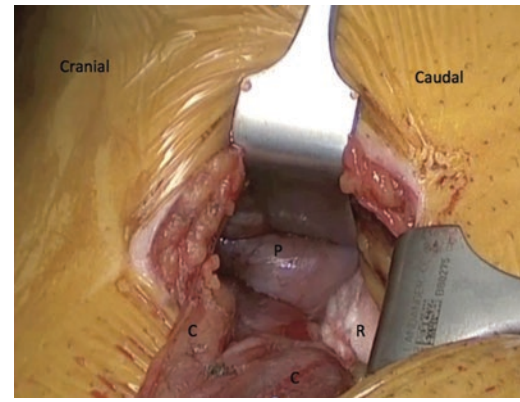

Fig. 31.7 Preperitoneal view during the parietalization (*C* cord; *P* peritoneum; *R* gauze in the Retzius space)

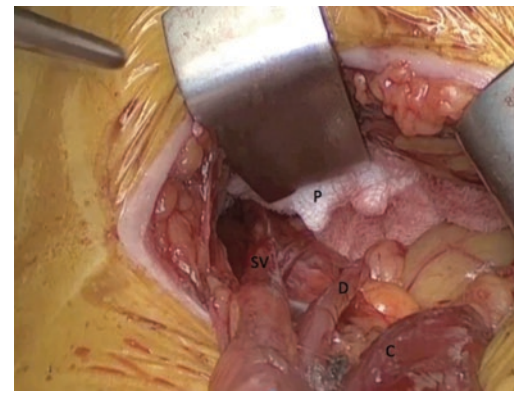

Fig. 31.8 External view of the laparoscopic "doom triangle" (*C* cord; *D* vas deferens; *P* gauze covering the peritoneum; *SV* internal spermatic vessels)

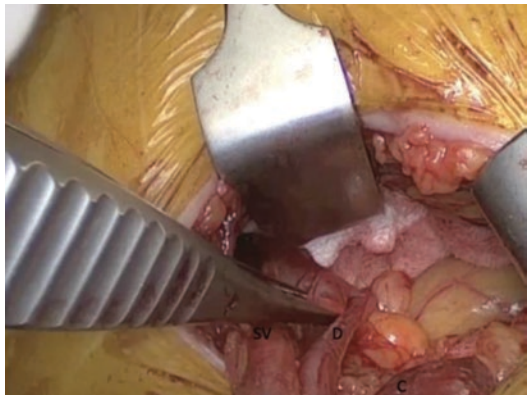

Fig. 31.9 The forceps shows the urogenital sheath in between the vas deferens (D) and the internal spermatic vessels (SV)

The vas deferens and the internal spermatic vessels are ensheathed in the urogenital fascia, well seen here in between them (Fig. 31.9), sheath or fascia described by Stoppa et al. [30, 31], and others. They are both gently separated from the peritoneum as far as needed (angulus of the deferens); psoas segment of the internal spermatic vessels visualizing the same "lamda" as in laparoscopic procedures (Fig. 31.8). The dissection, close to the peritoneum (Fig. 31.9), is conducted in the visceral compartment at the inner aspect of the sheath, exactly like in TEP and not in the lateral compartment where run the nerves, in particular the genitofemoral and caudally its femoral branch [32].

Its genital branch enters the inguinal canal laterally, at the very external edge of the deep inguinal ring and joins the external spermatic vein, the so-called "blue line" landmark [29].

31.3.6 Sixth Step: Anterolateral Release of the Peritoneum

Anteriorly and laterally the peritoneum is separated from the posterior aspect of the arch of the conjoin tendon. If the hernia sac has to be removed, remove it at this step.

The extent of dissection must be sufficient to accommodate the patch, but more extensive dissection is neither necessary nor useful. In practice, the length of the index finger in the direction of the pubis, and in the direction of iliac spine as well as the same in width, is adequate.

31.3.7 Seventh Step: Positioning the Mesh

At the end of the dissection, the gauzes are removed before proceeding to placement of the patch. The size of the Polysoft® patch (medium or large) is chosen according to anatomy. The medial half of the patch (widest side) is introduced first in direction of the pubic bone. To do so, one retractor lifts the epigastric vessels, and a blade retractor (Fig. 31.10) reclines the peritoneum medially, so as the Cooper ligament becomes visible. The widest end of the patch, grasped with the Kelly clamp, is introduced in the direction of the pubis (Fig. 31.11). Then, the clamp and retractors are removed.

To introduce the lateral part of the patch, two retractors lift the lateral edge of the internal orifice made up by the internal oblique muscle, and, using a clamp in one hand and a toothless forceps in the other, the surgeon manages to gently introduce the lateral half of the patch in the preperitoneal space. Then the lateral part of the ring is inserted between the parietalized elements and the peritoneum and the internal part of the ring behind to the conjoin tendon (Fig. 31.12). Then,

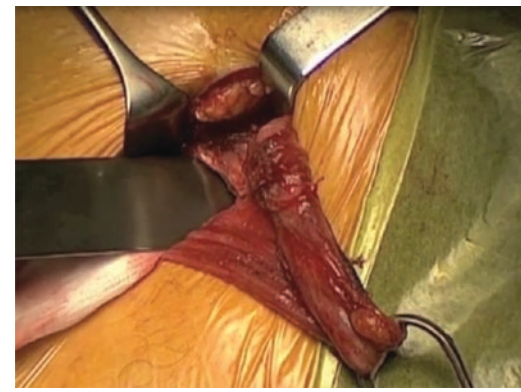

Fig. 31.10 A blade retractor helps for inserting the mesh in the preperitoneal space through the hernia orifice itself (no additional incision of neither the transversalis fascia nor the epigastric vessels)

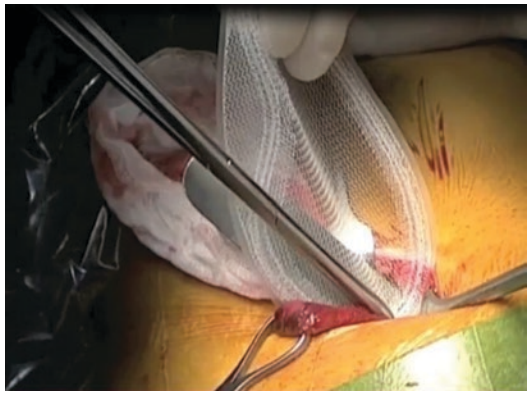

Fig. 31.11 Inserting the memory-ring polypropylene prosthesis in the preperitoneal space through the hernia orifice itself

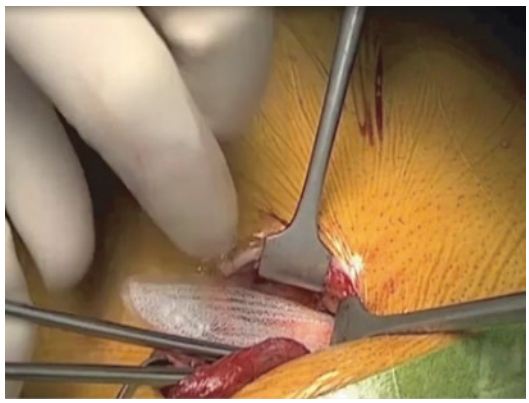

Fig. 31.12 Inserting the cranial part of the mesh behind the arch of the conjoin tendon

the retractors are removed, and deployment of the patch is achieved (and checked) with the finger by pushing on the memory-ring (Fig. 31.13).

The counterpressure exerted by the patient, especially under local or locoregional anesthesia, can facilitate and check a correct deployment (Fig. 31.14).

If the mesh does not correctly fit the space, and/or if the cranial part of the mesh remains unfold and sharp, consider that the dissection has not been wide enough. Remove the mesh, complete the dissection, and reinsert the mesh.

No fixation (Fig. 31.14) is performed, the mesh being firmly applied by the abdominal pressure to the deep aspect of the previously preserved inguinal floor (epigastric vessels not transected and transversalis fascia not open in case

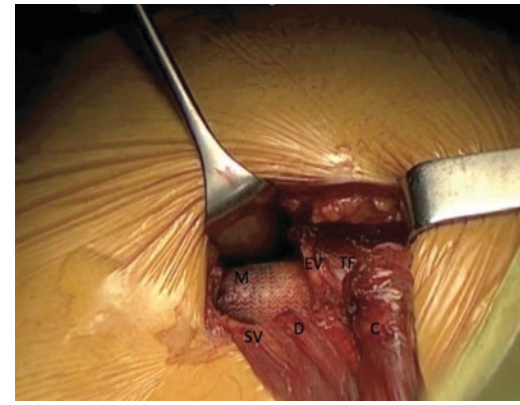

Fig. 31.13 Check the correct positioning of the mesh in between the peritoneum and the abdominal wall (*c* cord, *D* vas deferens, *EV* epigastric vessels, *M* mesh, *SV* internal spermatic vessels, *TF* transversalis fascia)

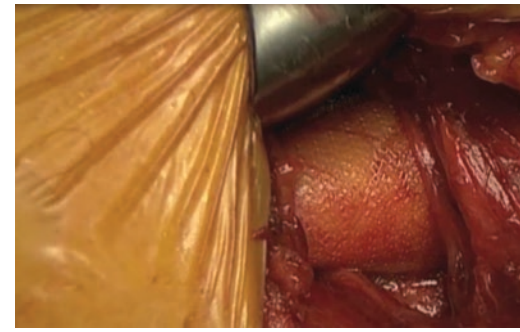

Fig. 31.14 Not any fixation is required

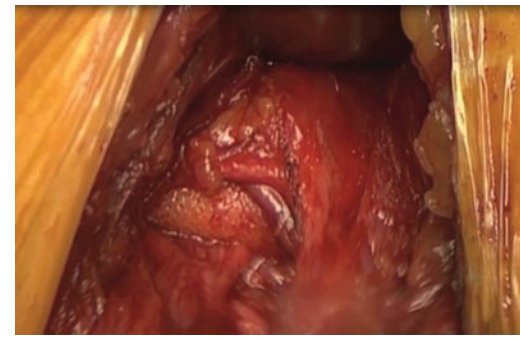

Fig. 31.15 While removing the retractors, the deep inguinal ring retracts

of lateral hernias, sutured in case of medial ones).

While removing the retractors, the deep inguinal ring retracts (Fig. 31.15), leaving the mesh totally retro-parietal (Fig. 31.16).

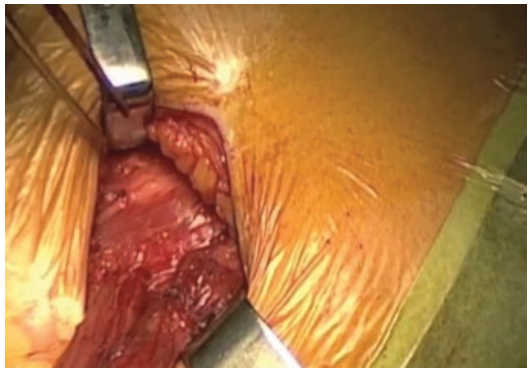

Fig. 31.16 And the mesh is totally retro-parietal

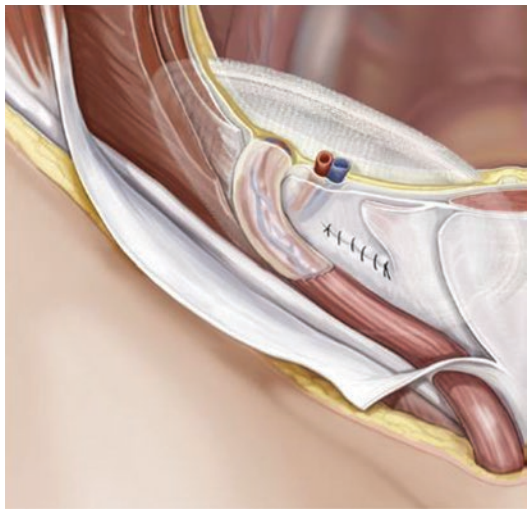

Fig. 31.17 Preperitoneal placement through an minimal invasive inguinal route (Right inguinal area)

The final positioning of the mesh is shown on Fig. 31.17.

If a laparoscopy was performed at the end of the procedure, we could see that the laparoscopic view is almost the same as in TEP (Fig. 31.18).

31.4 Operative Technique: Medial Hernia

In medial hernias, the herniated portion of the transversalis fascia is resected, and the hernia is separated and reduced leading to the preperitoneal space medially to the epigastric vessels. A gentle dissection follows the avascular plane between the

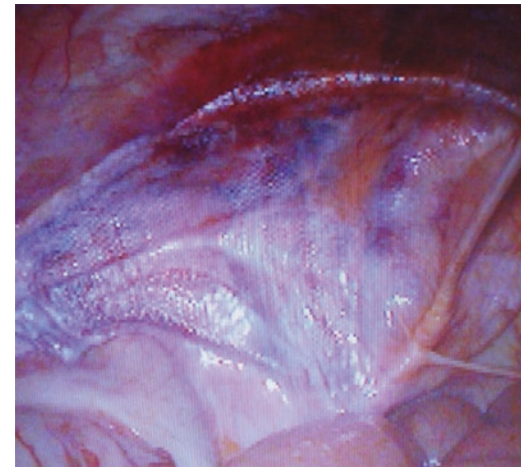

Fig. 31.18 Laparoscopic view of the TIPP mesh in place (Left inguinal area) (Reproduced from Berrevoet et al. 2009 [34])

Cooper's ligament and the preperitoneal fat up to the medial part of the Retzius space. The first gauze in inserted.

Then the dissection moves to the inguinal ring. The parietalization is done through the deep inguinal ring like in lateral hernia. It is easier and allows not to forget a little lateral sac. Moreover the complete preperitoneal dissection achieved in this technique avoids missing a femoral hernia and prevents a femoral recurrence.

In some rare cases of huge medial hernias, the conjoin tendon is sutured to the ilio-pubic tract.

In case of femoral hernias, one stitch can be inserted to fix the mesh onto the Cooper's ligament, but this is not mandatory.

The external oblique aponeurosis is sutured superficially to the spermatic cord, followed by the subcutaneous tissue.

If a TAP block has not been done at the beginning of the procedure, an analgesic infiltration with 20 mL ropivacaine is performed.

The skin is closed with an intraepidermic running suture.

The prescription for the first 3 days is as follows: 200 mg/24 h ketoprofen, 2 g/24 h paracetamol, and 37 mg tramadol before going to bed.

Actually many patients do not really use their pain killers.

31.5 Operative Technique: Tips and Tricks

The avascular preperitoneal plane of dissection is located between the deep aspect of the transversalis fascia and the preperitoneal fat, which is attached to the peritoneum. As small blood vessels are contained in the fat, they are not damaged when dissection is carried out in contact with the fascia. Therefore, for carrying out a bloodless dissection, the finger pad or the blunt tip of the Kelly clamp or the gauze ball must constantly face upward and keep in contact with the fascia. Doing so, there is no risk of tearing the small vessels embedded in the preperitoneal fat. The infiltration by local anesthetics can facilitate dissection. As for major vessels, they are easily palpated and protected by their vascular sheath.

The dissection gauze introduced in the preperitoneal space is not intended to create the pocket by its volume, but it is used to help finger dissection and to act as a passive retractor.

The two gauzes must be removed before introducing the patch, and the nurse is not allowed to give the mesh before the count of the gauzes has been done.

When grasping the patch with a toothless clamp to introduce it medially, one thing is important: The clamp must not hold the memory-ring, and one recommended that the clamp is positioned under the patch, so as the patch is bent over the clamp and its curvature fits with the convex shape of the peritoneal sac and the concave shape of the deep aspect of the abdominal wall. Doing so facilitates the patch deployment.

When introducing the lateral end of the patch laterally, do not follow the natural tendency to push in the direction of umbilicus. The correct direction is toward the iliac spine.

31.6 Results

TIPP fits well with day case surgery. In the initial series, it was performed with an overnight stay in half the cases, principally because of the French national regulation. However in a recent French series, the percentage of day surgery evolved with national rules and increased from 48% in 2010 to 72% in 2012 [28], and in the TULIP trial, the majority of repairs were performed as day cases [33].

Postoperative pain is indeed moderate. Pain assessed by visual analog scale was rated at 1.67/10 and 2.7/10 in two series [26, 34], and the percentage of patients who did not take analgesics was 6 and 15% [26, 34]. The time off work was around 2 weeks. Intraoperative events reported in one series [32] occurred in 4%. They included peritoneal tears and injury of epigastric vessels and were easily managed by peritoneum suture or vessel ligature. The percentage of postoperative complications was around 5–7%. All were benign superficial complications. There were 0.4–4% hematomas, but cases of severe bleeding have not been reported [26, 32, 34].

With a mean follow-up of 2 years, the recurrence rate was 0.4–1.5% [32, 34, 35]. In one study, three recurrences (2%) were diagnosed by systematic ultrasound, but they were not perceptible at physical examination [36], which makes their true significance debatable, since we know that ultrasound is highly operator dependent. No serious complications and no cases of testicular atrophy have been reported. The percentage of chronic pain ranged from 2.5 to 4.8% in two series [34, 36]. It was 7% in the initial evaluation but since the inventing surgeon wanted to be as objective as possible, this included one case of preoperative pain that remained unchanged after operation and three cases of pain that could clearly be related to causes other than surgery [35]. In the largest series looking at quality of life assessment, pain was globally rated as mild; only 0.8% of the patients rated their pain as severe, but they also declared they did not take any analgesics and experienced no impairment in professional and leisure activity, which suggests a possible misunderstanding of the rating scale used [32]. There was no case of debilitating pain, and none of the patients took regular analgesics, with 97% considering their overall result as good or excellent.

The TULIP trial was a randomized double-blind clinical trial comparing TIPP to Lichtenstein, using an accurate methodology,

focused on reducing the risk of errors in the dimensions of bias, random error, and the chosen outcome measures [33]. The operation time was shorter with the TIPP (34 min vs. 40 min). Postoperative complications were significantly less in the TIPP group (6.4% vs. 20.3%). Serious complications, especially bleeding, were not observed. Postoperative pain was not different in both groups, probably because in both repairs the wound was infiltrated with local anesthetic. The mean time to resume activities of daily life, including work and sport, was significantly shorter for patients of the TIPP group (9.9 days vs. 16.4 days). The recurrence rate was not significantly different, though it was higher in the Lichtenstein group (2.6% vs. 1.4%). There were significantly less patients experiencing continuous chronic pain as well as activity-related pain in the TIPP group (3.6% and 8.5%, respectively) than in the Lichtenstein group (12.9% and 38.5%, respectively). The percentage of persisting numbness was higher with the Lichtenstein (49.7%) than with the TIPP (10.5%).

Evaluation of the health status using the SF36 questionnaire showed that the dimensions physical pain and physical functioning were better for patients operated on by TIPP than by Lichtenstein [37]. The economic evaluation concluded that from a hospital perspective there were no differences between both methods, but from a societal perspective, a significant difference in favor of the TIPP was found with savings of 1472 Euros, essentially because the time off work was shorter in the TIPP group [38].

31.7 Advantages of the TIPP

Besides the benefits of the preperitoneal patch stated above, the TIPP technique provides additional advantages.

It is easier than laparoscopy: in the TULIP trial surgery was performed by senior surgeons assisted by residents, as well as by residents assisted by senior surgeons, and the mean operation time was only 34 min.

TIPP does not require general anesthesia with curare. It can be performed with the laryngeal mask without curare [32], which facilitates ambulatory surgery, or with spinal anesthesia. It can also be carried out in local anesthesia with sedation, provided correct infiltration of the preperitoneal space is performed using a sufficient volume of 0.5% lidocaine, rather than a smaller volume or long-action anesthetics [39]. Intraoperative events are easily managed, and the operating duration is less variable than with laparoscopy, which facilitates the planning of operative room and day surgery unit. For these reasons Gillion and Chollet, who had a large experience with the TEP, switched to the TIPP as their preferred method of repair [32].

Another advantage of the TIPP is that switching to another technique, when dissection of the preperitoneal space is difficult, due to a history of preperitoneal surgery, can easily be carried out by the same incision. In one series this was the case in a patient who had a sacral trauma with extensive bleeding some months earlier [30]. In another series, preperitoneal dissection was possible in eight cases with a history of urologic or vascular surgery, but it was not possible in nine cases, for which the surgeon easily switched to a Lichtenstein or a plug [39]. TIPP is the only technique of preperitoneal repair that allows conversion without having to perform an additional incision.

Contrary to laparoscopy, which involves a large dissection and a wide overlapping of the patch on iliac vessels, TIPP requires less extensive dissection. Only the preperitoneal pocket necessary to accommodate the patch is created and consequently, the contact between the patch and iliac vessels is minimal.

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Minimal Open Preperitoneal (MOPP) Technique

32

Marc Soler

32.1 Introduction

The use of a large preperitoneal prosthesis to treat groin hernias was proposed more than 50 years ago by Nyhus [1]. Wantz [2] with the same concept presented a transrectal procedure, which would allow, according to the author's wishes, the treatment of complex hernias (e.g., recurrent hernias) under local anesthesia in an ambulatory setting, but it was not possible to do it in practice.

The Ugahary technique [3, 4] achieved this ambition by combining the concept of visceral sac reinforcement by means of a large Stoppa prosthesis [5] with Ugahary's concept of minimally invasive surgery (small grid iron incision). However, for many authors, the realization was difficult to reproduce and difficult to teach.

The new Pelissier [6] prosthesis with a rigid peripheral ring has made the transinguinal preperitoneal (TIPP) technique possible.

Our minimal open preperitoneal (MOPP) technique is a TIPP technique that uses the Ugahary principle of preperitoneal space dissection with specific retractors (Fig. 32.1), through a 3–4 cm incision (Fig. 32.2). The main principle of MOPP is to unroll a large prosthesis far beyond the limits of the Fruchaud's myopectineal orifice. The prosthesis is applied against the abdominal wall by the underlying pressure. The incision is next to the deep inguinal ring (Fig. 32.2). The anesthesia can be local or with an ilioinguinal or transversus abdominis plane (TAP) block. In our

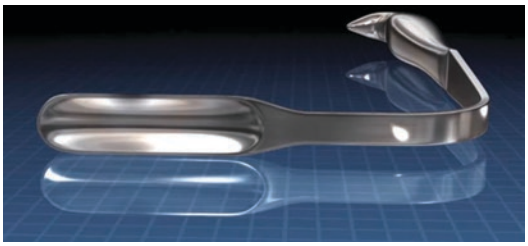

Fig. 32.1 Specific retractor

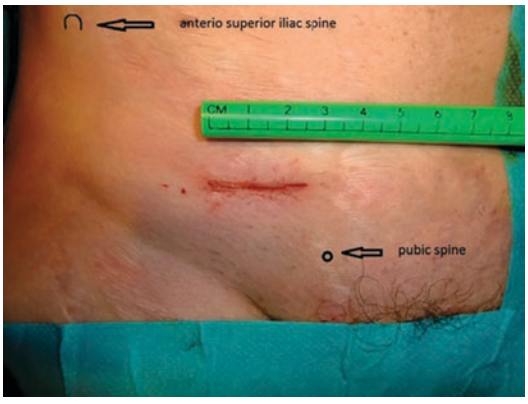

Fig. 32.2 MOPP incision

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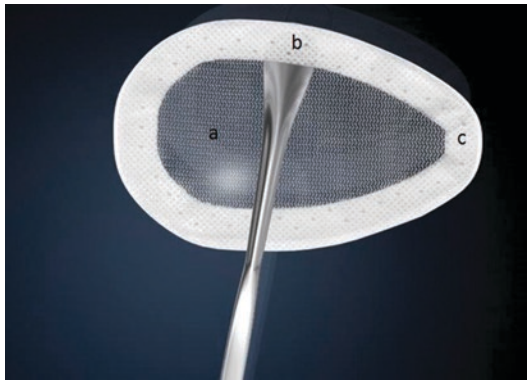

Fig. 32.3 The MOPP prosthesis. (**a**) Large pore size polypropylene mesh. (**b**) Non-knitted non-woven peripheral reinforcement. (**c**) Peripheral hem

practice we use general anesthesia with a laryngeal mask without intubation and without curarization, associated with local anesthesia. The instrumentation (Fig. 32.1) is simple but specifically dedicated. Rapid return to normal activities is an advantage of the technique, contributing to its low cost. When the general conditions allow, the procedure is performed as a day case (in more than 90% in our practice). Preoperative preparation and precautions are standard and show no specificity.

32.2 Prosthesis and Instrumentation

The prosthesis is selected according to the need to be unrolled in the preperitoneal space, through a small incision. A wide polypropylene mesh prosthesis has been specifically devised for this technique; it has a peripheral hem with a reinforcement (Fig. 32.3) to facilitate proper deployment of the prosthesis. The prosthesis is available in two sizes, 16.5 cm/12 cm and 13.5 cm/9 cm. The quality of the prosthesis allows for the minimally invasive technique. This technique requires some very long and narrow retractors (Fig. 32.1) allowing a wide and deep dissection. A long dressing forceps with an atraumatic end is used to introduce the prosthesis behind the pubic bone, in contact with the bladder, without any risk of causing injury to it.

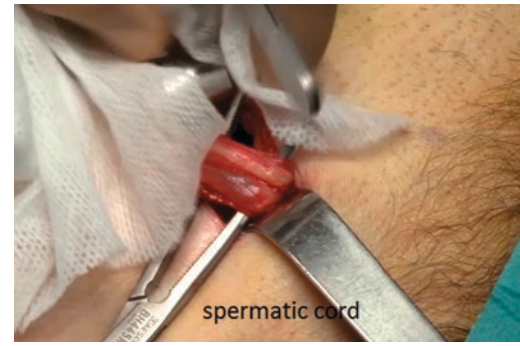

Fig. 32.4 Externalization of the spermatic cord

32.3 Surgical Technique

32.3.1 The Minimal Open Route Between the Skin and the Deep Inguinal Ring

The skin incision (Fig. 32.2) is deliberately small. With experience it can be between 25 and 40 mm. It lies immediately in front of the deep inguinal ring. Several landmarks can be drawn on the patient's skin. The easiest approach is to simply connect the superior anterior iliac spine to the pubic tubercle and draw the incision transversely to the union of the internal and middle third.

After incision of the skin and subcutaneous layers, the fascia of the external oblique muscle is incised in line with its fibers. The ilioinguinal nerve is generally identified and preserved.

The spermatic cord is dissected (Fig. 32.4), separating the funicular pedicle (the blue line) which is left behind. From time to time, it is necessary to separate an old and fibrous medial sac from the spermatic cord. The cord is also separating from the ilioinguinal nerve. I never cut the cremaster fibers; they are retracted medially. At this step, a lateral hernia sac is sought; locating a large and old sac is easy, but sometimes you find a small sac in the most proximal part of the cord.

The lateral sac is separated from the cord (Fig. 32.5). Similarly, a lipoma of the cord will also be dissected and resected, as its persistence may be responsible for postoperative pain, sometimes feeling like a pseudo recurrence. Parietalization of the sac is initiated, pushing it through the deep inguinal orifice.

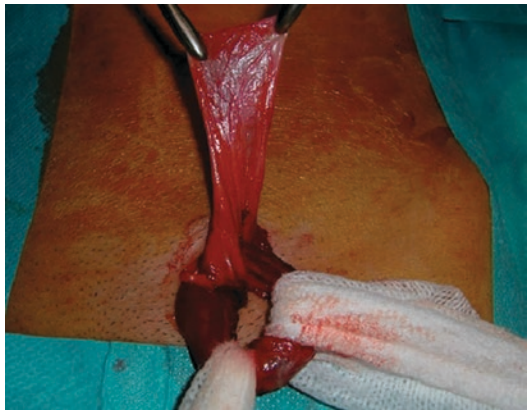

Fig. 32.5 Individualization of the lateral hernia sac

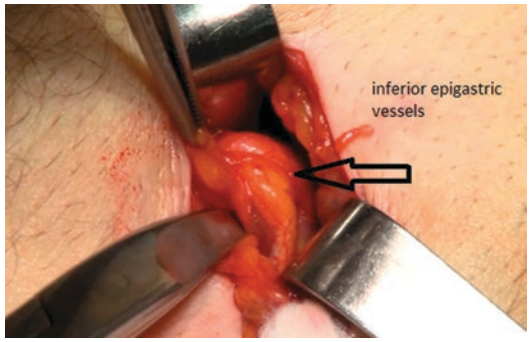

Fig. 32.6 Inferior epigastric vessels identified

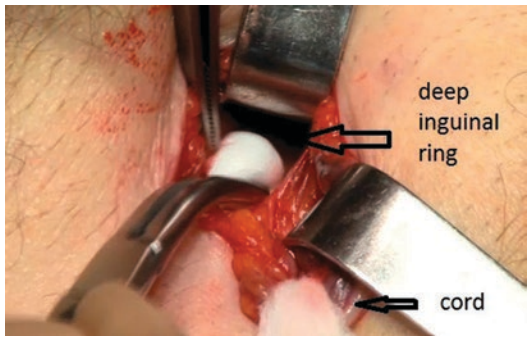

Fig. 32.7 Cleavage of the preperitoneal space is initiated through the deep inguinal ring

32.3.2 Cleavage of the Preperitoneal Space

Penetration into the peritoneal space starts through the deep inguinal ring, laterally to the epigastric vessels, previously identified (Fig. 32.6). Cleavage of the preperitoneal space is initiated (Fig. 32.7), back to the transversalis fascia which is very fine at this location – pushing it medially and progressing back to the inferior epigastric vessels; the vessels are pressed against the anterior abdominal wall, where they will be well protected throughout the procedure with a retractor. Using the dedicated retractors (Fig. 32.8), the dissection extends into the avascular plane medially and laterally along the inferior epigastric vessels in the direction of the iliac vessels, quickly and easily, cleaving the spaces of Retzius and Bogros. Cooper's ligament is easily spotted, the bladder pushed back, and the retropubic space is cleared (Fig. 32.9). Dissection of the space for accommodating the prosthesis continues inwards and upwards with retractors of increasing size. Facing the upper edge of the incision, the peritoneum may be more adherent to the superficial plane and must be gradually separated with scissors; it is imperative to widely open the plane at this level. The top and posterior dissection is easier to widely explore the psoas muscle.

32.3.3 Parietalization of the Spermatic Cord

The elements of the spermatic cord should be separated from the peritoneum, about 10 cm relative to the deep inguinal ring, so as to achieve parietalization of the cord (Fig. 32.10). During the dissection, the spermatic sheet described by R. Stoppa [7], uniting the vas deferens medially and the spermatic vessels laterally, must be carefully respected, if possible. After parietalization, this spermatic fascia can be interposed between the prosthesis and the external iliac vessels. After dissection of the cord, the "parietalization triangle," of which the summit is the spermatic cord, the medial edge the vas deferens, and the lateral edge the spermatic vessels, is well exposed (Fig. 32.11).

32.3.4 Placing the Prosthesis

We use a mesh having a peripheral reinforcement with a nonrigid hem (Fig. 32.3). The dissected preperitoneal space is held open by three retractors

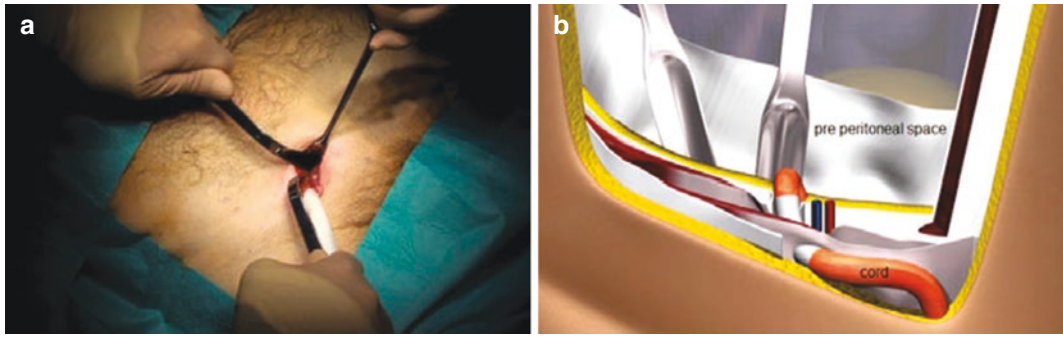

Fig. 32.8 (**a**) Dissection of the preperitoneal space with the specific retractors. (**b**) Dissection of the preperitoneal space with the specific retractors, synthetic image

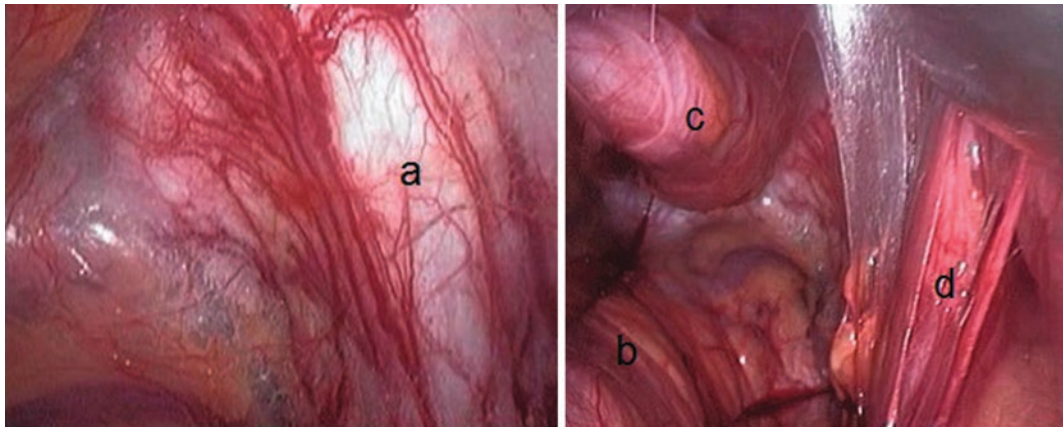

Fig. 32.9 Dissected preperitoneal space. (**a**) Cooper's ligament. (**b**) Bladder. (**c**) Visceral sac. (**d**) Spermatic cord with a large lateral sac

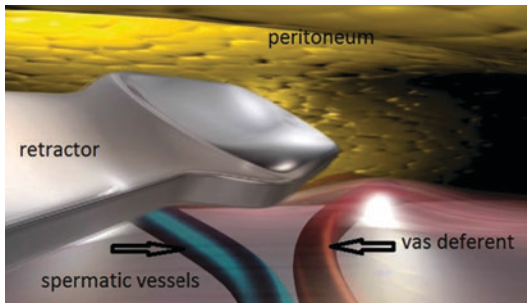

Fig. 32.10 Parietalization of the spermatic cord with the specific retractors, synthetic image

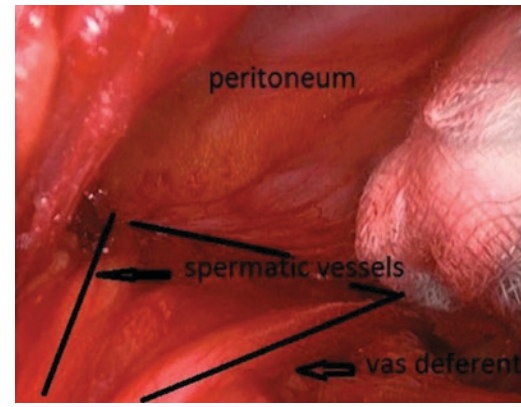

Fig. 32.11 The "parietalization triangle"

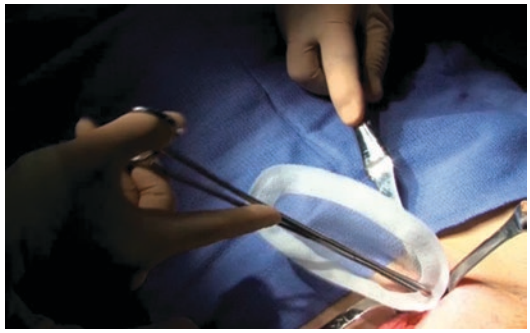

Fig. 32.12 Introduction of the mesh with the dressing forceps

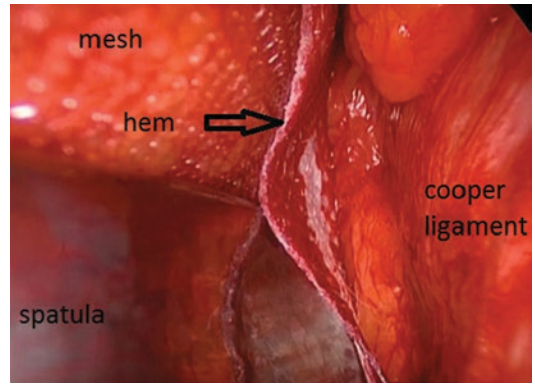

Fig. 32.13 Checking and improvement of the correct position of the prosthesis using a spatula

(Fig. 32.12). One of the retractors raises the anterior abdominal wall thereby protecting the epigastric vessels; the other two long and narrow retractors push back the visceral sac and the bladder.

To prepare for the introduction of the prosthesis, we use an atraumatic clamp (dressing forceps) that gauges the distance between the retropubic region released and the incision. The prosthesis is grasped with this atraumatic forceps at the middle part of its lower and median edge and introduced through the incision parallel to the inguinal ligament, up the retropubic region, taking into account the previously obtained measurement (Fig. 32.12).

The same forceps is used to grasps the upper and lateral part of the prosthesis and introduce it in the upper and lateral portion of the preperitoneal dissection area. The lower end of the prosthesis is placed behind the pubis. The upper end is placed in front of the psoas muscle. The prosthesis is thus partially deployed in the dissection space. Expansion of the prosthesis is completed by using retractors, finger, and forceps. The correct position of the prosthesis can be controlled and improved by using a spatula instrument, which can move along the hem of the prosthesis and possibly remove any folds, thus optimizing good spreading out of its periphery (Fig. 32.13).

The prosthesis is never fixed. When positioning of the prosthesis is satisfactory, the spermatic cord is reintroduced under the external oblique muscle fascia.

Once the prosthesis is in place, the operator sees the deep inguinal ring spontaneously close partially, "like a sphincter." It is not necessary to suture the musculofascial plane. During closure of the external oblique aponeurosis, the ilioinguinal nerve is carefully avoided. The subcutaneous plane is closed with two reversing stitches, and adhesive strips are applied to the skin.

Showering is permitted the following day. An adhesive bandage protects the adhesive strips; this is changed every day and requires no special care until final removal of the strips on day 10.

32.4 Indications

All primary inguinal or femoral hernias can be treated by this technique, in particular large scrotal inguinal hernias (Fig. 32.14) or femoral hernias (Fig. 32.15).

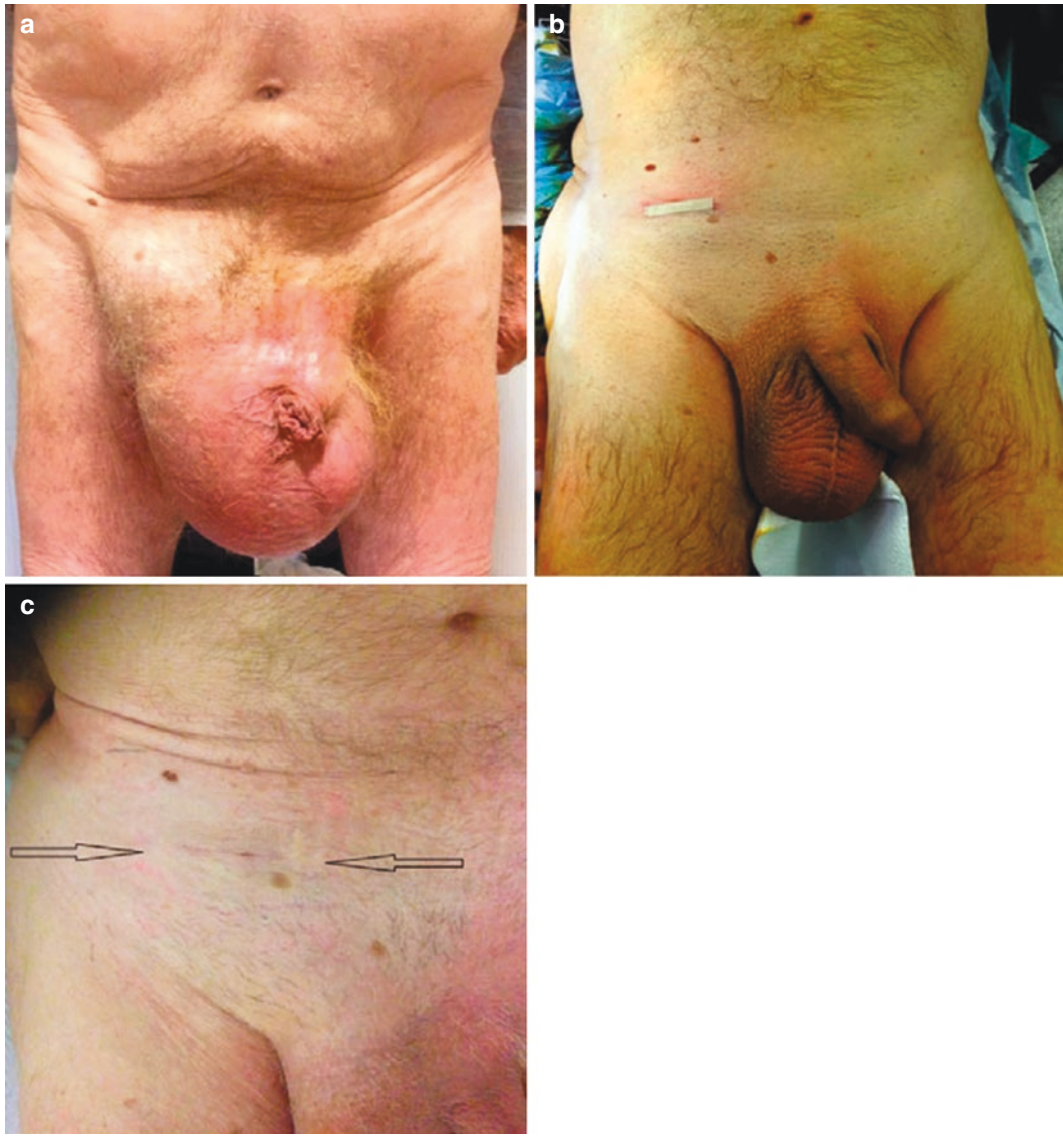

Fig. 32.14 Scrotal hernia. (**a**) Preoperative view. (**b**) Day 0 view. (**c**) Day 10 view

In the presence of bilateral hernia, both sides are operated on in the same operating session, and the two prostheses are superimposed on the midline. Recurrent hernias without material previously established in the preperitoneal space are a very good indication. Recurrent hernias after Lichtenstein are also an excellent indication (Fig. 32.16); with the possibility of setting up a new prosthesis, the preperitoneal space is often free of adhesion. If the previous prosthesis is retained, sometimes a plug must be resected.

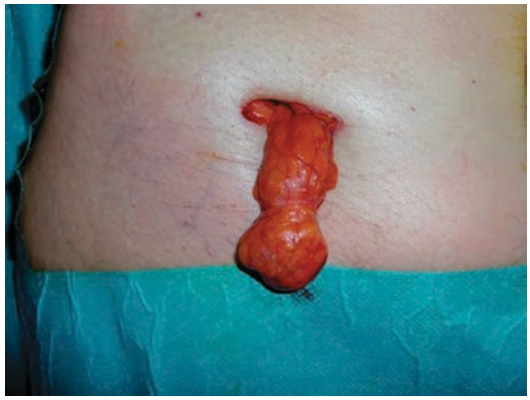

Fig. 32.15 Femoral hernia, externalization of the hernia sac

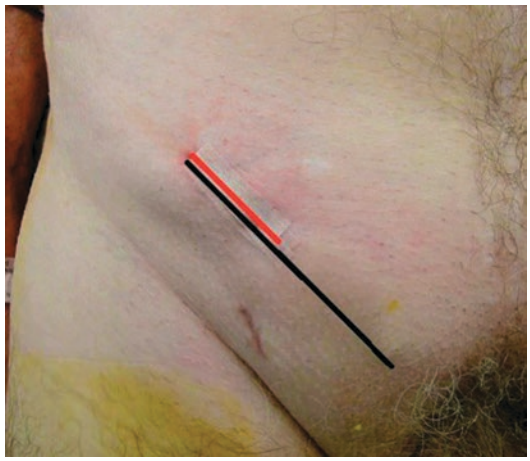

Fig. 32.16 Recurrent hernia after Lichtenstein. Black line, the initial Lichtenstein incision. Red line, the adapted MOPP incision to treat the recurrence

32.5 Special Cases

32.5.1 Female Hernias

The round ligament is always distally dissected and sectioned; it is largely repressed with a possible external oblique sac.

32.5.2 Femoral Hernia

This is an excellent indication for the technique; it is easy to expand the femoral ring with the finger and repress back fringes incarcerated fat. In its normal position, the prosthesis covers widely the femoral hole and the obturator foramen.

32.5.3 Scrotal Hernia

It is easy to dissect step by step a bulky inguinal scrotal sac; the distal part of the sac may be dropped in the scrotum.

32.5.4 Strangulated Hernia

It is also possible to treat a strangulated hernia. An intestinal loop can be resected if necessary, through an enlarged transverse incision. Then it is possible to complete the operation by the same way with or without using prosthetic material.

32.6 Contraindications

Previous radical prostatectomy, pelvic irradiation, or realization of a vascular bypass with dissection of the preperitoneal space can be a contraindication of the MOPP technique, as are recurrent hernias with prosthesis implanted in the preperitoneal space. However, with experience, even in these situations, it is often possible to start with the MOPP technique and, in the case of failure of the preperitoneal dissection, continue with the Lichtenstein technique with the same incision. It is not a conversion.

32.7 Personal Data

A total of 778 hernias were operated on between September 2011 and June 2015. All cases were treated in an ambulatory setting. Our results have been good, with few complications and no cases of reoperation (Table 32.1). Satisfaction at 2 years is excellent. There have been no cases of recurrence during this period. Pain was rated on VAS (visual analog scale), and the rate of severe postoperative pain is very low (Table 32.2). Only 97 patients reporting pain at 1 month were reviewed at 3 months (Table 32.2). For four

Table 32.1 Baseline demographic characteristics and outcome of 778 hernias operated between September 2011 and June 2015

Hernias operated	778	
Mean follow-up	711 days	
Technique	MOPP 644 Ugahary 74 Lichtenstein 25	
About MOPP	Patients 534	Men 483 (90.45%), women 51 (9.55%)
	Hernias 644	Unilateral 424 (79.40%), bilateral 220 (20.60%)
	Type of hernia	Lateral 401 (62.26%) Medial 251 (38.97%) Femoral 28 (4.34%): female 16, men 12
	Prosthesis *N* = 619	Large size (16.5/12 cm) ovoid polypropylene mesh 260 (42%) Medium size (13.5/9 cm) ovoid polypropylene mesh, 359 (58%)
	Length of stay	Day case 598 (92.8%) One night stay 30 (4.64%) More than one night 13 (2.01%)
	Complications	Bladder retention 2 Phlebitis 1 Superficial infection 2 Deep infection 0 Reoperation 0
	At two years *N* = 220	No discomfort 214 (97.27%) Discomfort 5 (2.27%) Satisfaction: Excellent 212, medium 1 No recurrence

Table 32.2 Postoperative pain and chronic pain at days 8, 30, and 90, based on VAS scores (visual analog scale)

	Day 8	Day 30	Day 90
N	624	553	97
VAS 0	337 (54%)	452 (81.73%)	77 (79.38%)
VAS 1–3	225 (36.05%)	77 (13.92%)	9 (927%)
VAS 4–6	57 (9.13%)	19 (3.43%)	10 (10.30%)
VAS 7–8	8 (1.28%)	5 (0.90%)	1 (1%)

patients, postoperative pain was worse than preoperative pain, but no medication or limitation of activity was required

Conclusion

The MOPP technique is a minimal open preperitoneal technique using a large wide mesh. Nearly all kinds of groin hernias, and all adult patients, can be treated. A frail elderly patient with a large hernia is a good indication as anesthesia can be adapted.

The patients are preferably treated in an ambulatory setting according to the usual criteria and precautions. There are no particular restrictions regarding the allowed postoperative activities. Our data show a low rate of chronic pain and no cases of recurrence.

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33 Total Extraperitoneal (TEP) Approach in Inguinal Hernia Repair: The Old and the New

Davide Lomanto and Eva Lourdes Sta. Clara

33.1 Introduction

Endoscopic inguinal hernia repair has three surgical approaches from totally extraperitoneal (TEP) repair to the transabdominal preperitoneal approach (TAPP) and the less common intraperitoneal onlay mesh repair (IPOM). The first two are widely utilized for the obvious advantages of lower recurrence and complication rates and better outcome when compared to the open repair while covering the entire potential hernia site in the myopectineal orifice with a large prosthesis [1, 2].

There are some benefits related to each technique: overall, in the TEP approach, there is minimal risk of intra-abdominal injury to organs and postoperative adhesions, while in TAPP the contralateral side can be examined for an occult or undiagnosed hernia, and it can be useful as a diagnostic tool in an emergency hernia repair or irreducible cases.

33.2 Indications

- Patient with primary or recurrent reducible inguinal hernia
- Fit for general anesthesia

33.3 Contraindications

- Not fit for general anesthesia
- Acute abdomen with strangulated and infected bowel
- Respiratory distress
- Pediatric patients

33.4 Relative Contraindications

- Irreducible hernia
- Sliding hernia
- Inguinoscrotal hernia
- Previous prostatectomy or pelvic surgery
- Previous TEP/TAPP repair

Previous lower abdominal surgery is a relative contraindication. Adhesions can pose difficulty to the attending surgeon; thus, a surgeon who is attempting this should be skilled in both TEP and the transabdominal preperitoneal approach. However, it should be explained to the patient that there is also a possibility that the operation may be converted to an open approach, as deemed necessary by the surgeon. Previous open appendectomies are usually not a problem but they require one to be more careful during the lateral dissection.

Recurrent hernia from a previous TEP is a relative contraindication. This can still be done through TEP depending on the expertise of the surgeon.

Large inguinoscrotal hernia is also a relative contraindication depending on the experience of

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the surgeon, since there would usually be a distorted anatomy and limited working space in this kind of inguinal hernias.

33.5 Preoperative Preparation

A thorough history and physical examination is necessary to assess the patient including fitness for general anesthesia. If there is any doubt in the diagnosis of the inguinal hernia (large defect, sliding hernia, multiple recurrent, etc.), it may be prudent to do a preoperative imaging work-up by dynamic ultrasound or CT scan.

It should also be explained to the patient that there might be a risk of conversion to transabdominal preperitoneal (TAPP) inguinal hernia repair or an open approach depending on the difficulty and safety of the procedure, which is based on the judgment of the attending surgeon. Risk for recurrence and complications should be properly explained to the patient including vascular, nerve and vas injury, seroma, mesh infection, postoperative chronic pain, etc. [3].

Prophylactic antibiotic treatment is recommended in the presence of risk factors for wound and mesh infection based on patient status (advanced age, recurrent corticosteroid use, immunosuppressive conditions, obesity, diabetes, and malignancy) or surgical factors (contamination, long operation duration, use of drains, urinary catheter) [4, 5].

Patients should also be advised to void prior to the procedure.

However, in the case of complicated hernias (partially reducible, large defect) and/or length of surgery more than 1.5 h, it is advisable to decompress the urinary bladder by inserting a urinary catheter which can be removed at the end of the procedure.

33.6 Operating Theatre Setup

33.6.1 Instruments

- 10 or 5 mm, 30-degree angled telescopes
- Trocars
  - 10-mm Hasson's trocar
  - 5-mm trocar
- Balloon dissector
  - Based on the IEHS guidelines, it is recommended to use a balloon dissector when creating the preperitoneal space, especially during the learning period, when it is difficult to identify the correct preperitoneal plane and space. Once the learning curve is overcome, to reduce the cost of the procedure, a blind dissection can be achieved by swiping the telescope along the midline. A self-made dissector balloon can be arranged using finger gloves over an irrigation device.
- Graspers and atraumatic graspers
- Scissors
- Prosthetic mesh
  - It is advisable to use a large-pore polypropylene or multifilament polyester mesh with a size of at least 10 × 15 cm. Using a smaller mesh will increase the risk of recurrence. However, for larger defects of more than 3–4 cm (L > 3 according to EHS classification [4, 5]), it is recommended to use a larger mesh (12 × 17 cm).
- Tackers and fixation devices
  - According to the IEHS Guidelines and EBM, fixation of the mesh is required only in particular cases like large hernia defect (>3–4 cm), especially if direct, to avoid translation of the mesh and to reduce the risk of recurrence. Today either absorbable or permanent staplers/tackers are utilized to fix the mesh to Cooper's ligament and to the rectus muscle. Sealants in the form of fibrin glue (Tisseel or Tissucol, Baxter USA) or synthetic glue (Liquiband, AMS UK; Histoacryl, BBraun, Germany, etc.) are also available, and several studies have shown their efficacy and benefits.
- Endoloops
  - Pre-made loop sutures are useful for closure of inadvertent tears in the peritoneum and ligation of the hernia sac. Based on the IEHS guidelines, it is recommended to close any peritoneal tears to decrease the risk of adhesions which may lead to bowel obstruction. If not commercially available,

the loop can be made using a 50–70 cm absorbable suture and an extracorporeal Roeder's knot.

33.6.2 Patient and Surgical Team Positioning

The patient lies supine in a slight Trendelenberg position (10–15°) with both arms tucked at the sides, under general anesthesia. The attending surgeon stands on the side opposite the hernia defect side and the assistant stands beside the attending surgeon at the cephalad side of the patient (Fig. 33.1). The nurse stands on the same side as the surgeon, near the feet of the patient. The monitor and video equipment are placed at the caudal end of the operating table, either midline or slightly ipsilateral to the defect. Monitors mounted on a boom arm will be helpful in improving visual space.

33.7 Surgical Technique

33.7.1 Entering and Creating the Preperitoneal Space

There are few techniques to enter and create the preperitoneal space. A 10-mm vertical infraumbilical incision is first made. Subcutaneous tissue is bluntly dissected to expose the anterior rectus sheath using (2) S-retractors (Fig. 33.2). The anterior rectus sheath is then incised, lateral from the midline, on the ipsilateral side of the hernia. This will avoid the linea alba and accidentally entering the peritoneal cavity. Then the rectus muscle is retracted laterally to expose the posterior rectus sheath (Fig. 33.3).

Once the preperitoneal plane is entered, there are a few techniques to create the space: (l) the optical balloon dissector, (2) the Veress needle technique, and (3) the most common blunt dissection. Using the trocar with an optical balloon dissector, the space is created by inflating the balloon

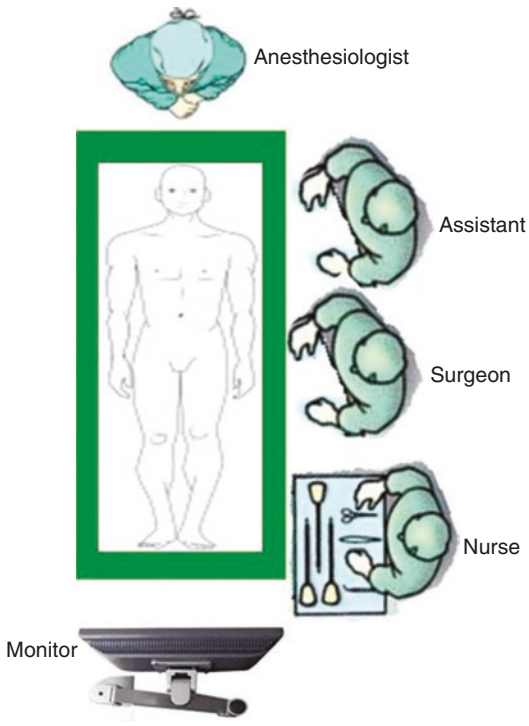


Fig. 33.1 Operating room setup

Fig. 33.2 Anterior rectus sheath exposed using S-retractors

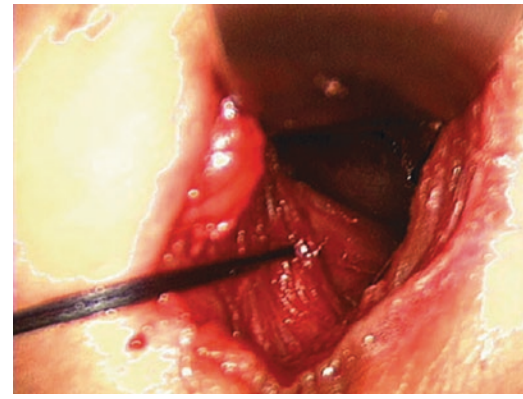


Fig. 33.3 Rectus muscle retracted laterally

under vision (Fig. 33.4). This is the plane one should maintain and create up to the symphysis pubis using a gauze, a finger, or a dissecting balloon, depending on the preference and expertise of the surgeon. A Hasson's trocar is then inserted, and the plane is confirmed by inserting a 30-degree trocar. The rectus muscle should be visualized in the anterior area to be in the right plane. Insufflation is done with carbon dioxide at 8–l2 mmHg.

Two 5-mm trocars are then inserted at the midline under direct vision to prevent any injury to the bladder, peritoneum, or bowels. The first 5-mm trocar is placed three fingerbreadths above the symphysis pubis. The second 5-mm trocar is then placed in between the Hasson's trocar and the first 5-mm trocar (Fig 33.5).

33.7.2 Medial Dissection (Space of Retzius or Prevesical Space)

Once all the working ports are inserted, using two atraumatic graspers, the dissection is conducted along the midline, below the rectus muscle, and toward the pubis arch. The dissection should go 2 cm beyond the symphysis pubis to the obturator fossa to avoid missing any obturator hernia and to allow the medial lower corner of the mesh to be fixated once the space is deflated (Fig. 33.6). The limits of the dissection are medially, 1–2 cm beyond the midline and below the pubis arch and inferiorly until the peritoneal reflection is identified at the border with the retroperitoneal space.

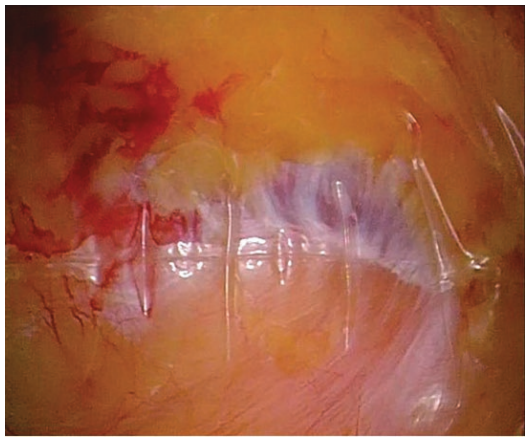


Fig. 33.4 Balloon dissector

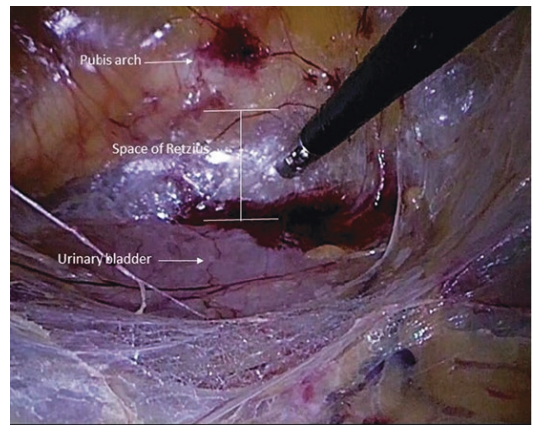


Fig. 33.6 Space of Retzius

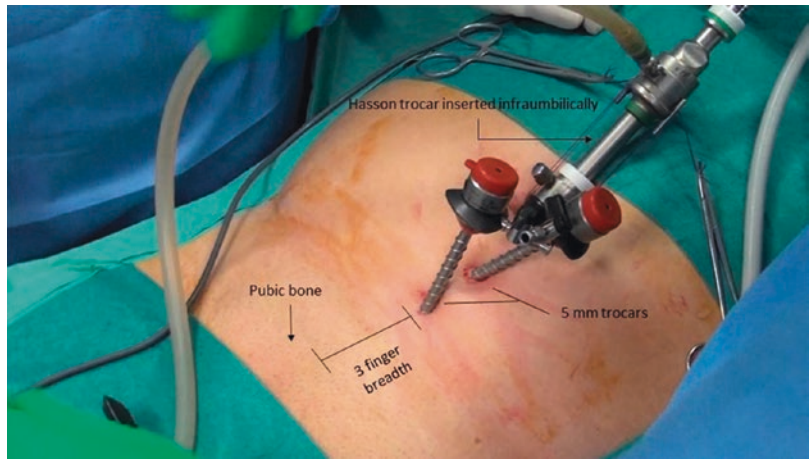


Fig. 33.5 Trocar placement

33.7.3 Lateral Dissection (Lateral Space of Bogros)

Moving toward the anterior superior iliac spine (ASIS), in a surgical plane that is below the inferior epigastric vessels (IEV) and above the peritoneum, the lateral dissection is made. This plane is confined by the two layers of the fascia transversalis. The dissection is continued by pushing down the peritoneum until the psoas muscle can be seen. The lateral space of Bogros is delineated and cleaned all the way up to the anterior superior iliac spine. Attention should be made to avoid dissecting further laterally, beyond the lumbar fascia in the so-called lateral triangle of pain. This will prevent injury to the latero-cutaneous and genitofemoral nerves. The thin layer of fat covering the lateral fascia should be preserved and not skeletonized; similarly, energy and diathermy should not be used at this level (Figs. 33.7 and 33.8). The limits of the lateral dissection are inferiorly the psoas muscle, superiorly the ASIS, and cranially the arcuate line.

33.7.4 Hernia Sac Identification and Reduction

Once the medial and lateral dissection is completed (Fig. 33.9), we should be able to identify the entire hernia defect, followed by a proper hernia sac reduction and repair. This will allow the surgeon to visualize all the anatomical landmarks, to lessen the risk of injuries, to have a wider space for placing the prosthesis, and, in case of inadvertent tear of the peritoneum, to continue to work safely without being affected by the pneumoperitoneum.

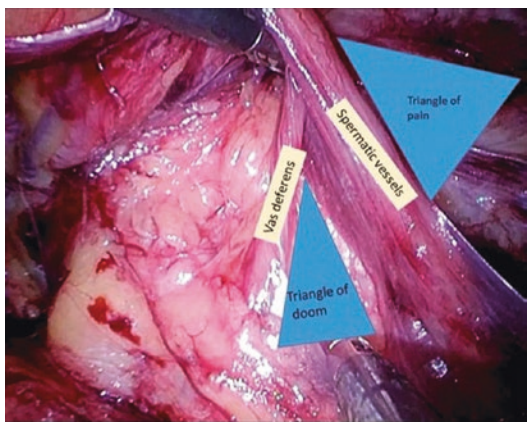


Fig. 33.7 Triangle of pain and triangle of doom

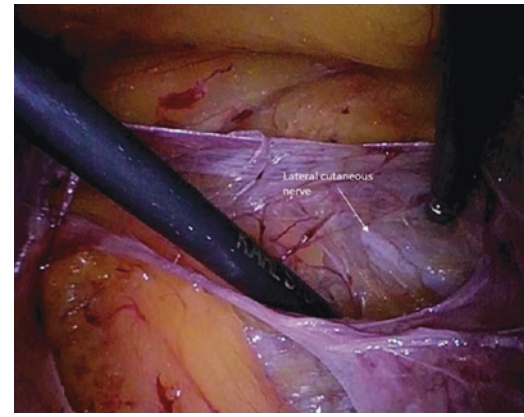


Fig. 33.8 Lateral cutaneous nerve at the space of Bogros

Exposure of the whole myopectineal orifice should be made after a complete medial and lateral dissection followed by the hernia sac reduction (Fig. 33.10).

33.7.5 Hernia Reduction

33.7.5.1 Medial or Direct Hernia

In the endolaparoscopic approach, a defect medial to the inferior epigastric vessels and at the level of the Hesselbach's triangle is a direct hernia. Reduction can be easily achieved by identifying and holding the hernia "pseudosac" and dividing it from the preperitoneal lipoma and peritoneum. Special care should be taken once the pubis arch is reached because of the risk of injury to the "corona mortis" and laterally to the iliac vessels and vas deferens. The "pseudosac" is grabbed and the hernia contents are then reduced.

33.7.5.2 Femoral Hernia

Reduction of the hernia sac and content is achieved by gentle traction keeping in mind that the vessels hide behind the content (Fig. 33.11). If the content is not reducible by traction due to the small size of the defect, it may be necessary

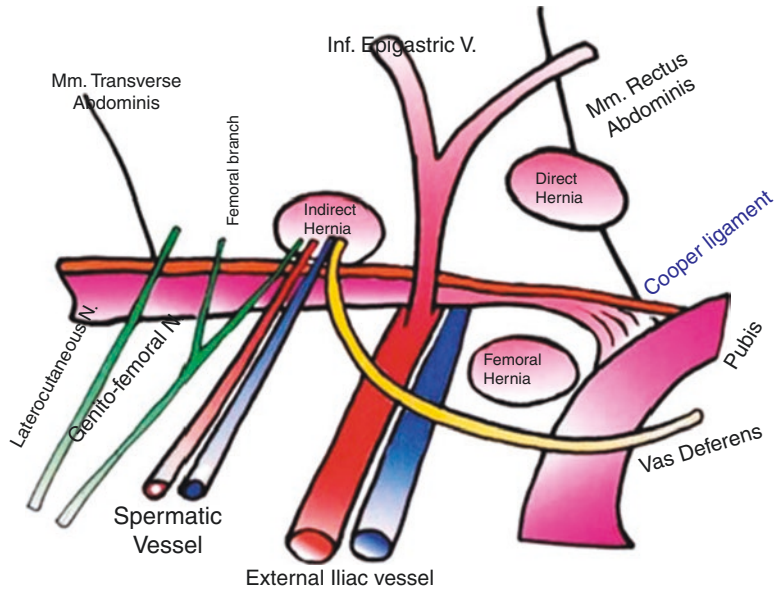


Fig. 33.9 Anatomic landmarks in endo-laparoscopic inguinal hernia repair

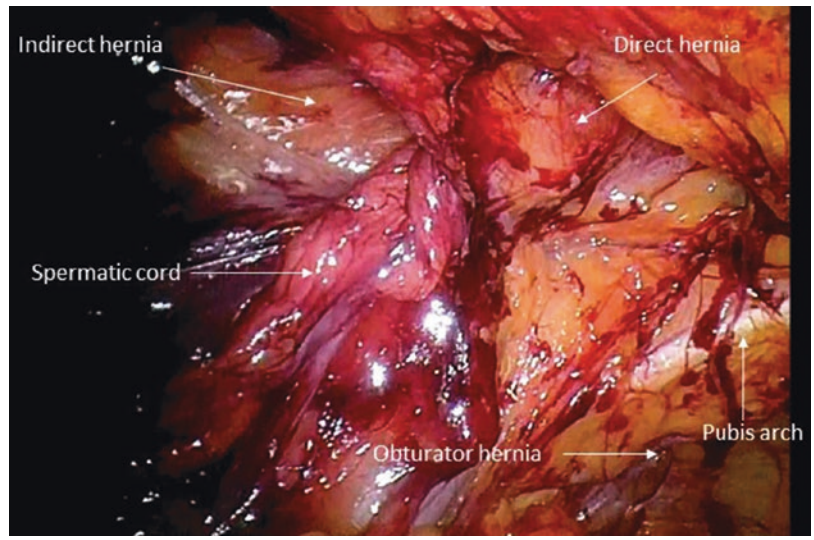


Fig. 33.10 Myopectineal orifice

to widen the femoral defect by using a hook diathermy *only* on the medial-upper side (Fig. 33.12). This will facilitate the hernia sac reduction.

33.7.5.3 Obturator Hernia

In the same canal where the obturator vessels are, it is possible that a preperitoneal fat and/or hernia sac is within. As in femoral hernia, a gentle traction will allow the reduction of the hernia sac (Fig. 33.13).

33.7.5.4 Indirect Hernia

Lateral to the IEV lies the deep ring and indirect hernia. The standard approach to indirect hernia repair requires the spermatic structures to be separated from the hernia sac. This can be achieved using the medial approach and four simple steps: (l) separating the whole sac and spermatic cord from the iliac vessels, (2) slimming the sac at the level of the deep ring with a partial reduction of both cord structures and sac, (3) separating the

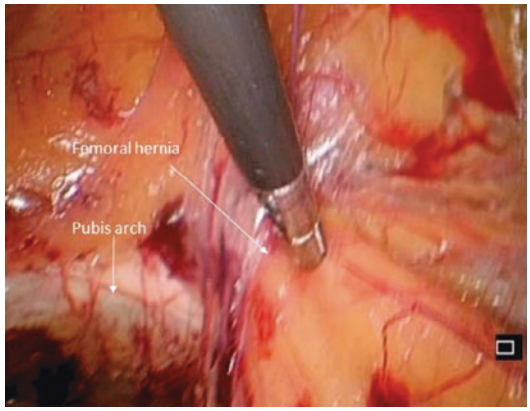


Fig. 33.11 Femoral hernia

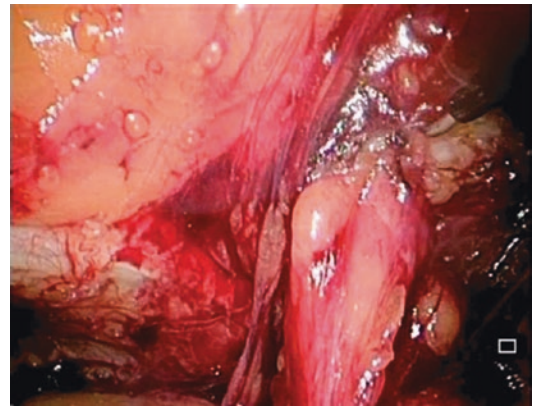
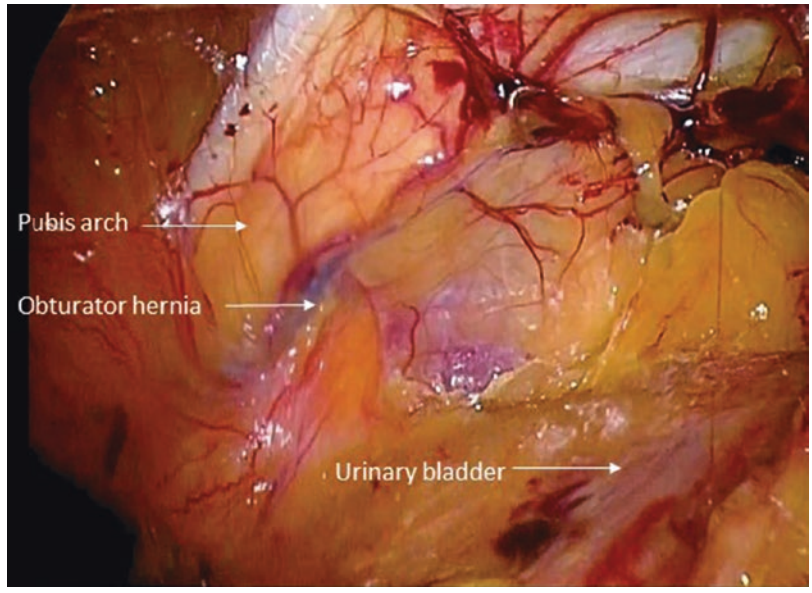


Fig. 33.12 Widening of the femoral ring at the medial-upper side

Fig. 33.13 Obturator hernia



cord structures from the sac on the inferior edge of the sac, and (4) reducing the sac by simple traction or transection. This can be necessary in cases of long or complete sac in order to minimize injury to the testis by overtraction. It is suggested to divide the sac using diathermy to reduce the risk of hematoma and to ligate the proximal part using pre-made suture loops. Lipoma of the cord should be fully reduced.

It is important to close all peritoneal holes/tears with absorbable suture loops or plastic clips (i.e., hem-o-lok, Teleflex Medical, USA) to prevent any internal herniation or adhesion formation with the mesh. Once reduced or ligated, the peritoneal sac should be further reduced until the peritoneal reflection is visualized and medially separated by the adhesion with the vas deferens.

33.7.5.5 Mesh Repair

The final step is the hernia repair, which is achieved by covering the entire myopectineal orifice with a synthetic large-pore prosthesis of 10 × l5 cm. The mesh is rolled up and inserted through the 10-mm trocar. A "no-touch technique" is mandatory to avoid mesh infection. The mesh is inserted into the preperitoneal cavity

avoiding any contact with the skin. The mesh is then placed horizontally and unrolled over the myopectineal orifice making sure to cover all the hernia sites. One-third of the mesh should be below the symphysis pubis, the upper margin reaching the lower trocar medially and laterally lying over the psoas muscle. In bilateral hernias, there should be a 1–2 cm overlap of the meshes at the midline. It is important to make sure that no part of the peritoneum is under the mesh to prevent any recurrence.

The mesh is then anchored using tackers or sealant to prevent mesh migration and possible recurrence. Two to three points of fixation are necessary: Cooper's ligament, medial to the inferior epigastric vessels at the rectus muscle and, if necessary, lateral to the inferior epigastric vessels. Avoid tacker or stapler fixation below the iliopubic tract and too laterally considering 15–20% of abnormalities in the nerve paths. This will help to prevent any nerve injuries and consequent postoperative chronic pain.

An accurate hemostasis should be guaranteed if the correct surgical plane is identified. The carbon dioxide is then released while checking visually that the mesh is not rolled, and the peritoneum stays in front of the mesh so as to prevent any recurrence. The lateral inferior edge of the mesh can be held with a grasper, if necessary. The ports are then removed, and the anterior rectus sheath incision at the 10-mm trocar site is sutured. The skin incisions are then closed with absorbable sutures or glue.

33.7.5.6 Reduced- and Single-Port Technique

Since the advent of the laparoscopic technique, the trend toward scarless surgical techniques continued. Since then, a few novel approaches have been utilized in hernia repair such as needlescopic surgery and the single incision endolaparoscopic surgery (SPES) [6, 7].

For needlescopic surgery, smaller size instrumentation is utilized to perform the procedure; challenges are the flexibility of the instruments especially in large defects or thickened peritoneal sac. Clinical studies showed comparable results with the standard technique, but nevertheless the needlescopic technique has never been successful with worldwide acceptance [6, 8].

The latest approach, SPES, which uses a single device in which all the telescope and working ports are inserted, has seen much enthusiasm not only for inguinal hernia repair but also for cholecystectomy, appendectomy, adrenalectomy, etc. [9–13]. The possible advantages of single or reduced port surgery in hernia repair can be attributed to less pain, better cosmesis, less risk for port-site hernia, and even shorter hospital stays. A technical challenge is the ergonomics, as the approach is more affected by constraints in exposure, adequate retraction, conflict between the instruments, and lack of triangulation [14]. In standard TEP with a midline approach, this is less evident because of the almost parallel axis of the two working ports, resulting in a shorter learning curve.

Recent studies also show at least equivalent pain scores, operative duration, and complication rates when comparing conventional laparoscopic surgery to reduced-/ single-port surgery in hernia repair, making this novel approach acceptable and comparable to standard TEP inguinal hernia repair [15, 16].

33.8 Postoperative Care

- Diet as tolerated is resumed.
- Analgesics are given (etoricoxib 90 mg daily for 3 days).
- Patient is discharged on the same day once voiding freely.
- Follow-up is at l week, l and 3 months.

33.9 Complications

Complications can be categorized into intraoperative and postoperative complications. Intraoperative complications specific to TEP occur in about 4–6% of the cases and can be due to injury to the vascular, visceral, nerve, and spermatic cord structures [17–19]. Vascular injuries would include injury to the external iliac vessels, inferior epigastric vessels, spermatic vessels, or

the vessels over the pubic arch including the corona mortis veins. The most common are injury to the IEV, and this can be avoided by using the midline approach and by inserting all the ports under direct vision. Injury to the major vessels is catastrophic; a correct lateral traction of the sac and spermatic structure with medial approach may be helpful in avoiding it. A careful practice should be used when retracting or dissecting closer to the "triangle of doom." Visceral injuries including but not limited to the bowels and urinary tract can be reduced by careful dissection and limiting the use of diathermy. Transmitted energy through the thin peritoneal layer may result in injury to the underlying bowel. Patients with previous pelvis surgery, sliding hernia, and large inguinoscrotal hernia are at risk for bladder injury, in which case urinary catheterization may be necessary. In the event of injuries, these can be managed by an endolaparoscopic suture repair. Nerve injuries can be prevented by accurate lateral dissection, limiting the number of staplers/tackers if fixation is needed and using of absorbable tackers or sealant. Spermatic cord injuries can be lessened by properly identifying the anatomy and avoiding too much traction of the cord. Tears in the peritoneum can also occur especially during the early stage of the learning curve. All peritoneal tears should be closed by using suture loops or hem-o-loks.

Postoperative complications like seroma commonly occur in patients with large direct and indirect hernias. The seroma usually appears after 7–10 days and does not require any treatment. It may be mistaken for an early recurrence. In principle, it should be treated conservatively and will be reabsorbed spontaneously within 4–6 weeks. However, if it is symptomatic and persisting after 2 months, it is advisable to drain it by aspiration and in sterile condition. In the case of complex sero-hematoma, an excision after 4–5 months can be necessary.

Early recurrence is usually due to inadequate surgical technique and can be due to wrong case selection for beginners, inadequate fixation of the mesh, inadequate mesh size, inadequate dissection of the myopectineal orifice, and failure to cover unidentified hernia defects [20].

Conclusion

Several clinical trials and meta-analyses have shown endoscopic preperitoneal hernia repair (TEP) performed by experienced surgeons to be associated with reduced postoperative pain, less need for postoperative analgesia, earlier return to work, fewer complications, and a low recurrence rate when compared to open mesh repair [1, 2, 21, 22]. These benefits will be more significant if the laparoscopic treatment is for bilateral or recurrent hernias. As for any successful surgical technique—but especially in hernia repair—a careful patient selection, a good understanding of the anatomy, an adequate surgical technique, and the surgeon's experience are very important key factors to achieve a good clinical outcome with a low rate of short-term and long-term complications.

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Primary Inguinal Hernia: TAPP

34

Diego Cuccurullo and Marta Cavalli

34.1 Introduction

The success of laparoscopic cholecystectomy in the late 1980s and the proposal of the giant preperitoneal reinforcement on the visceral sac (GPVRS) concept to cover the entire myopectineal orifice by an open approach by Stoppa [1] and, later, by Wantz [2] attracted the interest of the placement of the mesh in the posterior space and then the interest of laparo-endoscopic surgeons [3].

Three endoscopic techniques using a posterior approach were developed in the early 1990s: the transabdominal preperitoneal patch (TAPP) reported for the first time by Schultz [4] and Arregui [5]; the total extraperitoneal patch plasty (TEP) promoted by Dulucq [6], Ferzli [7], and McKernan [8]; and the intraperitoneal onlay mesh (IPOM) reported by Fitzgibbons [9].

In the latter a nonabsorbable prosthetic mesh is placed upon the defect, exposing the viscera to potential adhesion and morbidity. For this reason, it has been soon rejected by the surgeon community, and now it is considered an inappropriate and ineffective therapy [10].

The objective of the minimal laparo-endoscopic approach to groin hernia repair is the deployment of a large nonabsorbable mesh in a widely dissected preperitoneal space covering and overlapping all potential inguino-femoral defects. Both TAPP and TEP do reach the same final objective in different ways.

Recently, the key points of the techniques have been described and validated according to the criteria of evidence-based medicine (Oxford Classification) by Kukleta and Bittner (for TAPP) and by Chowbey, Köckerling, and Lomanto (for TEP) [11].

34.2 Indication for TAPP Technique

In the author's opinion, TAPP is indicated in the bilateral primary hernia and recurrent inguinal hernia after the previous anterior approach. In the latter case, it would always be advisable to know the real type of repair and mesh used in the previous surgery: the presence of a plug placed in the internal inguinal ring (Fig. 34.1) could make intraperitoneal dissection more difficult, especially during learning curve.

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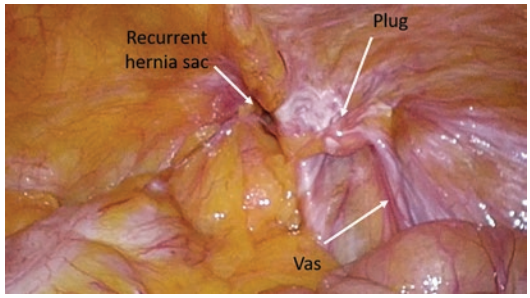

Fig. 34.1 Plug placed in previous surgery pushes out to the preperitoneal space

34.3 The Standardized TAPP Technique

This technique requires evidently general anesthesia. The patient is required to empty his/her bladder before the operation because a urinary catheter is not inserted routinely, but it is strictly recommended during learning curve and if a prolonged operating time is expected or in the presence of a recurrence in which the urinary bladder could be involved.

34.3.1 Pneumoperitoneum

The establishing of the pneumoperitoneum enlarges the preexistent virtual abdominal cavity and offers from the very start a spacious working environment.

There is no definitive evidence that the open-entry technique for establishing the pneumoperitoneum is superior or inferior to the other techniques currently available (level 1A).

The open access should be utilized as an alternative to the Veress needle technique, especially in patients after the previous open abdominal surgery (grade A) [11].

The pneumoperitoneum is established at a CO_2 gas pressure of 12 mmHg. A 10 mm 30° optic is normally used.

The exploration of the abdominal cavity allows the inspection of the anatomy of both sides of the groin, the real type of hernia, and the content of the sac, if it is an incarcerated hernia.

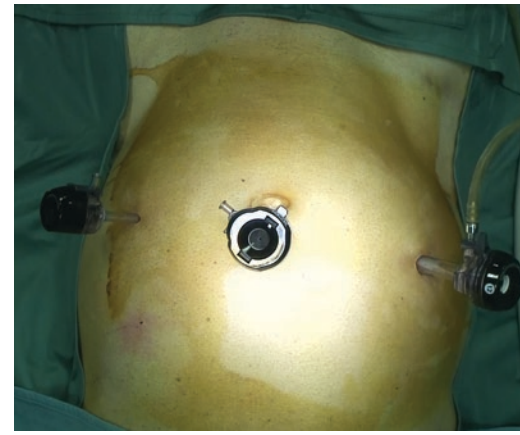

Fig. 34.2 Trocar placement: optical trocar at umbilical site, a 10 mm trocar at the right side along the lateral medio-clavicular line, 5 mm trocar at the left side along the lateral medio-clavicular line

34.3.2 Trocar Placement

The lateral working port is always inserted under direct vision. The radially dilating trocars cause less acute injuries, like bleeding, and less chronic tissue damage that could result in trocar hernias (level 1B) [11]. The cutting trocars should be avoided (grade A) [11]. If a bilateral hernia repair is expected, a 10 mm trocar is placed at the right side along the lateral medio-clavicular level of the umbilicus level and 5 mm trocar at the left side along the lateral medio-clavicular level at the umbilicus level (Fig. 34.2). Otherwise, in case of unilateral repair, the trocar at the opposite side of the hernia can be placed slightly caudally, allowing a more ergonomic position for the surgeon. The 12 mm trocar is necessary for mesh introduction and hemostatic clip dispenser.

When the trocar placement is completed, both the first surgeon and camera assistant stay at the opposite side of the hernia, and the patient is placed in a head-down position and slightly turned toward the surgeon.

34.3.3 Dissection

With a blunt grasper in the left hand and an electrified scissors in the right hand, the preperitoneal

space is entered through a planned incision of the visceral peritoneum 3–4 cm above the visible hernia defect; the incision is not tailored to hernia type and size (Fig. 34.3): a wide incision in the peritoneum is recommended to achieve broad and clear access to the preperitoneal space from the anterior superior iliac spine (ASIS, considered the first landmark of the procedure) to the medial umbilical ligament (MUL), which does not have to be transected. If more space is needed, a cranial extension of the peritoneal incision parallel to the MUL may be helpful.

The preparation of the peritoneal flap starts laterally in a fairly avascular plain, and it is supported by the "pneumodissection" of CO_2 gas under pressure (Fig. 34.4). Here it is important that the grasper in the left hand pulls in the right way. We are entering the space of Bogros. Crossing the epigastric vessels in a medial direction (second landmark), the endoabdominal fascia may continue being a solid barrier which must be entered to reach another spiderweb-like compartment—the space of Retzius.

These two anatomical spaces are not a continuation of each other, because they are not on the same level [12].

Further dissection deeper and medially finds the Cooper's ligament (third landmark, Fig. 34.5) and the superior pubic arch until the landmark of the symphysis pubis (Fig. 34.6). In case of a bilateral inguinal hernia repair, meshes should meet on the symphysis pubis.

Caudal and lateral of the onset of epigastric vessels and the inner inguinal ring, the figure of "A" is encountered (Fig. 34.7). The medial arm is the vas deferens complex and the lateral one the spermatic vessels. This region is often called "doom triangle" (because of underlying extern iliac vessels). Medial to the spermatic cord, a vascular anomaly of arterial or venous corona mortis (or both) anastomosis between the iliac and the obturator vessels can be found in about 20% of the population.

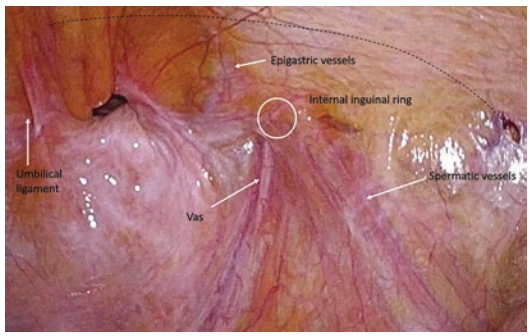

Fig. 34.3 Right inguinal region with landmarks. Incision line is dotted. Direct inguinal hernia is present

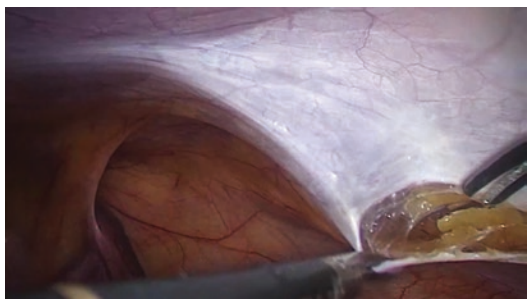

Fig. 34.4 Preparation of the flap in the right inguinal region

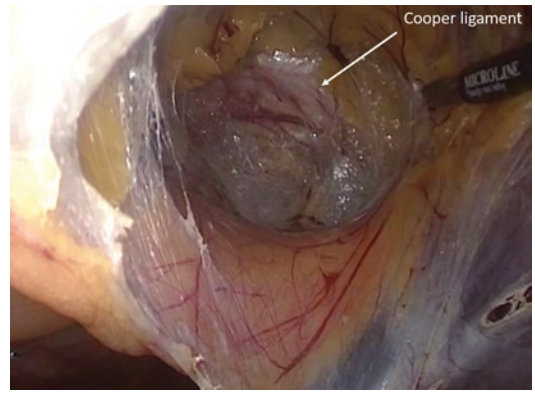

Fig. 34.5 Identification of Cooper's ligament

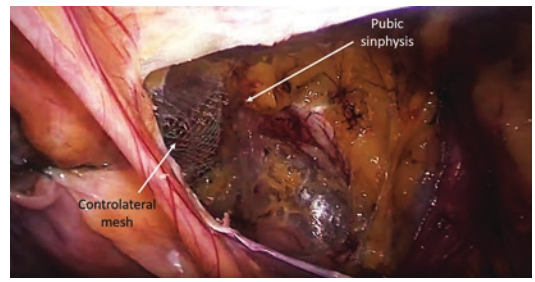

Fig. 34.6 Right inguinal side: the dissection of Cooper's ligament is complete, and now the mesh placed on the contralateral side is reached

The femoral canal is encountered between the iliopubic tract, Cooper's ligament, and external iliac vein.

Lateral of the onset of epigastric vessels, the top of figure "A" enters the inguinal canal. Lateral of the spermatic vessels, a fat pad covers some nerves of the lumbar plexus (the genitofemoral nerve, the lateral femoral cutaneous nerve, and the femoral nerve). This area is called "pain triangle" (Figs. 34.8 and 34.9).

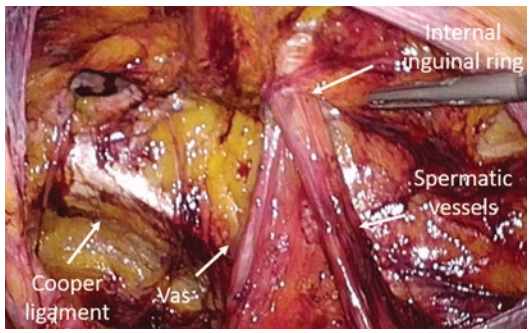

Fig. 34.7 The dissection is complete, and the figure of "A" is encountered

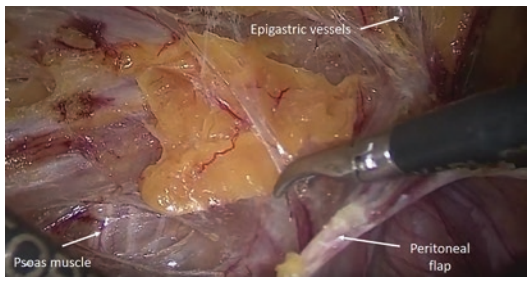

Fig. 34.8 Dissection proceeds laterally in the left inguinal region: psoas muscle is identified with nerves running on it

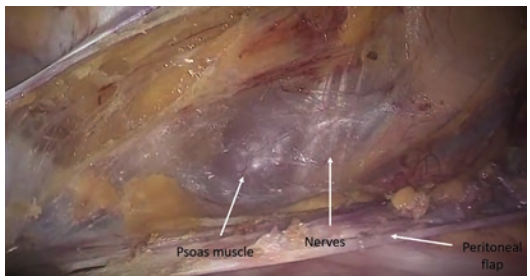

Fig. 34.9 Psoas dissection is complete: iliohypogastric, ilioinguinal, and genitofemoral nerves are visible

In case of insecurity during the dissection, the TAPP technique allows the immediate view of intraperitoneal structures behind the flap, thereby avoiding possible sectional or thermal damage.

Whereas dissection of a direct hernia sac is a simple procedure, dissection of an indirect sac may be very difficult. The following steps are recommended: first, complete dissection of the spaces of Retzius (medial) and Bogros (lateral). Second, remove all adhesions between the hernia sac and other structures, including the spermatic cord and vessels (Figs. 34.10, 34.11, 34.12), the epigastric vessels and the external iliac vessels.

Cord lipomas or lipomas in the femoral canal may mimic a hernia recurrence, and for this reason, they should be dissected (level 2C) [11].

If dense adhesions to the cord structures are present in a long hernia sac, the sac may be transected at the level of the inner inguinal ring in order to prevent injury to the cord structures (grade D) [11].

The incidence of seromas in direct hernias can be significantly reduced when the lax transversa-

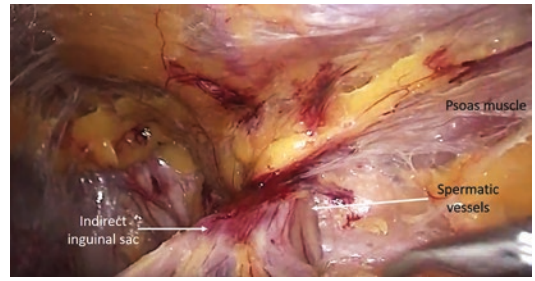

Fig. 34.10 During the dissection of an indirect inguinal sac, spermatic vessels are recognized

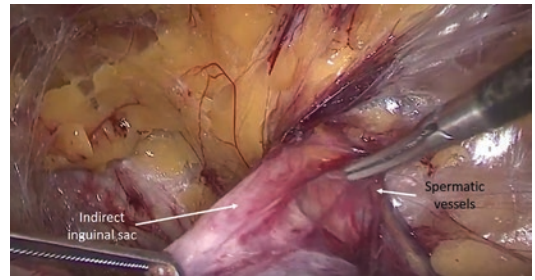

Fig. 34.11 Smooth dissection between indirect inguinal sac and spermatic vessels

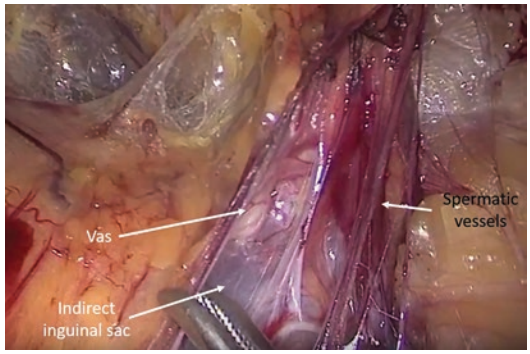

Fig. 34.12 The same procedure in Fig. 34.10 and Fig. 34.11. Dissection proceeds and vas appears medially to spermatic vessels

lis fascia is inverted and fixed to Cooper's ligament (level 2B) [11].

The dissection of the upper flap can be easily performed bringing it with a grasper in both hands and overturning toward cranial direction.

A complete anatomical dissection of the pelvic floor is completed if a flat and wrinkle-free placement of the mesh is possible.

34.3.4 Mesh Placement

Once the correct extent of the landing zone is achieved and hemostasis is secured, an adequate mesh is inserted. Based on the hypothesis that heavyweight mesh could be involved in postoperative pain, surgeons assisted in the last 15 years to a slight trend to reduce the material amount, using large-pore and so-called lightweight meshes. However, a clear recommendation cannot be made based on currently published RCTs [13]. Two of the three meta-analyses found no significant differences in terms of early postoperative pain, recurrence rate or return to work [14, 15]. The reduced incidence of chronic groin pain is only in one meta-analysis [16] significantly lower after low-weight mesh implantation.

We usually choose a lightweight synthetic mesh (ENDOLAP® by DynaMesh or ULTRAPRO® by Ethicon).

According to the EHS [17] and the IEHS guidelines [11], today "adequate" mesh size means a 15 × 10 cm or larger mesh. Less than 2–3 cm of mesh overlapping the hernia openings may lead to a protrusion of the mesh into the defect. The larger is the hernia opening, the more overlap there should be. In large direct defects, the danger that the mesh will protrude into the opening is increased (level 4) [11]. We usually smooth out all the corners.

According to the register-based (Herniamed) analysis of more than 10,000 cases [18], the only highly significant factor impacting onset of recurrence following TAPP for primary unilateral inguinal hernia repair in men is a medial or combined hernia. That finding is also confirmed in the systematic review by Burcharth et al. [19]. Therefore, the requirements for adequate overlap in patients with this type of hernia are more stringent.

We usually roll up the mesh along the long side, and we insert it by the lateral 10 mm trocar with a grasper. It is advisable to maintain the mesh with the grasper until it is placed beyond the peritoneal flap previously prepared (Fig. 34.13), so in the preperitoneal space, only in that moment, one grasper keeps the superior edge of the mesh in the correct position, and the second grasper unrolls down the mesh (Fig. 34.14).

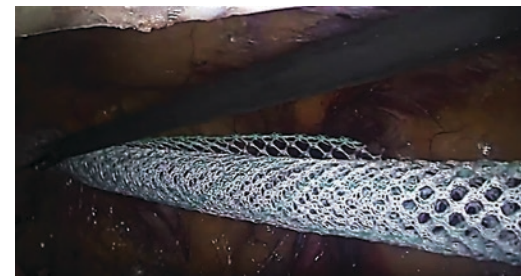

Fig. 34.13 Introduction of the mesh

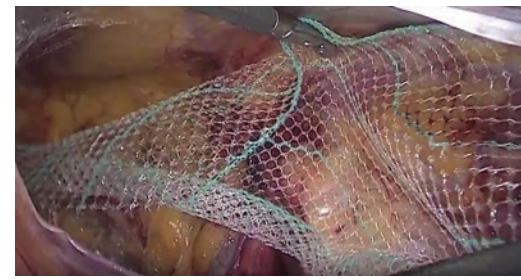

Fig. 34.14 The mesh is unfolded

The mesh should be placed wrinkle- and fold-free respecting the well-defined anatomic landmarks. Especially the inferior mesh margin has to show a security distance from the lowest lateral dissection area of the "landing zone" in order to prevent its lifting up when closing the peritoneum.

34.3.5 Fixation

This step is still controversial. There is an evidence-based insight that not all preperitoneal hernia repairs require a mesh fixation. In fact, preperitoneal mesh placement works according to the physical law of Pascal; thus, fixation does not compensate for inadequate mesh size or overlap.

Moreover, mesh fixation to the underlying structures of the landing zone by tissue penetration is to be avoided due to the risk of damaging vessels and nerves.

Fixation and non-fixation of the mesh are associated with equally low recurrence rates; however, in most studies, the hernia opening was small (<3 cm) or not measured. Consequently, non-fixation could be considered in type LI and LII and MI and MII hernias (EHS classification) [20] (grade B). For TAPP repair of big defects (LIII, MIII), the mesh should be fixed (grade D).

According the paper previously cited [18], in case of a large medial or combined hernia, fixation of the mesh is needed, and the type of fixation does not impact the recurrence rate.

We are used to fix the mesh in any case with fibrin glue (Fig. 34.15) or cyanoacrylate. There are some types of self-fixating meshes (e.g., ProGrip, Medtronic, made with monofilament polylactic acid (PLA), reabsorbed in 18 months; and Adhesix mesh, Bard Davol, covered by a layer of self-adhering reabsorbable glue).

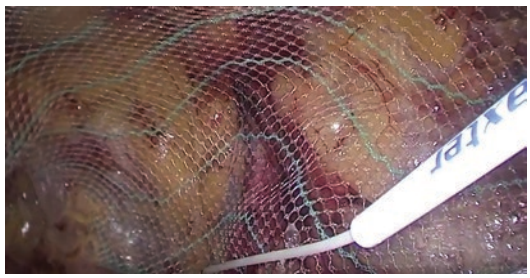

Fig. 34.15 Fixation of the mesh with fibrin glue

34.3.6 Peritoneal Closure

Meticulous running suture of the peritoneal flap prevents any contact of prosthetic with the intestinal loops and avoids any obstructive event based on incarceration or strangulation within a defect in an incomplete closure. We are used to perform this running suture with a self-locking suture (V-lock 2/0), from lateral to medial, with reverse needle in the right hand, taking first the lower flap and then the upper flap, so that with a single gesture, it is possible to take both edges (Fig. 34.16).

34.3.7 Closure of the Trocar Incisions

The trocars are extracted under vision as in any laparoscopic procedure, and the working ports of 10 mm or more can cause trocar hernias and therefore should be closed in layers [11].

34.3.8 Antibiotic and Thromboembolic Prophylaxes

According to the International Endohernia Society guidelines [11], antibiotic and thromboembolic prophylaxes for elective laparoscopic inguinal hernia repair are not universally recom-

Fig. 34.16 Closure of the peritoneal flap with running suture

mended. Antibiotic prophylaxis is recommended only in the presence of risk factors for wound and mesh infection based on patient (advanced age, corticosteroid usage, immunosuppressive conditions and therapy, obesity, diabetes, and malignancy) or surgical complications (contamination, long operation time, drainage, urinary catheter). Despite this, we normally give a one dose of cephalosporin at general anesthesia induction.

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Biological Prosthesis in Inguinal Hernia Repair

35

Stefano Lafranceschina, Fausto Catena, Luca Ansaloni, and Mario Testini

35.1 Introduction

Hernia surgery has developed significantly during the two last decades. The main improvement has taken place in the use of tension-free repair techniques based on the use of alloplastic, nonabsorbable prosthetic materials [1–3]. It brought a significant reduction in postoperative pain degree and recurrence when compared with the older non-prosthetic hernioplasties [3]. This leads to define the characteristics of the ideal mesh for repair of the inguinal hernia defects: strength, ease of manipulation, biocompatibility, resistance to adhesion formation, low seroma formation and a low susceptibility to infection [2].

Over the years, we have been widely using nonabsorbable meshes made of polypropylene (PP), expanded polytetrafluoroethylene, polyester and lightweight PP or a combination of these materials [4]. Permanent synthetic meshes have been used in clean wounds with excellent long-term results, low recurrence rates and low infectious complications [4]. In addition, indications for mesh inguinal hernia repair are well established and widely diffused [5]. However, controversies still exist about the indication in using the different materials and principally about the biological ones [5]. Furthermore, potential or certain contamination of the surgical wound poses a dilemma as the use of nonabsorbable synthetic material historically is considered contraindicated, given the risk of postoperative infectious complications and need for mesh removal. The introduction of biological prosthesis (BP) has provided an alternative. Either allograft or xenograft, BP might be better able to tolerate bacterial contamination and have a lower incidence of surgical site infection. Multiple reports on their use in abdominal wall repair have been made [1], even if large-scale studies are still needed [2].

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35.2 Biological Prosthesis

35.2.1 Features

More than a dozen of BP are currently available (Table 35.1). All of them derive from human or mammalian tissues [5]. These materials are all essentially composed of an extracellular matrix stripped of its cellular components and differ in their source [6].

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Table 35.1 Biological prosthesis currently on the market

Name	Manufacturer	Tissue source	Material	X-linking
AlloDerm	LifeCell	Human	Acellular dermis	No
AlloMax	Bard	Human	Acellular dermis	No
Flex HD	Ethicon/MTF[a]	Human	Acellular dermis	–
DermaMatrix	MTF[a]	Human	Acellular dermis	No
Permacol	Covidien	Porcine	Acellular dermis	Yes
CollaMend	Davol/Bard	Porcine	Acellular dermis	Yes
Strattice	KCI/LifeCell	Porcine	Acellular dermis	No
XenMatrix	Brennan Medical	Porcine	Acellular dermis	No
Surgisis	Cook	Porcine	Small intestine submucosa	No
Surgisis Gold	Cook	Porcine	Small intestine submucosa	No
Lyosis	Cook	Porcine	Lyophilized small intestine submucosa	No
FortaGen	Organogenesis	Porcine	Small intestine submucosa	Yes
SurgiMend	TEI Biosciences	Bovine	Foetal dermis	No
PeriGuard	Synovis	Bovine	Pericardium	Yes
Veritas	Synovis	Bovine	Pericardium	No
Tutomesh	Tutogen	Bovine	Pericardium	No
Tutopatch	Tutogen	Bovine	Pericardium	No

[a]MTF: Musculoskeletal Transplant Foundation

In contrast to current nonabsorbable prosthetic repairs, where the prosthesis is intended to strengthen the defect lifelong, the extracellular matrix of BP implanted into the host has a direct strengthening function only initially. Subsequentially, the matrix is gradually degraded while inducing neovascularization and colonization by host cells that progressively cause a site-specific remodelling process until the reconstruction of a new and mature autologous fascia is complete. Eventually, this mature structure restores the original supportive function of the abdominal wall [6].

BP implants would act as a scaffold inside which the host tissue cells and fibroblasts can replicate. They also provide resistance to tension and stress by supporting the abdominal wall until it is fully recovered. Times of remodelling range between few months and few years [5]. It depends on prosthesis characteristics and host tissue properties. One of the problems of using them is that surgeons have not widely assumed the capability to manage BP: the way to consider them should be completely different from current nonabsorbable synthetic repair. These last ones are considered as a "patch applied on the hole"; essentially they trigger a foreign body host response leading to encapsulation of the prosthesis with intense fibrous reaction. On the contrary, BP activates a remodelling process in which the host remodels the prosthesis and his own tissues by producing new healthy tissue [5].

35.2.2 Cross-Linked and Non-Cross-Linked

BP, independent from the origin, could be basically divided into two main classes: cross-linked and non-cross-linked. The partial remodelling (cross-linked) prosthesis is made of porcine or human dermal collagen and bovine pericardium collagen. The complete remodelling (not cross-linked) is principally made of swine intestinal submucosa, swine dermis, human dermis, bovine dermis and bovine pericardium.

Each type of mesh encourages host tissue ingrowth, but different meshes can feature different clinical attributes. Thanks to the chemical cross-linking between the collagen chains, the presence of additional linkages strengthens cross-linked prosthesis, reduces the efficacy of bacterial and host collagenase enzymes and improves the resistance to mechanical stress for a longer period. This is important especially at the weakest moment of the remodelling process, when there coexists a minimal strength due to advance prosthetic degradation and

only minimal initial remodelling process, although in case of infection, an increased collagenase production might enhance prosthetic degradation and cause an early graft failure. In order to increase early graft stability and induce a more organized collagen deposition, cross-linked BP is used; but the prolonged presence of chemically linked collagen molecules might influence the remodelling process bringing prosthetic encapsulation [6]. These differences in remodelling times should be kept in mind when these materials are chosen for abdominal wall repair [5]. On the other side, non-cross-linked materials allow a faster integration, resorption, degradation and reduce foreign body sensation compared to cross-linked devices [7]. Another factor that should be kept in mind is that non-cross-linked material exhibits more favourable remodelling characteristics [5]. Regardless of the type of BP used, at initial remodelling process, it has been demonstrated that fibrin sealant improves the often poor implant integration [7].

35.2.3 BP Physiopathological Process Compared to Synthetic Meshes

The use of nonabsorbable prosthetic materials such as polypropylene, polyester and ePTFE has hence expanded and is now widely used in reparative surgery for abdominal wall hernias [3]. When implanted, these nonabsorbable materials, although extremely biocompatible, stimulate a foreign body reaction within the host. After the initial inflammatory phase, the reaction is followed by an intense deposition of nonspecific fibrotic tissue and concluded by a permanent encapsulation of the alloplastic material in the host's tissues. In particular PP meshes stimulate a foreign body reaction, producing an intense deposition of nonspecific fibrotic tissue that concludes with permanent encapsulation of the alloplastic material in the host's tissues. These physiopathologic bases explain the successful use of PP mesh in hernia surgery. The complication rate, including intestinal obstruction and fistulization, is low when PP is placed in direct contact with abdominal viscera. The infection rate is also low; in addition, foreign body sensation, postsurgical pain and long-term discomfort are decreased over the years using PP. If these are the physiopathological bases that explain the success of alloplastic nonabsorbable prosthetic materials in hernia surgery, they are also the reasons why complications such as infections, foreign body sensation and chronic pain require the use of different materials to be solved [3]. On these basis, new materials have been sought through different physiopathological mechanisms to overcome these complications: first the biosynthetic meshes and second the biological ones [8].

35.3 Which Kind of BP to Use?

A diagram to simplify the decisional process in using BP has been elaborated by the Italian Biological Prosthesis Work-Group (Figs. 35.1 and 35.2). It keeps into consideration the different kinds of BP, the infection of the surgical field and the tissue loss. The diagram suggests the type of BP that should be used by combining these three variables together [5].

35.4 Complications

The complexity of hernias could derive from contamination/infection, tissue loss, dimensions, anatomic position and clinical or pharmacological data. The introduction of tension-free techniques, thanks to the use of prosthetic materials, has greatly facilitated the duty. On one hand, prosthetic techniques have been demonstrated to reduce the recurrence rate; on the other hand, they introduced a series of new variables to take into consideration prosthetic infection, chronic pain, shrinkage, adhesion formation, dislocation, fistula formation and skin erosion that complicate the decisional process. The introduction of resorbable materials has completely changed the way to face the abdominal hernia surgery, and BP introduced the tissue engineering in the surgical practice [5]. Some of these complications have been reduced especially in several fields. On the contrary, it has

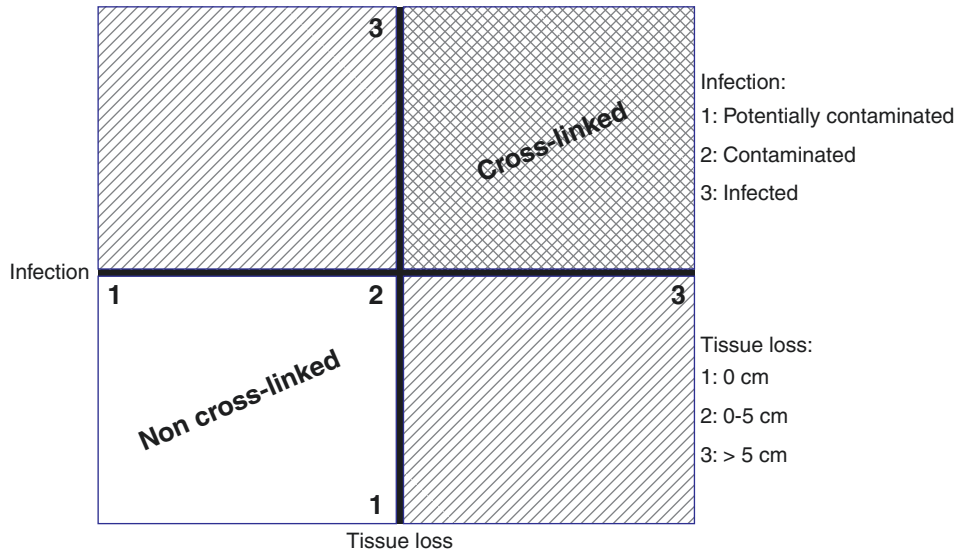

Fig. 35.1 Decisional model diagram: the product of the infection and the loss of tissue scores gives as a result the value which indicate the kind of biological prosthesis to use

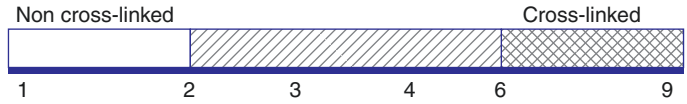

Fig. 35.2 Decisional line: the different results indicate the kind of biological prosthesis to use

been demonstrated that BP durability has a direct impact on the recurrence rate [5, 9]. However, durability depends on the implant intrinsic properties and also on the environment into which the BP are placed [5]. Furthermore, the recurrence rate in BP can be attributed to the inexperience of surgeons: it suggests that a biologic repair might require some added technical skill and experience [9]. Moreover, it has been shown that the use of BP extends the operating times, thus also resulting in an increase in costs. All this goes together with the evident difference in cost between using a BP and synthetic ones [7, 9]. It should be noted that only the recurrence rate is registered as outcome in almost all studies. Other data regarding the use of BP as wound classification, contamination risk/grade, associated therapy or comorbidity are seldom reported. These data are needed to completely assess the usefulness, the efficacy and the versatility of BP. All reported data are derived by retrospective uncontrolled series of limited number of patients, and the methodology is seldom reported and/or poorly described [5]. Considering the complications, it should be kept in mind that BP has a sensible improvement in bodily pain and decrease postsurgical incidence and degree of discomfort when used in groin hernia repair [5]; and there are a few doubts about the intraperitoneal use of BP from the biomechanical point of view. It has been demonstrated that the best integration is reached if they are placed pre-peritoneally with a greater incorporation and strength, less adhesion area and lower adhesion scores compared with intraperitoneal placement [5]. In the end, compared with synthetic meshes, better biocompatibility is an important advantage of biologic mesh, which theoretically may result in less incidence of complication and limitation in patients' daily activities, even if actually these results require further studies [9].

35.5 Clean Fields

For a long time, synthetic meshes and especially polypropylene represented the gold standard for the treatment of inguinal hernia in clean fields with excellent results, low recurrence rates and low infectious complications. Based on pathophysiological characteristics described so far, BP act as valid alternative to synthetic meshes not only in particular situations as in contaminated fields. It is likely to extend their possibilities of use in uncontaminated fields: the BP remodelling process would be favoured not only by its intrinsic characteristics but also by a less pronounced inflammatory reaction in respect to their use in contaminated fields. These conditions help to limit the collagenase degradation, suffered by BP in the early stages of the remodelling process, and allow a more gradual and physiological reconstruction of the abdominal wall. This option, faced in randomized studies, seems to improve both postoperative pain/discomfort and foreign body sensation without a different short−/medium-term recurrence, without however forgetting the costs of this choice [8–12].

35.6 Contaminated Fields

With increasingly complex procedures being performed across the field of surgery, along with frequent comorbidities, hernia repair in contaminated fields has become a frequent challenge to surgeons [13]. One avenue to combat infections was developed with the introduction of bioprosthetics. With the ability to remodel into native tissue and avoid permanent foreign body presence, biologic meshes were touted as a preferable alternative to permanent synthetic options for contaminated operative fields. With respect to the initial goal of bioprosthetic devices, recent data call into question their "biologic" behaviour and long-term efficacy in these challenging fields [13]. The implant of biologic materials elicits a cascade of events leading to new healthy tissue deposition and prosthesis remodelling. It also allows blood, growth and pro−/anti-inflammatory factors and drugs to reach the surgical field during the first phases of the healing process. This for sure enhances the effect against potential or definite contamination/infection [5]. Furthermore, when associated with bowel resection, BP presents lower incidence in terms of overall morbidity and wound infection rate [2]. Compared with BP, the assumed drawback of synthetic material in contaminated fields has become less rigid as several authors have proclaimed its safe use, particularly using new lightweight synthetic meshes [1]. Despite this, in hernia repair of infected or potentially infected fields and in patients at high risk of developing surgical site complications (i.e. immune-depressed patients), a potential advantage of biologic over synthetic material was even suggested [1, 8, 14].

35.7 Inguinal Sports Hernias

Biologic mesh has been considered for the repair of inguinal sports hernias of young patients, where there is a fear of leaving behind a long-term foreign body [9]. The remodelling process of biologic meshes clears up the low postoperative pain at medium term and the low degree of discomfort, and its features became important for the regular practice of an agonistic activity, where inguinal constraints can be noticeable [8, 11].

35.8 Hernia Repair in Emergency Surgery

Nowadays it is still not likely to find correct indication of mesh implant in emergency hernia surgery: there is still an open debate if to use nonabsorbable prostheses in potentially or truly infected operating fields [3]. Any area, with a possible risk of bacterial contamination, in which surgery is performed (bowel resections, cholecystectomy, operations on the bile duct, parastomal hernias, etc.), is potentially at risk for prosthetic repair. On one side, there is a common consensus on what should be done in evidently contaminated areas such as what occurs in case of peritonitis. In fact the opinion is not to position any kind of nonabsorbable prosthetic material

due to a very high risk of infection. On the other side, it is not demonstrated that there is an increased risk of contamination of the mesh in case that simultaneous operations on the digestive tract are performed (potentially contaminated surgical fields) [3]. Considering all its issues, in emergency hernia repair of infected or potentially infected fields, it is already possible to identify clear indications to the use of BP.

Conclusion

The best operative solution for hernia repair in clean-contaminated and contaminated wounds and in emergency hernia surgery remains not clear. The proposed advantage of BP is that the patient's immune cells can infiltrate the material to defend against the bacterial load and eventually replace the biologic mesh with the host tissue. However, the price of biologic grafts has caused an alarming increase in the cost of abdominal reconstructions [4]. More generally, the use of mesh in contaminated hernia repair remains a hotly debated topic with no clear consensus; furthermore, debate on whether biologic or synthetic meshes offer the safest and most efficacious reinforcement in these scenarios remains active [13]. Actually despite the risk of infections, mesh reinforcement continues to play a critical role in hernia repair in contaminated fields, and biologic materials are often promoted for use in clean-contaminated and contaminated fields [7]. These discrepancies are probably due to the poorness of cases for each single centre, and no definitive evidence-based conclusions could be obtained from the literature. Most surgeons stated that they use BP in "difficult" situations, especially those with contaminated or infected fields [5].

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Inguinal Hernia Recurrence

36

Ivy N. Haskins and Michael J. Rosen

36.1 Introduction

Inguinal hernia repair is one of the most commonly performed general surgery procedures [1, 2]. Despite its prevalence, there is no consensus regarding the optimal approach to inguinal hernia repair [2]. With an estimated recurrence rate of 0.2–17%, there is no doubt that recurrent inguinal hernias have a significant impact on the global healthcare system and that a durable, primary repair is ideal [3, 4]. A thorough preoperative patient evaluation, inspection of all potential locations of a groin hernia, and meticulous surgical technique all contribute to primary repair success. Nevertheless, recurrent hernias do occur, and a general knowledge of the causes for a failed primary repair and surgical approach to recurrent hernias is essential. In this chapter, we will discuss the risk factors associated with inguinal hernia recurrence and the operative approach to recurrent inguinal hernia repair.

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36.2 Risk Factors for Inguinal Hernia Recurrence

There are several patient and operative characteristics that increase the risk of inguinal hernia recurrence. Patient factors include malnutrition, immunosuppression, obesity, diabetes mellitus, and smoking, all of which negatively impact the wound healing process [5]. Significant time should be spent during the preoperative evaluation at minimizing or resolving these patient factors. One method that has been successful in improving preoperative optimization at our institution is engaging patients in addressing their high-risk factors. Previous studies have shown that inguinal hernia recurrence is the most important long-term outcome and measure of success from a patient's perspective [6, 7]. Therefore, instilling a sense of self-responsibility in patients to their surgical outcome often leads to increased motivation to achieve preoperative goals.

Technical errors also increase the risk of inguinal hernia recurrence. Large inguinal hernias, undue tension which leads to tissue ischemia, incomplete dissection of the hernia sac, inadequate mesh size, and wound infection all increase the risk of inguinal hernia recurrence [4, 5, 8–10]. Larger groin hernias stretch and attenuate the surrounding fascial planes to a greater extent than smaller groin hernias. This leads to the incorporation of a weaker tissue during repair of larger hernias as compared to smaller groin hernias [10]. As with other hernia repairs, mesh

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utilization has led to a more durable inguinal hernia repair, which is likely due to a reduction of medial recurrences at the pubic tubercle [4, 9]. However, incomplete coverage of the pubic tubercle or at the internal inguinal ring by prosthetic material can lead to recurrences at these sites. Recurrence at the internal ring can also be caused by improper ligation of the hernia sac [8]. General surgeons must be conscious of these risk factors during inguinal hernia repair operations in order to maximize the potential for successful primary repair.

36.3 When to Repair Recurrent Inguinal Hernias

Despite the fact that a majority of first-time and recurrent groin hernias are asymptomatic at presentation, the long-term teaching has been to repair these hernias due to the perceived risk of associated bowel obstruction and/or strangulation [11, 12]. Further studies are needed to determine the ideal approach to asymptomatic recurrent groin hernias. Nevertheless, we do recommend surgical repair of all symptomatic recurrent inguinal hernias to prevent worsening of patient symptoms and to avoid the associated risk of emergency surgery should these hernias progress to bowel involvement.

36.4 Surgical Approach to Recurrent Inguinal Hernias

The European Hernia Society's (EHS) recommendation for repair of recurrent inguinal hernias is to "modify technique in relation to previous technique. [1]" Although this may seem oversimplified, approaching a recurrent inguinal hernia in a different surgical plane than the original operation leads to the best chance of repair success. The reason for this is twofold. First, surgery in a previously operated field is distorted with scar tissue. Scar tissue complicates the dissection in the inguinal canal and increases the risk for adverse outcomes such as testicular ischemia in a male patient or missing the recurrent hernia sac [3]. Second, the tissue in a healed wound is always weaker than the virgin tissue. This increases the risk for recurrence with each subsequent inguinal hernia repair [3]. Therefore, review of prior operative reports requires scrutiny in an effort to avoid previous operative fields during recurrent inguinal hernia repair whenever possible.

In concert with the EHS, our recommendation for approaching recurrent inguinal hernias can be broadly categorized based on the prior failed surgical approach. Patients with a prior anterior repair (i.e., tissue repair or Lichtenstein repair) should have a posterior approach for repair of their inguinal hernia recurrence. Similarly, patients with a failed posterior approach (i.e., laparoscopic repair or Kugel repair) require an anterior repair for inguinal hernia recurrence. Finally, patients who underwent initial inguinal hernia repair in a bilaminar fashion with mesh in both the anterior and posterior compartments (i.e., Prolene Hernia System repair or plug and patch repair) should undergo repair of their inguinal hernia recurrence with an approach that the operating surgeon has most experience.

36.5 Anterior Approach to Recurrent Inguinal Hernia Repair for Prior Failed Posterior Repairs

The anterior approach to recurrent inguinal hernia repair should be used in patients with previous posterior repairs such as laparoscopic or Kugel-type repairs. The procedure of choice in these cases is a Lichtenstein repair with mesh utilization. The Lichtenstein repair is the ideal anterior approach to recurrent inguinal hernia repair after a prior posterior repair. This is because it utilizes a completely different operative field and allows for the utilization of mesh, two factors proven to decrease the risk of inguinal hernia recurrence [3, 4, 6]. For further details on the Lichtenstein repair, please refer to Chap. 1.

36.6 Laparoscopic Approach to Recurrent Inguinal Hernia Repair After Failed Anterior Repair

The laparoscopic approach to inguinal hernia recurrences should be used following open anterior inguinal hernia repairs. The laparoscopic approach to inguinal hernia repair includes both the transabdominal preperitoneal (TAPP) repair and the total extraperitoneal (TEP) repair. The decision to proceed with a TAPP versus a TEP repair of a recurrent inguinal hernia is based largely on surgeon preference.

The laparoscopic approach to recurrent inguinal hernia repair offers several advantages over the open approach to recurrent inguinal hernia repair which will be discussed. However, it should also be mentioned that a missed cord lipoma is a pitfall of the laparoscopic approach to inguinal hernia repair [13]. Therefore, should patients not have an identifiable groin hernia during laparoscopic exploration, further investigation of the preperitoneal structures should follow to rule out a missed lipoma.

The benefits of a laparoscope approach to recurrent inguinal hernia repair are numerous. Similar to the anterior approach following posterior failure, the laparoscopic approach also allows for an operation through a virgin, unscarred field following anterior inguinal hernia repair failure [3]. Furthermore, the laparoscopic platform allows for visualization of all potential hernia sites, including the femoral and obturator canals. In a study published from the Swedish Hernia Registry, 42% of women with inguinal hernia recurrence actually had a femoral hernia at the time of reoperation [14]. In addition, several other case series have found that 9% of all inguinal hernia recurrences are actually femoral hernias [3]. This underscores the fact that femoral hernias are often overlooked during open inguinal hernia repair due to lack of visualization of the femoral canal. Moreover, the laparoscopic approach to inguinal hernia recurrence may provide for a more durable repair. A previous long-term study by Bisgaard et al. found that the rate of re-recurrence following laparoscopic repair of recurrent inguinal hernia was significantly lower than the rate of re-recurrence following an anterior approach [15]. Finally, the laparoscopic approach offers the other proposed benefits to laparoscopic surgery, including decreased postoperative pain and earlier return to normal activity [3, 16, 17].

36.7 Approach to Inguinal Hernia Repair After Failed Anterior and Posterior Repairs

Re-recurrent inguinal hernia poses a clinical challenge to the surgeon. With each subsequent inguinal hernia repair, weaker fascia and tissue are incorporated into the repair, and the risk of cord injury and testicular ischemia increases [10]. These are real risks that must be discussed with the patient during the informed consent process prior to proceeding with any surgical intervention.

Previous studies have shown that the risk of re-recurrence after laparoscopic inguinal hernia repair is significantly less than the risk of re-recurrence following Lichtenstein inguinal hernia repair [6, 15, 18]. Nevertheless, in high-risk procedures such as re-recurrent inguinal hernia repair, it is most important to be able to perform an operation that addresses the hernia recurrence while keeping the patient safe. Therefore, it is our recommendation that re-recurrent inguinal hernia repair operations be performed with the approach that is most comfortable to the surgeon. In other words, surgeons more comfortable with an anterior approach should perform a Lichtenstein repair, while surgeons who are better versed with the laparoscopic approach should perform either a TAPP or a TEP. Alternatively, a Rives-Stoppa approach to re-recurrent inguinal hernia repair can be utilized. All re-recurrent inguinal hernia repairs are technically challenging and should utilize mesh for reinforcement of the weaker tissue incorporated into the repair due to operation in a previously scarred operative field.

36.8 Special Attention to the Femoral Canal

Indirect inguinal hernias remain the most common hernia in both men and women. Nevertheless, the risk of non-inguinal hernias, specifically femoral hernias, is significantly higher in women [3, 19, 20]. Furthermore, the incidence of femoral hernia repair during presumed inguinal hernia recurrence surgery is significantly higher than at primary groin hernia repair [14, 20]. Although femoral hernias are typically associated with elderly women, femoral hernias following inguinal hernia repair often occur in both middle-aged men and women [20]. The proposed pathogenesis for the increased incidence of femoral hernia following groin hernia surgery is thought to be related to either overlooking a femoral hernia present at the time of the original surgery or the spontaneous development of a femoral hernia postoperatively due to widening of the femoral canal during inguinal hernia repair [19, 20]. As femoral hernias are associated with an increased risk of emergency surgery, bowel strangulation, and postoperative morbidity and mortality, we recommend the routine exploration of the femoral canal during both primary and recurrent inguinal hernia repair operations [20, 21].

Conclusion

Inguinal hernia recurrence remains a common pathology encountered by the general surgeon. Preoperative evaluation and planning must take into consideration modifiable patient risk factors for hernia recurrence and prior surgical approaches to hernia repair. As recommended by the EHS, approach to recurrent groin hernia repair should be different than the original inguinal hernia repair whenever possible. In addition, special attention should be directed to the evaluation of the femoral canal due to the increased risk of femoral hernia diagnosis during presumed recurrent inguinal hernia repair.

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37 Giant Hernia: Hug and TOP Technique

Giampiero Campanelli, Piero Giovanni Bruni, Francesca Lombardo, and Marta Cavalli

37.1 Introduction

Giant inguinoscrotal hernias have been defined as those that extend below the midpoint of the inner thigh with the patient in the standing position [1]. Giant inguinoscrotal hernias, with a significant secondary abdominal cavity, are infrequent in developed countries; nevertheless, on rare occasions, patients visit their clinician after years of neglect and refusing to admit their problem. Even among underserved populations, the incidence of giant inguinoscrotal hernias is less than that of large inguinoscrotal hernias: indeed, this evidences the real distinction between giant and large inguinoscrotal hernias. Giant inguinoscrotal hernias are not only those that extend below the midpoint of the inner thigh when the patient is standing but also those with an anteroposterior diameter of at least 30 cm and a laterolateral diameter of about 50 cm and have been not reducible for more than 10 years (Figs. 37.1 and 37.2).

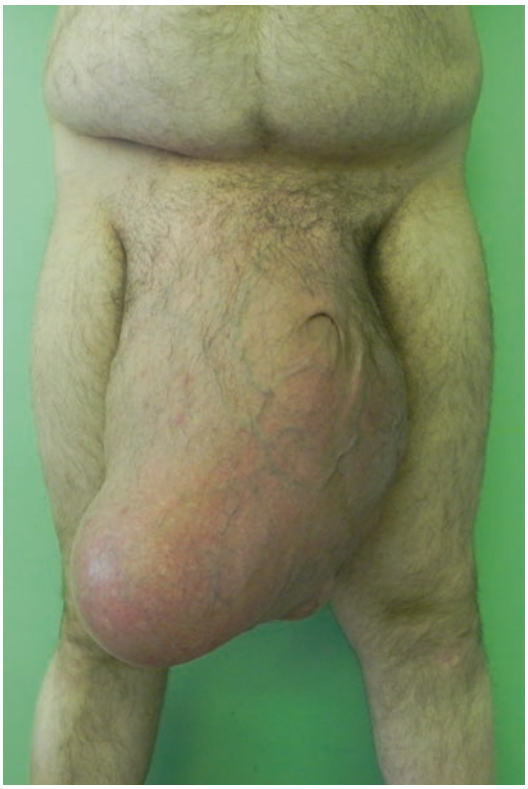

Fig. 37.1 Preoperative image (frontal view): the penis is not visible

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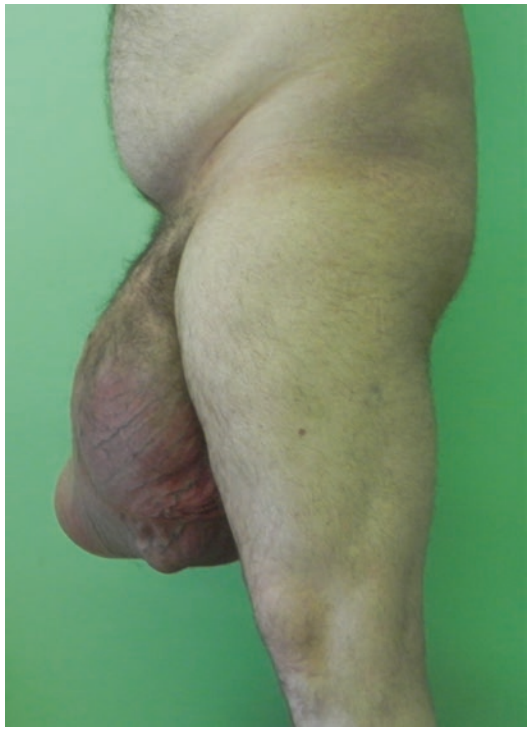

Fig. 37.2 Preoperative (lateral view)

37.2 Clinical Presentation

The size of the hernia often causes difficulty in walking, sitting, or lying down. The penis is frequently buried inside the scrotum, causing urine to dribble over the already distended scrotal skin. This can lead to ulceration and secondary infection. Patients may also complain of difficulty in voiding [2]. Peristaltic movement can be seen through the enlarged scrotal sac. Testes are normally impalpable. Obviously other complications, such as intestinal obstruction and strangulation, are also possible, though rare.

37.3 Literature Review

The surgical management of giant inguinoscrotal hernias can lead to potentially fatal complications [2] as the surgeon is faced with the problem of returning herniated viscera to the abdominal cavity after years of scrotal displacement. Precipitous reduction of hernia contents into the contracted peritoneal cavity may produce changes in intra-abdominal and intrathoracic pressure, potentially precipitating severe cardiac and/or respiratory failure and a compartment syndrome [2–7]. Moreover, reduction under excessive tension places the patient at risk of wound breakdown, with the incidence of wound dehiscence and recurrence of the hernia reported in up to 30% of patients [8].

The restoration of domain has been addressed by various techniques, most of which have originally been reported for the treatment of massive ventral hernias. The first option involves debulking the abdominal contents, i.e., performing an omentectomy, colectomy, or small-bowel resection [2, 5, 9]. Of course, this technique facilitates visceral reduction but can be complicated by peritoneal contamination with visceral and mesh infection [10].

Another technique, described by Moss [6], uses an elemental diet as a means of reducing visceral volume by minimizing intestinal secretions and fecal volume. Although Moss described a decrease in visceral volume of approximately 2 L over a period of 1 month, the efficacy of this technique in extremely large hernias remains questionable.

Induction of preoperative progressive pneumoperitoneum to treat very large hernias with loss of domain was introduced in 1940 by Goňi Moreno [11]. It is usually recommended for giant ventral hernias but rarely for giant inguinal hernias [12–18]. Preoperative progressive pneumoperitoneum (PPP) was recommended for patients with giant loss of domain hernias, including a large amount of viscera in the hernia sac. PPP increases the capacity of the retracted abdominal cavity, achieves a pneumatic lysis of intestinal adhesions, allows the reduction of the hernia contents, and improves diaphragmatic function. PPP also facilitates dissection of the hernia sac and can locate other hernias or weak zones that may not have been evident in the initial examination. Stretching of the hernia sac from PPP has been found to be helpful in skin cleansing before the operation and can potentially decrease the incidence of infections [14–16, 19]. Preoperative

progressive pneumoperitoneum is contraindicated in patients suffering from cardiac and pulmonary insufficiency and abdominal infections, and it requires a prolonged preoperative hospital stay that ranges from 7 to 18 days [13, 14, 20, 21].

Some authors report technical failure of PPP, with air spreading into the hernia sac and only succeeding in expanding the sac with minimal effect on the contracted abdominal cavity [3, 4, 7, 22].

During our nearly 30-year experience, we have designed an original technique [23] for the reduction of viscera, avoiding the sac opening and intestinal resection, with the placement of a not absorbable mesh in the preperitoneal space.

It could be considered an evolution of TOP technique (see Box 1).

Box 1: The TOP technique

Stoppa proposed the open posterior preperitoneal repair for the first time in 1965 [24, 25], under the name of "giant prosthetic reinforcement of the visceral sac" (GPRVS). Later, in 1989, Wantz [26] proposed a similar procedure, differencing from Stoppa technique for a monolateral repair.

In both procedures, a large bilateral Dacron mesh was placed in the preperitoneal space, covering Fruchaud's myopectineal hole with extensive overlap in all directions so that the peritoneal sheet cannot be extended.

The myopectineal hole is the weak spot at which all hernias of the groin begin; it is covered just by the transversalis fascia and includes the Hesselbach triangle, the deep inguinal ring, and the Scarpa triangle of the femoral region [27]. A mesh placed in this space is compressed by the internal abdominal pressure and fixed against the internal abdominal wall, according with the hydrostatic principle by Pascal: when there is an increase in pressure at any point in a confined fluid, there is an equal increase at every other point in the container.

We propose a modified open posterior preperitoneal approach, called TOP (Total Open Preperitoneal) technique, which we usually use for the repair of giant and large inguinoscrotal hernia [23], recurrent inguinal hernia [28, 29], and femoral hernia or in the treatment of postoperative chronic pain [30].

The TOP technique can be done under local, spinal, or general anesthesia (the last one is suggested during the learning curve and obliged for giant inguinal hernia) and requires a suprapubic transversal lateral 5–8 long-incision and 2 cm below the superior-anterior iliac spin (ASIS) [26, 31]. See also Chap. 42.

37.4 Surgical Technique

Before surgery, we require, in addition to standard tests (complete blood count, chest X-ray, ECG), a spirometry, arterial blood gases, and a CT scan of the abdomen.

We usually prepare the patients as we will have for a bowel operation with a colon preparation.

We normally administer double antibiotic therapy (cephalosporins plus metronidazole) as antibiotic prophylaxis at anesthesia induction.

Prior to surgery, patients sign an informed consent, in which orchiectomy and bowel resection were included, in addition to standard surgical risks.

Surgical technique includes the following steps:

1. Single pararectus incision extending from the level of the umbilicus to the groin region and extending down the proximal half of scrotum.
2. Isolation of the entire large sac from the scrotal cavity, taking care not to open the sac (Figs. 37.3, 37.4 and 37.5). Testis is normally hypotrophic and covered with scar tissue, and cord route is not clearly evident (Fig. 37.6), so an orchiectomy is advised.

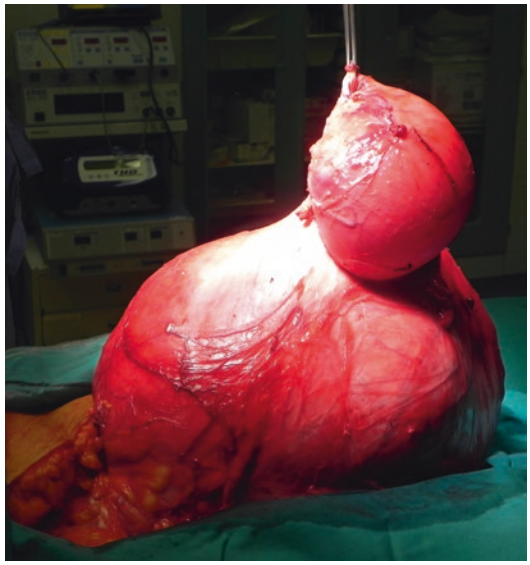

Fig. 37.3 Isolation of the entire large sac from the scrotal cavity

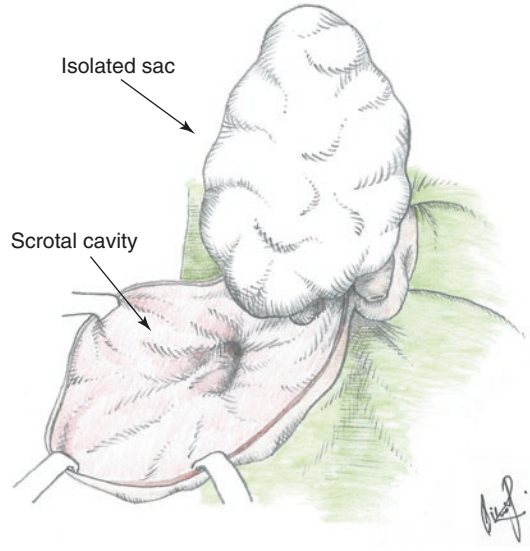

Fig. 37.5 Drawing of isolated sac from the scrotal cavity

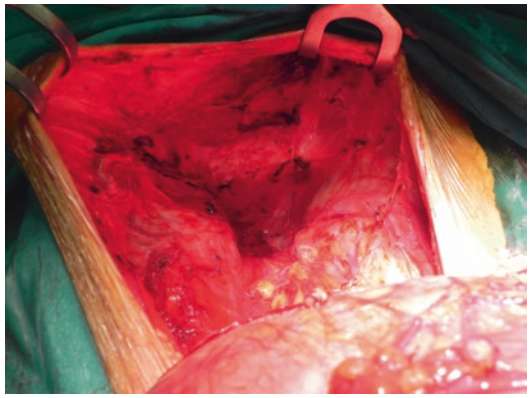

Fig. 37.4 Scrotal cavity after isolation of the entire sac

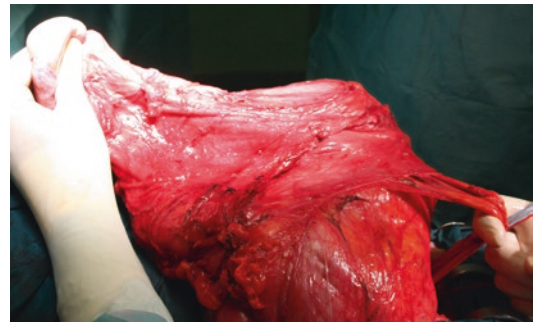

Fig. 37.6 Identification of the testis

3. Opening of the inguinal channel and component separation. Incision of the lateral margin of the anterior rectus sheet, starting at the level of the umbilicus until to the level of the external inguinal ring (anterior component separation). This pararectus incision includes the medial insertions of the internal oblique muscle fascia to the rectus muscle fascia and, behind these, the deep portion of the transversalis fascia (transversus abdominis release, TAR). This separation of the lateral margin of the rectus muscle from the internal oblique muscle at the level of the umbilicus (Fig. 37.7) is continued distally to the internal inguinal ring and below it. At this level the fibers of the internal oblique muscle are completely cut, and the epigastric vessels are separated and ligated (Figs. 37.8 and 37.9). In this way the entire internal ring is cleared, and a complete opening and communication between the posterior and anterior inguinal region are achieved, allowing the preperitoneal space to be approached widely. Practically speaking, the approach to the preperitoneum is achieved through a classical pararectus incision, completed with the section of the epigastric vessels and the internal ring. Just to remind, normally the internal ring is bounded, above

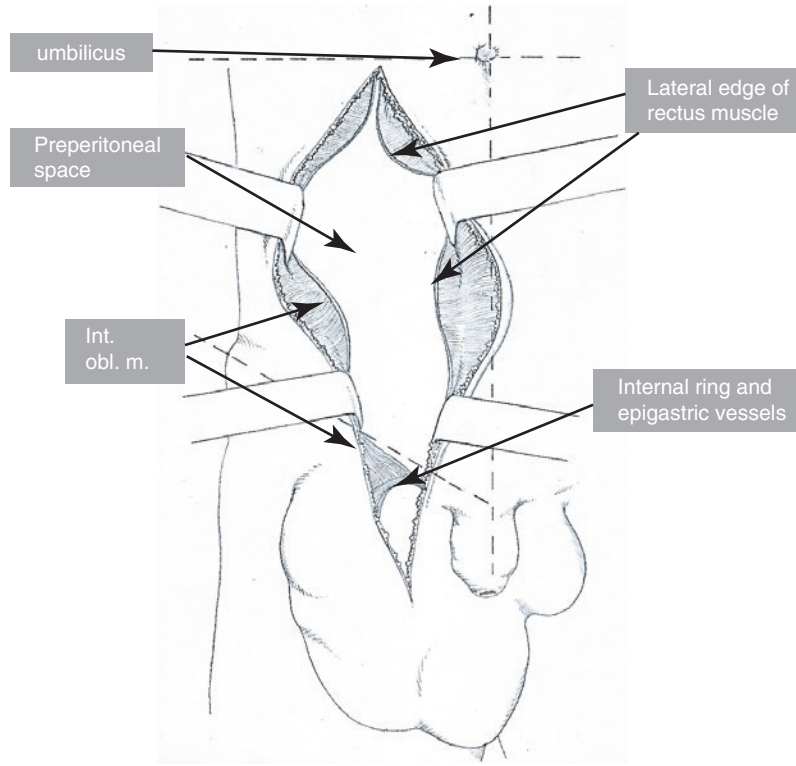

Fig. 37.7 Drawing of the preperitoneal space achieved by pararectus incision. The pararectus incision extending from the umbilicus to the groin region and to the mid-scrotum with the separation between rectus muscle and oblique muscles. The internal oblique at the level of the internal ring and the epigastric vessels in this drawing are not yet separated

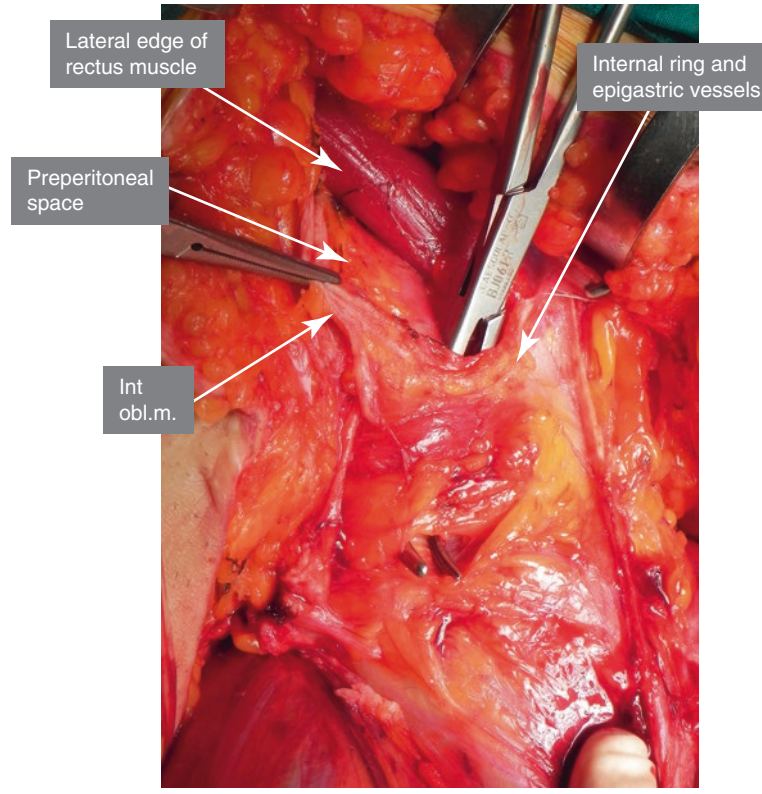

Fig. 37.8 Opening of the posterior wall of the inguinal canal with the clamp below the upper and lower portion of the internal inguinal ring and behind the epigastric vessels. They will be separated in order to achieve a complete communication between the anterior and posterior space

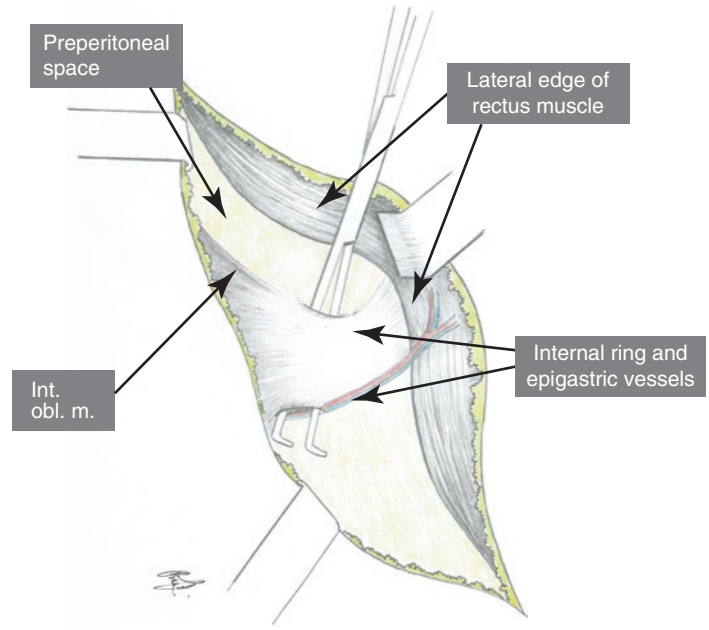

Fig. 37.9 Drawing of complete division of the muscles fibers of the internal oblique and the epigastric vessels

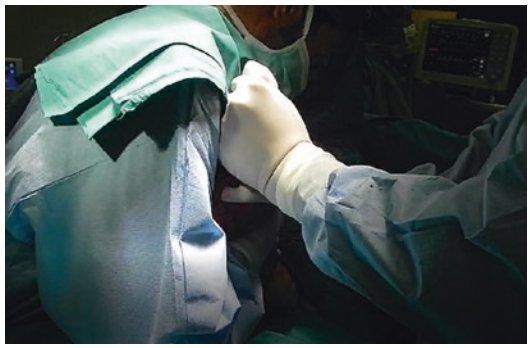

Fig. 37.10 The hug technique

and laterally, by the arched lower margin of the transversalis fascia and the inferior portion of the internal oblique muscle and, below and medially, by the inferior epigastric vessels. It is important to understand that in the giant inguinal scrotal hernia, the anatomy and the anatomical structures of the internal ring are subverted as the fibers of the internal oblique muscle are pushed upward and the anatomical separation between anterior and posterior inguinal region does not exist anymore.

4. Reduction of viscera in abdominal cavity. The hug technique (Figs. 37.10 and 37.11) permits a progressive reduction of the viscera without opening the sac. The surgeon gently embraces the entire sac with his arms inducing a slow, progressive, and continuous emptying of bowel content into the distal portion. In this way, the "volume" of the content inside the jejunal-colonic loops becomes slowly little by little, and all the contents of the sac can be gradually and completely reduced into the cavity. The sac reduction normally requires about 1 h; during this time surgeon should feel abdominal cavity resistance being slowly overcome. The opening of the sac would make the reduction more difficult because the huge amount of free jejunal-colonic bowel would spread across the operating field with constant escape of the other loops once some have been reduced. This situation normally forces then to intestinal resection.
5. Preparation of the space and placement of the mesh. The space behind the rectus muscle, from the pubic symphysis and the contralateral Cooper ligament until the umbilicus, is prepared. The Retzius space, the ipsilateral Cooper ligament, the iliac vein and artery in the Bogros space, the obturator region, and the psoas region are dissected. In this space, an approximately 30 × 30 cm heavyweight polypropylene mesh (Figs. 37.12 and 37.13) is

placed and fixed with nonabsorbable sutures to the fibrous tissue of the internal pubic symphysis and to Cooper ligament (ipsilateral and contralateral). In addition, one absorbable suture is placed in the psoas muscle, and a nonabsorbable transmuscular suture is placed in the rectus muscle. The choice of a heavy-weight mesh is justified by the totally destroyed posterior wall and the wide component separation needed to achieve a sufficiently large preperitoneal space. Once placed, the mesh covers the area from the contralateral retropubic space to the ipsilateral psoas muscle region, from below the umbilicus to the prevesical Retzius space (3–4 cm below the inferior edge of the pubic bone), and it is folded toward the retroperitoneal space in order to achieve a complete reinforcement of the visceral sac. Fibrin glue can be sprayed on the entire mesh surface to better fix it to the wall and to reduce the risk of seroma after the wide dissection.

A drain is normally placed.

6. Abdominal wall closure. First the internal oblique fascia is reapproximated to the inguinal ligament to restore the posterior wall of the inguinal channel. Then the lateral edge of the rectus muscle is reapproximated to the medial edge of the internal oblique muscle. Next is the closure from up to down of the anterior rectus sheath to the internal oblique fascia and finally the closure of the external oblique aponeurosis.
7. Scrotal skin reductive plastic surgery. Starting from the proximal scrotum, two longitudinal incisions are made continuing distally removing from each side 25% of the excess skin, paying careful attention to hemostasis of the subcutaneous Dartos fascia. A running suture

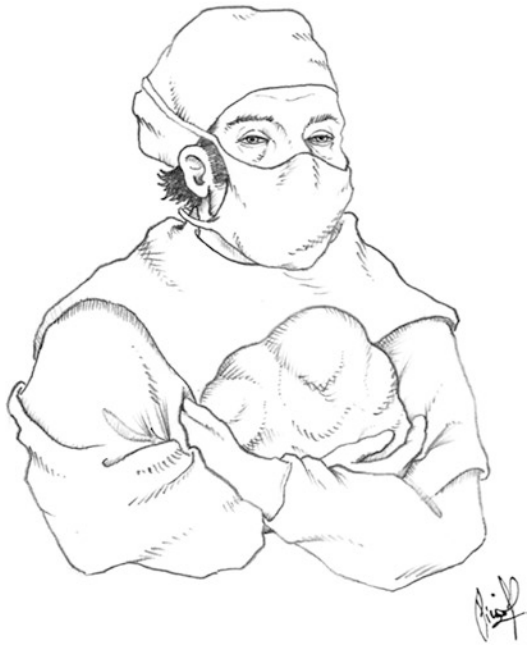

Fig. 37.11 Drawing of the hug technique

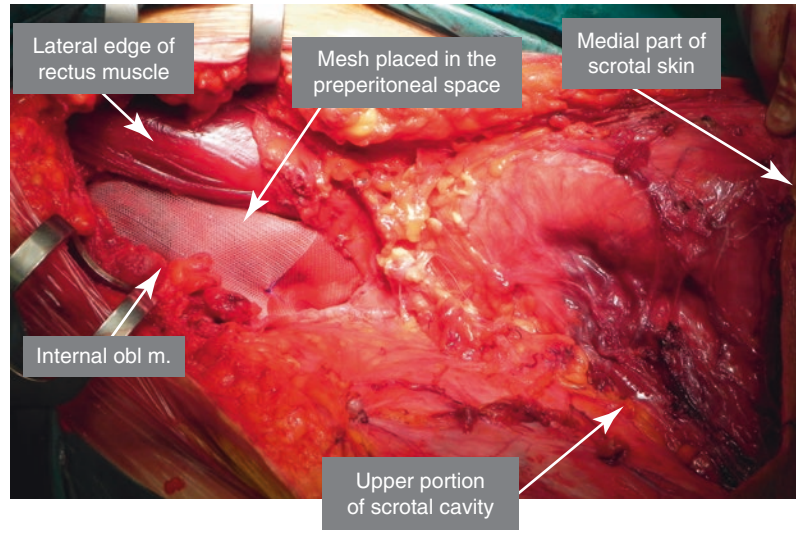

Fig. 37.12 Two polypropylene meshes are sutured together and placed in the preperitoneal space for a total surface of 30 × 30 cm. The mesh is spread in the prepared space toward the contralateral retropubic space from one side and covering all of the psoas muscle on the other side (anterior view)

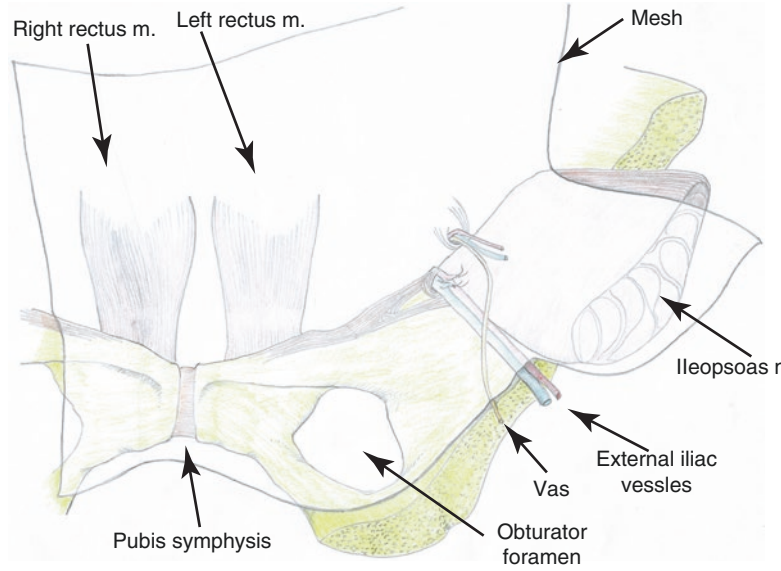

Fig. 37.13 Drawing of the final position of the mesh (posterior view)

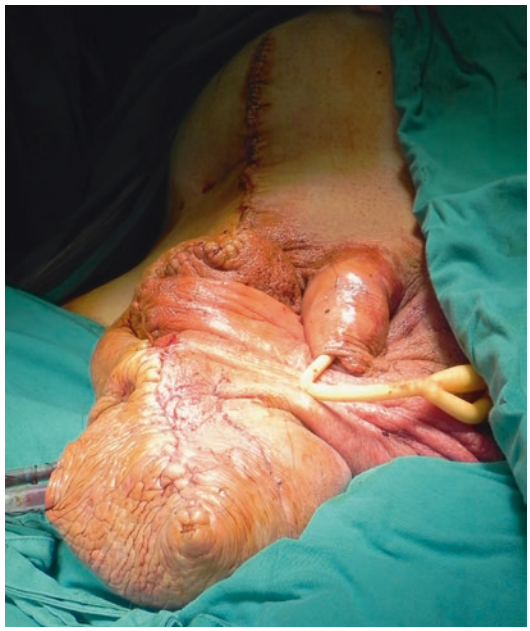

Fig. 37.14 Scrotal size after reductive plastic surgery: the penis is now visible

of all the subcutaneous tissue planes is performed from the distal to proximal scrotum achieving a complete closure of all the cavity and dead spaces. The skin is then closed with interrupted sutures or staples (Fig. 37.14).

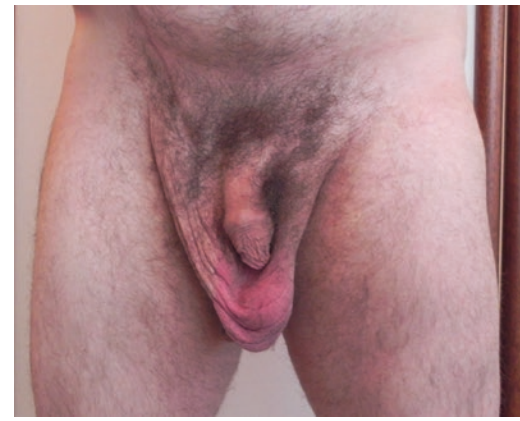

Fig. 37.15 Long-term follow-up

Patients are normally admitted to the intensive care unit for 24–48 h, for prolonged mechanical ventilation and monitoring of their respiratory function. Respiratory physiotherapy must start as soon as possible, after extubation. Liquid diet can be admitted in the second day. Antibiotic prophylaxis is administered for the entire hospitalization. Normally patient is discharged after 6–7 days after surgery.

Figure 37.15 shows one of our patients at long-term follow-up.

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Pubic Inguinal Pain Syndrome (PIPS)

38

Giampiero Campanelli, Piero Giovanni Bruni, Francesca Lombardo, and Marta Cavalli

38.1 Introduction

The pubic inguinal pain syndrome (PIPS) is a controversial condition which presents itself as chronic groin pain. There has been no clear consensus, especially on its nomenclature (sportsman's hernia, inguinal disruption, athletic pubalgia, and chronic groin pain), which has been regarded as difficult to accurately diagnose and manage.

There are many publications on the effect of treatments in athletes with long-standing groin pain but very limited information on acute groin injuries. Only 6% of the included studies were high quality [1].

We have proposed the term PIPS to give a more complete definition; it is a clinical condition where there is often no real hernia, and it frequently occurs in professional athletes but can affect anyone, even a non-sportsman [2].

38.2 Clinical Aspect

Patients affected by PIPS are usually males and the average age at the time of diagnosis is 20–50 years [2–4]. The incidence is between 0.5 and 6.2% and is more common in soccer and ice hockey players where specific activities and stress involve rapid accelerations and decelerations with sudden directional changes [5–7]. Other sports such as cycling and swimming have rare occurrences of this condition as these sports do not have the increased pelvic and torso movements that are known to predispose to a painful groin [8]. Pain can become a serious debilitating condition and may place an athlete's career at risk [9]. Moreover, PIPS can be encountered even in normally physically active people [6, 10, 11].

It is accepted that this chronic pain caused by abdominal wall weakness or injury occurs without a palpable hernia [6, 8]. In PIPS the pain experienced is recognized at the common point of origin of the rectus abdominis muscle and the adductor longus tendon on the pubic bone and the insertion of the inguinal ligament on the pubic bone [7].

The absence of the bulge therefore leads to the need to exclude another pathology prior to the inguinal canal. Multiple coexisting pathologies

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are often present such as posterior inguinal canal weakness, conjoint or adductor tendinopathy, osteitis pubis, and peripheral nerve entrapment syndrome [12].

Anatomy of the groin, although a small area, is rather complex. The inguinal ligament itself arises from the anterior superior iliac spine and inserts into the pubic tubercle, and at the pubic level also arise both the rectus abdominis muscle and the adductor longus tendon. Therefore, there are a number of forces that are either pulling or pushing at the pubic bone, and over time this can present with pain. In addiction the inguinal canal has two congenital weaknesses with the internal and the external inguinal rings [13].

The inguinal area is mainly supplied by three nerves which all come from the lumbar plexus.

The iliohypogastric nerve (L1) pierces the transversus abdominis muscle above the iliac crest and then travels in the neurovascular plane between the transversus abdominis and the internal oblique muscles. It then pierces internal oblique at a variable point along the anterior abdominal wall, eventually passing through external oblique, providing sensory innervation to the suprapubic skin.

The ilioinguinal nerve (L1) similarly pierces the transversus abdominis muscle to travel in the neurovascular plane and then passes through the internal oblique to enter the inguinal canal. It runs with the cord structures and exits the canal via the external ring to provide sensory innervation to the overlying skin of the upper medial thigh, anterior scrotum, and base of the penis (or labium majus and mons pubis).

The genitofemoral nerve (L1–L2) divides into a genital and a femoral branch. The genital branch travels along the external iliac artery and then ascends to meet the vas deferens at the internal ring. Entering the inguinal canal, it becomes part of the spermatic cord lying on its inferior surface with a companion vein. In the male, it passes into the scrotum via the external ring and provides motor innervation to the cremaster muscle and sensory innervation to a small part of the scrotum. In the female, it provides sensory innervation to the mons pubis.

38.3 Diagnosis

The diagnosis of chronic groin pain is difficult due to considerable etiological variability and the fact that most injuries are not identifiable on physical examination or even with specialized imaging.

However, early diagnosis is very important, since morbidity will be reduced. The combination of complex anatomy [5], variability of presentation, and the non-specific nature of the signs and symptoms make the diagnostic process problematic.

There is no evidence-based consensus available to guide decision-making, and most studies available concerning investigation and management are only level IV recommendations at best [6, 10]. Only one randomized, prospective study was conducted on 60 patients with a diagnosis of chronic groin pain and suspected sportsman's hernia. This controlled clinical trial demonstrated that an endoscopic, preperitoneal hernioplasty was more effective than nonoperative treatment for sportsman's hernia [14].

Proper and detailed medical history paying attention to the type and intensity of pain, the time of onset and its correlation with physical activity, its resolution, drugs, and physical therapies, if done, is very important [15]. The history must include questions directed at referred lumbar abnormalities, including back pain, radiculopathy, and sensory disturbances. Urologic information must be gathered, including urinary symptoms and any testicular lumps or masses.

The majority of patients complain of unilateral inguinal pain, often radiating to the pubic tubercle and inner thigh or across the midline, and may recall the specific event that initiated the pain, but more often the onset is insidious. The symptoms are exacerbated by activity such as kicking, sprinting, and forceful, lateralizing movements and relieved with rest [6, 10, 16]. However, the pain returns when these activities are resumed.

Physical examination is the essential step in the diagnosis of groin pain, although symptoms are often vague and diffuse. Meticulous physical examination is so important, first in upright

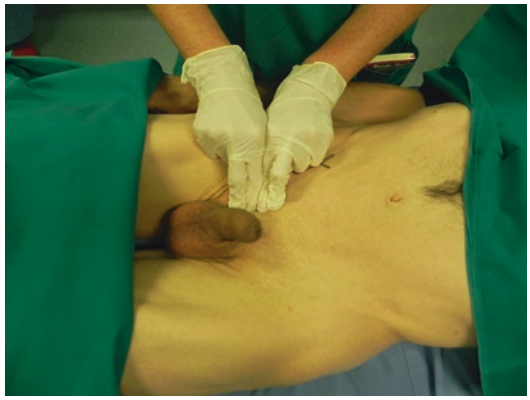

Fig. 38.1 The rectus test: the patient should be lying supine with hips adduced and extended. The test is positive if the patient, while lifting both, feels a keen groin pain

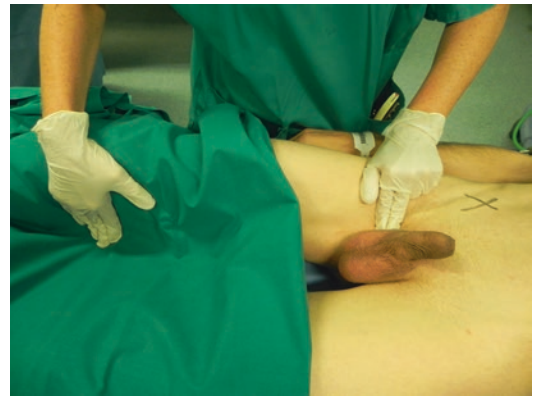

Fig. 38.2 The adductor test: the patient should be lying supine with hips abducted and flexed and with knees flexed at 90°. The test is positive if the patient, while attempting to adduct his legs against pressing in the opposite direction, feels a sharp pain in the groin

position and then in supine position. In upright position, the testis is evaluated and inguinal canal explored: a small bulge of the posterior wall is usually present during coughing or Valsalva maneuver, and the patient often complains of dull and burning pain at this moment, although the absence of a real inguinal hernia is crucial. In supine position, the rectus and the adductor tests are accomplished [15]. The rectus test: the patient should be lying supine with hips adduced and extended. The test is positive if the patient, while lifting both, feels a keen groin pain (Fig. 38.1). The adductor test: the patient should be lying supine with hips abducted and flexed and with knees flexed at 90°. The test is positive if the patient, while attempting to adduct his legs against pressing in the opposite direction, feels a sharp pain in the groin [9] (Fig. 38.2).

The regional examination is crucial for positive and negative findings and to help the differential diagnosis. Findings include tenderness at the pubic tubercle, pain with resisted hip flexion, internal rotation, and abdominal muscle contraction. [6, 10, 16]

The lumbar spine, sacroiliac, and hip joints must be put through a range of motion and examined for tenderness. The symphysis is examined for instability and tenderness, as osteitis pubis is a relatively common entity in the athletic population. Muscle origins, including the rectus femoris and sartorius, are palpated for sites of tenderness, possibly indicating muscle strain. In addition, these muscles are tested against resistance, in an attempt to provoke the symptoms. The testis and rectum should be examined for the presence of masses, and the prostate palpated for tenderness or bogginess. A gynecologic examination may be required in a female patient [6].

Currently there is no consensus on the ideal imaging method for sportsman with chronic inguinal pain.

Inguinal pain due to acute muscular, tendinous, or osseous injuries may be radiologically visualized. Ultrasonography (US) is a useful noninvasive and less expensive imaging modality [17]. It provides information about tendinous injuries allowing to visualize discontinuous fibers within the fibrillary tendon tissue [11]. Dynamic ultrasound scan can be useful to assess the conjoint tendons and inguinal ligament as far as the tendon of rectus for size, integrity, echotexture, and tenderness, detect the presence of a protrusion of the posterior wall, evaluate the symphysis pubis for irregularity and tenderness, and assess the adductor longus origin for size, integrity, echotexture, and tenderness. The common disadvantages of this technique are that it is operator dependent and, therefore, has variable reproducibility.

Direct X-ray may reveal congenital abnormalities such as femoroacetabular impingement,

developing dysplasia of the hip, as well as degenerative conditions of hip-spine-sacroiliac joints. They may also indicate the symmetric bone resorbs in osteitis pubis, sclerosis, and symphysis widening [18].

Pelvic and lumbar MRI should be done to exclude the presence of osteitis pubis and vertebral disease. MRI is superior to CT for musculotendinous imaging, and it should be used always to exclude other copathologies such as vertebral disease.

However, imaging studies are often negative, and the only clinical sign is a deep pain to palpation located near the pubic tubercle and below inguinal ligament at adductor insertion. In such cases, a clinical diagnosis of PIPS can be suspected [11].

38.4 Management

38.4.1 Conservative Treatment

The first line of management includes rest from physical activities for 2 months and inflammatory and pain killing drugs for a week or until complete resolution of the pain. Very important is an evaluation by a physiotherapist to start exercises with the goal of stretching iliopsoas, rectus abdominis and adductor longus muscles. After 2 months, if pain persists when physical activities restart, operative management may be necessary.

38.4.2 Surgical Treatment

Based on available literature, operative intervention is indicated for chronic groin pain refractory to conservative treatments including rest, physical therapy, nonsteroidal anti-inflammatory medications, and nerve blocks [19].

Various operative approaches for groin pain in athletes have been proposed depending on the suspected nature of injury. These operative approaches include methods of hernia repair, tenotomies of muscle tendons close to the pubic bone, transection of inguinal ligament, as well as release or transaction (neurotomy) of nearby nerves [14].

Surgery has been at the forefront of treatment for patients with PIPS. Surgical approach includes various types of open techniques with or without mesh and laparoscopic transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP) herniorrhaphies with mesh. These techniques are the same as those used in the repair of inguinal hernia. Although the results reported in several studies are good, the superiority of either laparoscopic technique or open technique as performed by experienced hands has not been demonstrated to date [20].

A controlled clinical trial demonstrates clearly that an endoscopic, preperitoneal hernioplasty was more effective than nonoperative treatment for PIPS with groin pain in athletes [14]. However, it should be kept in mind that 10% of the patients in this group received preoperative open tenotomy.

Other studies underline the efficacy of TEP technique [20]; it is less traumatic than intra-abdominal or anterior technique. Postoperative pain and wound complication are less as compared to the open technique, and it is characterized by low mobility and rapid return to full sports activity [21]. However, TEP might not be performed due to prostate surgery or previous lower abdominal surgery.

Many surgeons have acknowledged that laparoscopic therapy ensures an effective and quicker return to full sports activity (82–92% of patients in 2–8 weeks) [17, 22].

Other surgeons encourage open minimal repair (OMR) for the posterior wall weakness especially when someone promotes the use of no mesh combined with an early return to sporting activity [18].

Dojcinovic proposed a Shouldice repair with resection of the genital branch of genitofemoral nerve and ilioinguinal nerve neurolysis, and, when adductor tendinosis was present, the complete adductor tenotomy was done [23].

Our approach is based on the etiopathogenetic theory that the situation is caused by three factors: (1) the compression of the three nerves of the inguinal region, (2) the imbalance in strength of adductor and abdominal wall muscles caused by the hypertrophy and stiffness of the insertion

of rectus muscle and adductor longus muscle, and (3) the partial weakness of the posterior wall.

We propose a surgical procedure with the release of all three nerves of the region, the correction of the imbalance in strength with the partial calibrated tenotomy of the rectus and adductor longus muscles, and the repair of the partial weakness of the posterior wall with a lightweight or biological mesh sutureless.

After a blood test, ECG, and chest X-ray, patients are operated on under local anesthesia. No patients received any sedation, so they are able to cooperate during surgery with cough, soft crunch, and leg adduction in order to calibrate the double partial tenotomy of the rectus abdominis and of the adductor longus. The inguinal canal is approached through a transversal inguinal small incision (3–5 cm) [15]. At this step, the iliohypogastric nerve is usually found to be piercing the aponeurosis about 1–2 cm cranially to the medial pilaster of the external ring. The medial pilaster is usually inserted on the pubic tubercle in a stiff manner so that the iliohypogastric nerve appeared stretched. After accurate infiltration of the external oblique muscle aponeurosis, in order to share it from the nerves running below, the inguinal canal is opened.

The cord with the ilioinguinal nerve and the genital branch of genitofemoral nerve often appear pressed between the aponeurosis of external stiff ring and a small bulge of the posterior wall. The rectus muscle tendon generally is tense and contributed to making the iliohypogastric nerve stretch. The tendon of the adductor longus also appears tense and hypertrophic: both tendons are evaluated dynamically during surgery by asking the patients to cooperate with their contraction (crunch and adductor). A little indirect lipoma or sac is often isolated and reduced.

The procedure that we perform is the same on all the patients:

- Partial tenotomy (1 cm) of the insertion of the rectus muscle on the pubis. At this level we find also an interesting intraoperative peculiarity in PIPS: a thickened sheet (lamella) behind the rectus, where normally there should not be any fascia (Fig. 38.3). This atypical finding stresses us to persist in the research on PIPS to understand if this lamella is the result of a fibrotic process that is formed as an effect of a constant stress on the region of tendons insertion on the pubic bone or if this lamella is a genetic predisposition. Dissecting this lamella, the usual yellow preperitoneal fat is seen. The partial tenotomy allows to stretch the rectus muscle and release the iliohypogastric nerve (Fig. 38.4)
- Partial section (1 cm) of the insertion of the adductor longus tendon on the pubis (Fig. 38.5)
- Positioning below the cord a lightweight or biological mesh sutureless or fixed sometimes with fibrin glue in order to reduce the

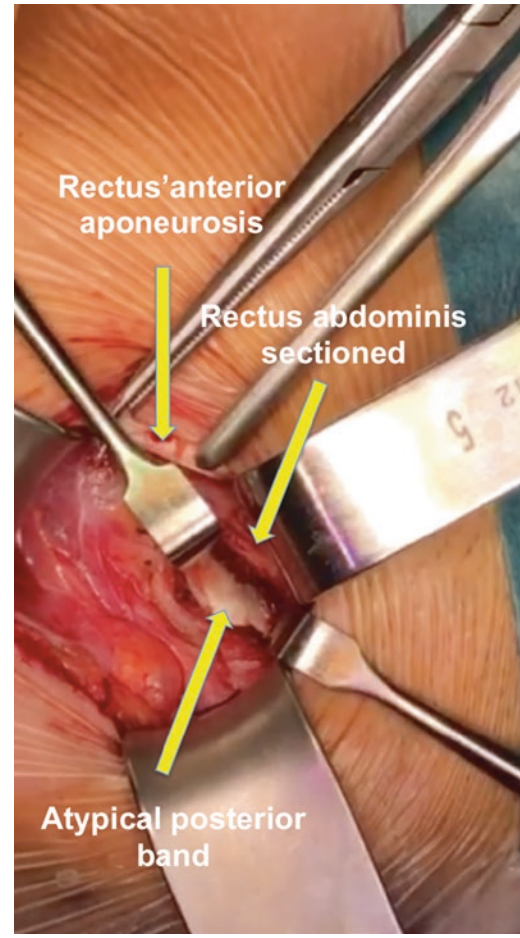

Fig. 38.3 Intraoperative peculiarity in PIPS, thickened posterior sheet to the rectus muscle

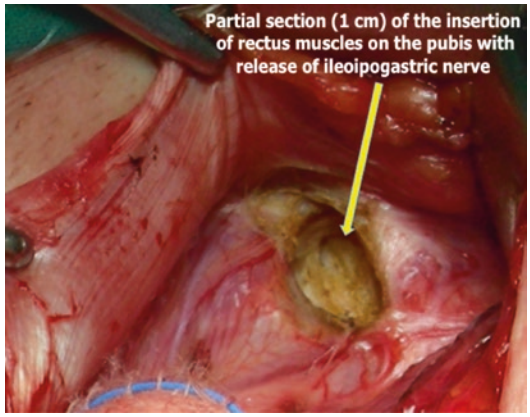

Fig. 38.4 Partial section of the insertion of the rectus muscle on the pubis and of its atypical posterior band in order to stretch the muscle and release the iliohypogastric nerve

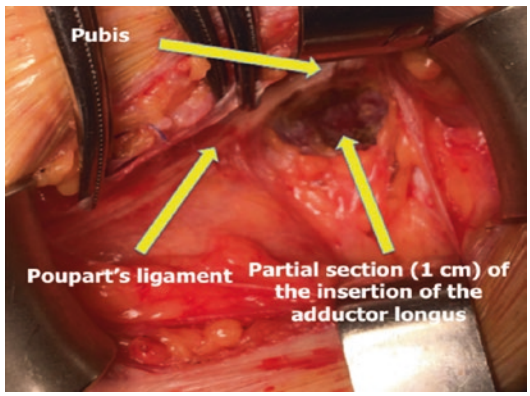

Fig. 38.5 Partial section of the insertion of the adductor longus tendon on the pubis

compression of the cord and nerves by the posterior wall (Figs. 38.6 and 38.7)

– Closure of the external oblique muscle aponeurosis moving the entire cord, together with ilioinguinal nerve and genital branch of genitofemoral nerve in the subcutaneous space (Figs. 38.8 and 38.9)

In this way the nerves were released and the posterior wall was softly reinforced [15].

All the patients are discharged the day of operation or the following day if they live more than 1 h by car or 40 km from the hospital.

Paracetamol or conventional nonsteroid antiinflammatory drugs are used for postoperative

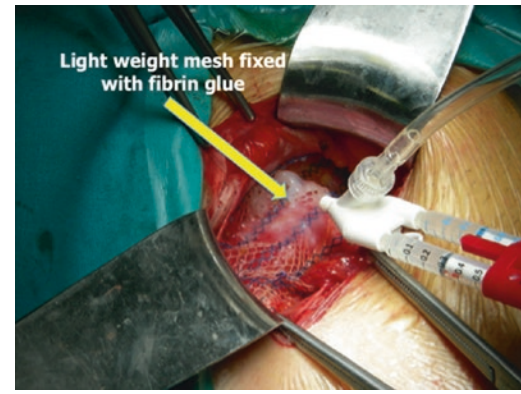

Fig. 38.6 Positioning below the cord a lightweight sutureless fixed with fibrin glue

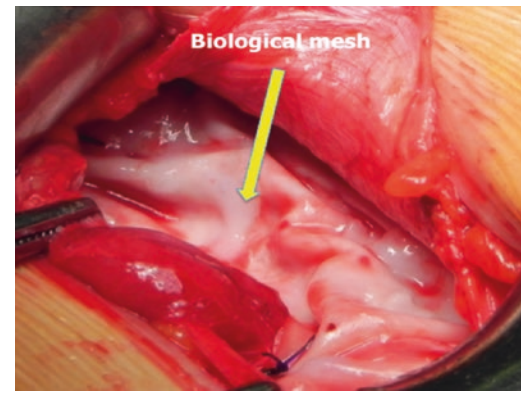

Fig. 38.7 Positioning below the cord biological mesh sutureless fixed with fibrin glue

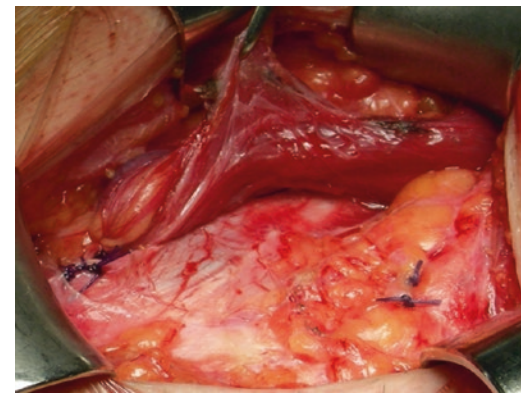

Fig. 38.8 The entire cord with ilioinguinal nerve and genital branch of genitofemoral nerve in the subcutaneous space

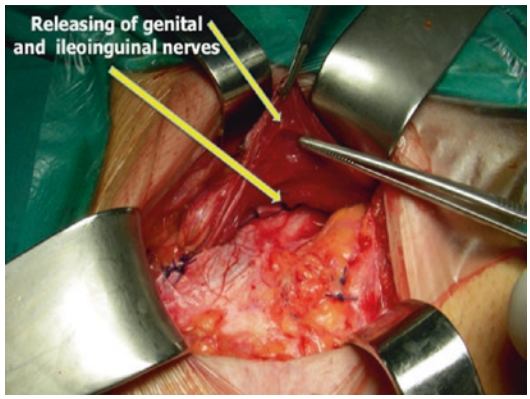

Fig. 38.9 Releasing of ilioinguinal nerve and genital branch of genitofemoral nerve

pain relief. Patients are allowed to resume normal activities the day after surgery except physical exercise and lifting more than 10 kg. They resume FKT after 15 days and sport or physical exercise 1 month after surgery.

This treatment reported excellent results with complete relief of symptoms after resumption of physical activity in more than 90% of cases [15].

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Surgical Emergencies in Inguinal Hernia

39

S. Rocchetti, R. Ariotti, G. Burtulo, and M. Carlucci

Emergency surgery for inguinal hernias is associated with a high risk of postoperative complications as well as increased perioperative mortality rates.

Complicated hernias may have different presenting symptoms such as local or abdominal pain, hernia irreducibility, vomiting, and intestinal obstruction. Different studies showed older patients in the emergency patient groups, usually with higher ASA scores and, sometimes, previous nonsurgical indication due to clinical story or comorbidity.

The most common emergency hernias are inguinal, but emergency femoral hernias need a small bowel resection in a higher percentage of cases.

Although therapeutic management of inguinal hernia allows elective treatment in the vast majority of cases, complications frequently constitute real surgical emergencies; these are represented by incarceration, intestinal obstruction, and strangulation.

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39.1 Definition and Clinical Presentation

39.1.1 Incarcerated Hernia

It is a condition that occurs when the herniary content is no longer reducible into its original cavity (abdomen). It is generally caused by adherence between the hernia content (the sac) and the ring. Usually this condition can occur more frequently when the constricting ring is weak in elasticity and small in size compared to the hernia content, in fact we can observe a higher incidence of incarcerated hernia in femoral hernia than inguinal ones. An incarcerated hernia generally appears as a non-reducible swelling; however, clinical presentation may not always be obvious especially in cases where the hernia is small and/or the somatic constitution of the patient does not allow physical examination. Especially when it occurs acutely (e.g., following a physical effort), the patient can experience intense local pain, and it can be difficult to clinically distinguish incarceration from strangulation. Therefore, the onset of an acute non-reducibility must be treated as an emergency.

39.1.2 Intestinal Occlusion

Inguinal hernia is the second cause of small bowel occlusion (in the United States). It is usually due to accumulation and difficult transit of intestinal

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material inside the hernia bag. This can occur because of compression caused by the collar or for an abnormal rotation of the intestinal limbs inside the sac. This condition can often be solved by reducing the hernia content, but it is frequently associated with real incarceration and subsequent irreducibility. This results in mechanical occlusion: symptoms may include constipation, local pain, cramping abdominal pain, abdominal swelling, and vomiting; the abdomen may become hyper-tympanic, and the bowel sounds may be initially hyperactive and high-pitched and lately reduced or absent due to onset of ileus.

39.1.3 Strangulation

It is definitely the most dangerous complication; it occurs when the blood supply to part of the bowel is blocked.

Although it is often the result of an acute event (such as a physical effort), it can also occur in the absence of an apparent cause.

Strangulation is characterized by irreducibility and acute pain, usually of considerable intensity (both to palpation and spontaneous); almost always it leads to intestinal occlusion.

It must be quickly treated, since in a few hours it evolves to gangrene of the ischemic bowel, followed by perforation, peritonitis, and septic shock.

39.2 Diagnosis

Clinical history and physical examination are of crucial importance in the diagnosis of inguinal hernias and their complications with particular attention paid to the duration and severity of symptoms. Although complications are rarely the symptom of the onset of hernias, in most cases, they occur in patients with a previous history of inguinal hernia or with a history of a previous surgery for hernia.

When clinical examination does not allow a certain diagnosis, several instrumental investigations can be helpful, such as ultrasound, X-ray, computed tomography, and nuclear magnetic resonance imaging.

39.2.1 Physical Examination

Physical examination must always be accurately performed both in the supine and in the orthostatic positions, evaluating both the inguinal and the femoral regions with and without Valsalva maneuver. The inguinal canal should be examined by inserting the tip of the finger inside the inguinal outer ring. Any inguinal swelling should be evaluated for size, reducibility, consistency, and pain. The whole abdomen should be evaluated in an attempt to look for any sign of obstruction.

39.2.2 Ultrasound

Ultrasound, performed with dynamic poses, is the first-choice instrumental investigation. It is cheap, always available, and fast and does not expose the patient to biologically potentially dangerous radiations. However, the sensitivity and specificity of this method are operator dependent. US may be useful in identifying undiagnosed hernias and can provide information about the size of the collar and the content of the hernia bag (small or large bowel tract, liquid effusion, fat, etc.).

39.2.3 Abdominal Radiographs

Incarcerated and strangulated groin hernias frequently occur with abdominal pain that can be precisely localized or arise with peritonitis and acute abdomen. Abdominal X-ray (both with clinostatic and orthostatic acquisition) is a simple and fast method necessary to exclude differential causes and investigate the possible occurrence of abdominal obstruction.

39.2.4 Computed Tomography

Although computed tomography represents a second-level instrumental investigation for inguinal hernia, according to some authors, this is the method of choice for investigating the sudden

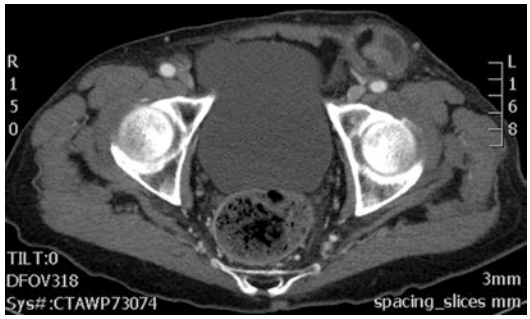

Fig. 39.1 CT scan showing an incarcerated femoral hernia containing bowel that shows reduced enhancement of the wall as for ischemia

change, or worsening, of the symptoms. Computed tomography has a high positive and negative predictive value (respectively, 94 and 96%) and high specificity and sensitivity (83%), especially when performed with dynamic poses and with oral administration of contrast medium. It may help to understand presence/absence of bowel ischemic suffering and to choose the subsequent adequate operative treatment (Fig. 39.1).

39.2.5 Nuclear Magnetic Resonance Imaging

For its ability to discriminate soft tissues, magnetic resonance imaging offers the highest sensitivity and specificity, even higher than computed tomography. However, this method is expansive and too time-consuming to be actually used under emergency conditions.

39.2.6 Laparoscopy

Incarcerated and strangulated hernias are traditionally repaired through open surgery.

Laparoscopy is time-consuming and requires an experienced laparoscopic surgeon. However, recent studies have shown its importance as diagnostic tool allowing an exhaustive inspection of the intestinal loops ruling out ischemic damage.

Laparoscopy approaches (transabdominal or total extraperitoneal) are discussed in the following chapter.

39.2.7 Deep Inguinal Ring Laparoscopy

Following inguinotomy, the trocar is inserted through the deep inguinal ring. This allows an evaluation of possible ischemia damage in the intestinal loops.

Hernias may spontaneously be reduced, for example, after administration of muscle-relaxing anesthetic drugs. In this case, ischemic damage should be nevertheless ruled out before performing the hernia repair, especially if the hernia was incarcerated or strangulated. In this case, laparoscopy is both feasible and safe, and it is also a quite accurate diagnostic tool. Compared to laparotomy, complications are less frequent, and postoperative recovery is both faster and less painful for the patient.

39.3 Surgical Options

The European Hernia Society (EHS) guidelines state that the gold standard for elective inguinal hernia repair in adults is the Lichtenstein technique. However, the optimal technique to cure incarcerated and/or strangulated inguinal hernia remains controversial. Morbidity and mortality are significantly increased in patients presenting with a complicated hernia, and likewise, the durability of these repairs is significantly lower than elective repairs. As expected, emergent groin hernia repairs have increased morbidity and mortality compared to elective repairs. The pathology that contributes to this increased morbidity and mortality is often the presence of necrotic or ischemic bowel causing intra-abdominal sepsis. The crux of the clinical decision is operating early on incarcerated hernias prior to the transition to strangulation. This decreases the likelihood of bowel ischemia, perforation, and need for resection. Strangulated hernias have a much greater likelihood of mortality and morbidity and significantly limit the choices for repair.

Patients undergoing emergent inguinal hernia repair in the absence of bowel resection, ischemia, or peritonitis have no increased risk of mesh-related morbidity.

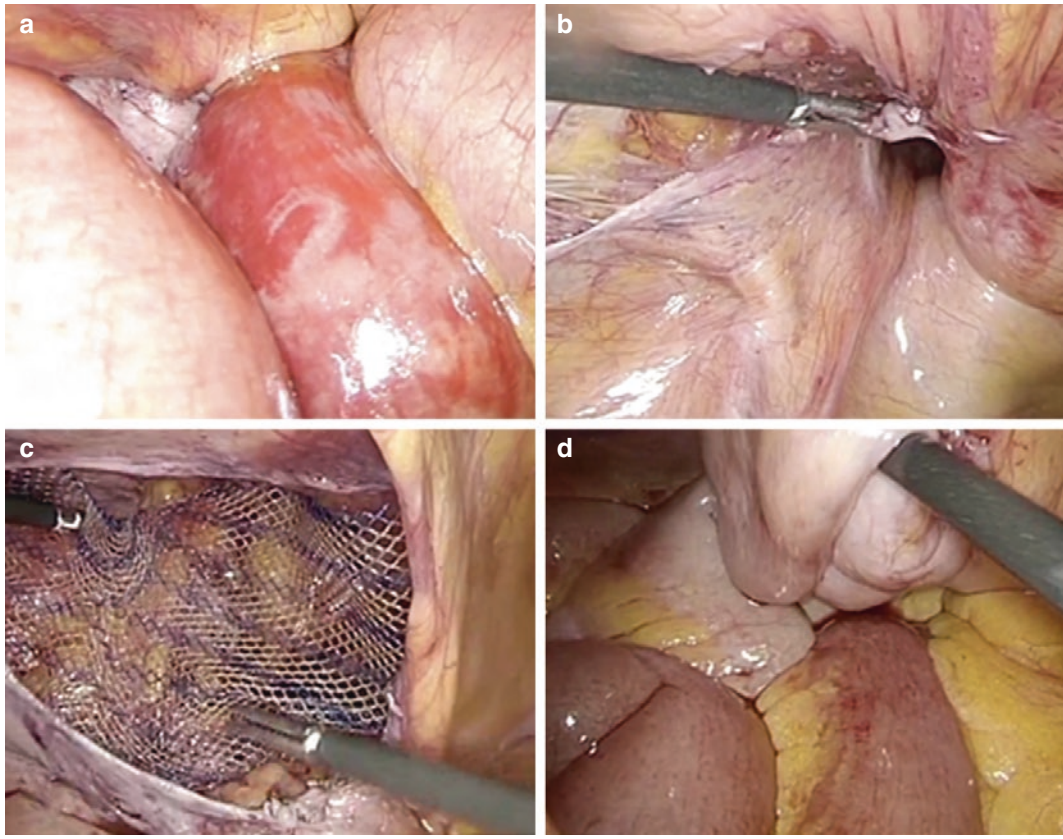

Fig. 39.2 Laparoscopic repair of an incarcerated inguinal hernia. (**a**) Ischemic incarcerated small bowel, (**b**) hernia sac after reduction of the incarcerated bowel, (**c**) mesh positioning, (**d**) appearance of the incarcerated bowel after the repair: the jejunal loop is vital and no resection is needed

On the other hand, classical surgical teaching contraindicates the use of prosthetic materials in the setting of strangulation due to the fear of a higher rate of mesh-related complications in those settings. Furthermore, the consequences of wound infection in the presence of grafts may be more difficult to treat. If gross contamination occurs or if a surgeon feels that the risk of mesh infection is high, the only available options are tissue repairs (commonly employed are the Bassini, McVay, and Shouldice repairs), Lichtenstein with biologic mesh, and absorbable mesh plug such as polyglactin mesh.

In case of incarceration, prior to assessing the actual contamination of the surgical field due to bowel necrosis, two approaches can be considered: open and laparoscopic. Laparoscopic hernia repair has merit in selected patients. Diagnostic laparoscopy can be performed with attempted manual extracorporeal reduction and/or laparoscopic reduction. Aside from the minimally invasive approach for reduction, bowel viability can be easily inspected, and laparoscopic hernia repair could be followed (Fig. 39.2).

Open repair can proceed in one of two ways, supra-inguinal or via laparotomy. If bowel is unable to be reduced safely, or resection and anastomosis will be technically challenging, then laparotomy should be performed to facilitate resection and anastomosis. The hernia is often constricted by the internal inguinal ring; therefore, sharply incising the internal inguinal ring can allow reduction and/or evaluation of the hernia contents. Once performed, it is key to prevent the hernia from reducing into the abdominal cavity until the hernia sac has been opened and

contents identified. If the hernia content was reduced, laparoscopy again is a useful adjunct to evaluate for bowel viability.

Strangulated bowel can be addressed via the groin incision, laparotomy, or laparoscopy. If the bowel is not grossly ischemic or infarcted, then reduction into the abdominal cavity is appropriate. It is prudent to ascertain return of blood supply prior to the definitive repair.

In case of incarceration with no sign of strangulation or contamination of surgical field, a Lichtenstein repair is appropriate and safe, with a small risk of recurrence.

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40 Results and Complications of Inguinal Hernia Repair

David K. Nguyen and David C. Chen

Inguinal hernia repair is performed annually on approximately 20 million individuals worldwide, making it one of the most common operations performed [1]. Inguinal hernia operations have evolved a great deal since the first descriptions involved ligation of the hernial sac and reapproximation of muscular and fascial tissues to reinforce the posterior inguinal canal. In the late 1880s, Bassini defined the inguinal anatomy and developed a viable tissue-based repair fostering the modern era of successful hernia repair techniques with minimal morbidity. Introduction of mesh prosthetics in the 1960s resulted in the widespread adoption of tension-free mesh-based repairs as a way to further reduce recurrence. In the 1990s, laparoscopic posterior approaches allowed greater exposure and understanding of the myopectineal orifice and preperitoneal placement of mesh. The evolution of technology with regard to materials, prosthetics, devices, optics, and robotics has contributed additional tools and techniques to the treatment of inguinal hernias.

A general surgeon should have familiarity and competency with the available tissue- and mesh-based and endoscopic techniques for repair. Detailed knowledge of current outcomes and complications of inguinal hernia repair is crucial to improve personal outcomes and operative technique and to appropriately manage patients affected by potential complications. Patients, especially in developed countries, are well informed and expect a surgeon who can engage them in thoughtful, shared decision-making. In resource-limited settings, it is important to know which techniques are most effective and durable, as a successful repair can mean the difference between a person remaining a functional, contributing member of society and one who is unable to work and care for themselves or their loved ones.

40.1 Watchful Waiting

There is a growing body of literature suggesting that surgeons may be overtreating inguinal hernias, especially those that are asymptomatic or minimally symptomatic [2–9].

40.2 Results and Complications

In 2006, Fitzgibbons et al. conducted an RCT with 720 men, looking at superiority of elective inguinal hernia repair over watchful waiting in asymptomatic or minimally symptomatic men [2]. Primary outcomes were pain interfering with normal activities and change in physical function as measured by the physical component score of the SF-36 at 2 years. Secondary outcomes included complications, and patient reported

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pain, functional status, activity levels, and satisfaction. At 2 years, pain interfering with normal activities occurred in 5.1% of the watchful waiting group and 2.1% in the operative group ($p = 0.52$) [2]. However, long-term follow-up of this study and similar RCTs all demonstrate crossover rates of greater than 60% primarily due to pain 2–4 years out from study inclusion [2–6]. A more recent trial published in 2017 examined the non-inferiority of watchful waiting versus inguinal hernia repair in asymptomatic to minimally symptomatic men over the age of 50 [5]. This study involved 496 men with a primary endpoint of 0.20-point difference in pain scores as evidence of non-inferiority with 24 months of follow-up. Their results did not demonstrate non-inferiority. Only 40% of watchful waiting patients crossed over at 2 years, with no differences in postoperative complications or recurrences compared to the initial surgery group [5].

Long-term data regarding watchful waiting was published by Fitzgibbons in 2013 as a follow-up to their original randomized clinical trial [5]. Two hundred fifty-four patients in the original watchful waiting cohort were followed for at least 10 years. Eighty-one (31.9%) crossed over to surgical repair before the end of the original 3-year study. The cumulative crossover rate at 10 years was 68% with men over 65 years crossing over at a considerably higher rate than younger men (79% vs. 62%) [9]. At 10 years, the incidence of morbidity remained low with no mortality. The authors concluded that watchful waiting is reasonable and safe, but symptoms, especially pain, are likely to progress with eventual need for surgery [9].

In 2014, a group out of England reported on the clinical implications of a watchful waiting strategy [10]. Their retrospective comparison of 1000 patients pre- and post-implementation of watchful waiting was performed with a 59% rise in emergent hernia repairs. These emergent hernia repairs were also associated with significantly more adverse events (18.5% vs. 4.7%). However, the study inadequately controlled for the prior medical histories of the patients [10].

Inguinal hernia repair is effective, but there will always be patients hesitant to undergo surgery or with significant medical comorbidities. For this subgroup of patients who are asymptomatic or minimally symptomatic, it is appropriate to continue watchful waiting after a discussion regarding complications of emergent surgery, the likelihood of potential complications while waiting, and the high likelihood of requiring surgery later in life.

40.2.1 Open Inguinal Hernia Repair

40.2.1.1 Mesh-Based Repair

The use of mesh in inguinal hernia repairs was first proposed in the 1960s primarily in elderly patients with recurrent inguinal hernias. Favorable long-term results from these early operations emboldened surgeons to use mesh in younger patients with primary inguinal hernias. Lichtenstein and Amid subsequently popularized the concept of a mesh-based, tension-free technique for routine inguinal hernia repair, and since then several variations of mesh repair including plug and patch, bilayer mesh, and preperitoneal mesh have been developed.

In 2009, the European Hernia Society (EHS) published guidelines on the basis of grade A evidence stating that all male adults over age 30 with a symptomatic inguinal hernia should be treated with a mesh-based repair [11]. In the 2015 EHS updated guidelines, mesh-based repairs were again given a strong recommendation [12].

40.2.1.2 Mesh Types

It is difficult to study and identify an ideal mesh for inguinal hernia repairs. Mesh comes in many different materials, shapes, sizes, weights, and porosity. Each variation is touted for its benefits and has its fair share of limitations. The ability to withstand stress, repetitive loading, and good biocompatibility all contribute to outcomes including repair durability, return to activity, and incidence of chronic postoperative inguinal pain. Studying each characteristic and each potential effect while risk-stratifying for potential confounders makes comparisons of mesh types and translating those findings to clinical practice difficult. Three-dimensional meshes and plugs

incite different foreign body reactions as compared to the aforementioned flat, large-pore meshes and are difficult to directly compare. There are few studies looking specifically at flat or large-pore meshes. With regard to weight, lightweight meshes are compared to midweight or heavyweight meshes with regard to the outcomes of recurrence and chronic pain.

In open repairs, studies demonstrated a short-term lower incidence of pain with lightweight mesh, with no difference between lightweight and heavyweight with long-term follow-up [13–21]. Notably, foreign body sensation was also less frequent with lightweight mesh [16–21]. For laparoscopic TEP and TAPP repairs, there were also higher rates of chronic pain with heavier mesh with the same recurrence rates [22–24]. The variations in porosity, however, limit the implications of these studies as porosity greatly affects ingrowth and inflammation. More recent meta-analyses attempting to address the question of mesh weight and outcomes also reported conflicting results [22–24]. Most of these studies found that lightweight mesh was associated with less foreign body sensation and chronic pain [22–24]. However, they did not agree upon whether recurrence was increased with lightweight mesh compared to heavyweight mesh. These studies were also heterogeneous in nature, with variations in study inclusion, fixation technique, and lack of comparison between fixation and mesh characteristics in contributing to chronic pain and recurrence [13–24].

40.2.1.3 Lichtenstein Repair

In 2012, a systematic review and meta-analysis covering all prior randomized controlled trials (RCT) up until September of 2011 examined Shouldice repair versus other open techniques [25]. This review looked at 6 RCTs with 1565 patients comparing the Shouldice technique versus open mesh repairs (one study with plug and patch, the rest with Lichtenstein). Overall, RCT quality was rated as low and all studies examined recurrence as the primary outcome. There was no standardization of acute and chronic pain definitions and measurements. The studies were quite heterogeneous, and the authors had concern regarding standardization of techniques and hernia classifications.

Recurrence rates were higher in the Shouldice group compared to the mesh group (five studies) (OR 3.65, 95% 1.79–7.47, NNH 36). No significant differences were identified between mesh and Shouldice groups in terms of postoperative stay, chronic pain, seroma/hematoma, or wound infection. Operative time was shorter for mesh repairs compared to the Shouldice repair (WMD 9.64 min; 95% CI 6.96–12.32).

Since the Cochrane review, several additional RCTs have been published but with small sample size or not directly comparing Shouldice to Lichtenstein [26–29]. One RCT did compare the Desarda technique, which is a new tissue-based repair to the Lichtenstein repair [30]. In 208 patients with short-term follow-up, there was a comparable 1.9% recurrence rate with no significant differences in postoperative pain.

Two large population-based studies from Denmark involving more than 24,000 patients evaluated outcomes between tissue-based repairs and the Lichtenstein repair [31–33]. These studies were limited by the fact that not all tissue repairs were Shouldice operations (13% Shouldice). In addition, reoperation was used as a proxy for recurrence, so true recurrence rates are not known. The reported recurrence rates for tissue repairs in this large population study were 8% for tissue repairs and 3% for the Lichtenstein repair [31–33]. This study does provide valuable insight into real-life practice patterns and outcomes and is thus useful for surgeons in their discussions with patients.

In summary, the Lichtenstein repair has recurrence rates in the largest population studies of about 3%. In RCTs involving a Lichtenstein repair, recurrence rates range between 1 and 7%. Chronic pain for the Lichtenstein repair, while defined heterogeneously in various studies, ranges between 6 and 12%.

40.2.1.4 Non-Lichtenstein Mesh Repairs

Several mesh-based alternatives for open anterior inguinal hernia repairs exist in addition to the classically described Lichtenstein operation [34].

These include the use of a mesh plug and onlay patch, bilayer hernia systems, self-gripping mesh, and open mesh fixation with glue [35–38]. For preperitoneal approaches, these include the Kugel technique, the transinguinal preperitoneal (TIPP) approach, the transrectus sheath preperitoneal (TREPP) approach, the Wantz technique, the Onstep technique, and the Rives technique [39–44]. Generally speaking, TIPP, Onstep, and Rives access the preperitoneal space through the inguinal canal, whereas TREPP, Kugel, and Wantz approach the preperitoneal space without entering through the inguinal canal.

40.2.1.5 Plug and Patch

Two meta-analyses of seven RCTs have accrued and analyzed the best data on plug and patch repairs compared to Lichtenstein repairs [45, 46]. In these studies, there were significantly shorter operative times (5–10 min) with plug and patch repairs compared to the Lichtenstein. In addition, two RCTs performed long-term follow-up of their patient cohort [47, 48]. The first study, with a median follow-up of 7.6 years, found that recurrence rates were 9.9% and 5.6% for plug and patch and Lichtenstein repairs, respectively ($p = 0.77$) [47]. Chronic pain rates were similar at 5.6% and 5.5% [46]. In the second study, with median follow-up of 6.5 years, recurrence rates were 7.8% and 8.1% for plug and patch versus Lichtenstein repairs, respectively ($p = 0.92$) [48]. Chronic pain, rated as a visual analog score (VAS) greater than 3, was not significantly different between the two groups [48].

40.2.1.6 Bilayered Mesh System

Bilayered mesh repairs (Prolene Hernia System (PHS)/Ultrapro Hernia System (UHS)) utilize an anterior flat-based mesh connected to a posterior flat mesh to cover both the inguinal canal and myopectineal orifice. The highest-quality study comparing outcomes of bilayer repair had a mean follow-up of 7.6 years [47]. This study had a PHS arm, Lichtenstein arm, and plug and patch arm with 270 patients completing long-term follow-up. Comparison of PHS to Lichtenstein demonstrated a recurrence of 3.3% and 5.6%, respectively ($p = 0.77$). Chronic pain was 6.7% and 5.6%, respectively ($p = 0.785$).

Bilayered mesh repair and plug and patch both involve the anterior and posterior compartments in addition to being three dimensional with more risk of foreign body sensation. While acceptable as standard repairs for inguinal hernias with favorable outcomes, they do not provide any added statistical benefit over the Lichtenstein repair. Furthermore, violation of both anterior and posterior compartments at one operation makes it more difficult to address pain and to utilize an alternative compartment to address a potential recurrence. Recommendations from HerniaSurge and the EHS also suggest that there can be issues with meshoma formation and mesh erosion and migration, and meticulous operative technique is essential to replicate best practice outcomes [12]. These issues will be addressed further in the Sect. 40.2.3 of this chapter.

40.2.1.7 Self-Gripping Mesh

There have been seven RCTs and five meta-analyses examining five of the RCTs published comparing self-gripping mesh to the Lichtenstein repair [47, 49–60]. An RCT in 2014 with 557 male patients demonstrated recurrence rates of 1.5% vs. 2.8% in self-gripping and Lichtenstein repairs ($p = 0.289$) [61]. Immediate postoperative pain scores were significantly lower with self-gripping mesh compared to Lichtenstein, as well as an average reduction of 7.6 min of operating time. However, follow-up at 1 year showed no significant difference in long-term pain scores. Among the rest of available RCTs and meta-analyses, there were comparable recurrence and chronic pain rates between the two groups, with a shorter operative time of 1–12 min in the self-gripping group [49–60].

40.2.1.8 Glue Fixation

Campanelli et al. performed an RCT of fibrin sealant mesh fixation versus standard Lichtenstein repair in 319 patients with a primary endpoint hypothesis of 50% reduction in postoperative pain/numbness/groin discomfort and 1 year follow-up [38]. Pain, numbness, and groin discomfort were rated by category on a VAS of 0–100.

The scores were then combined as a composite, and values greater than 30 reflected chronic disabling symptoms. At 12 months, the prevalence of one or more disabling complications was significantly lower with glue fixation versus suture fixation (8.1% vs. 14.1%, $p = 0.0344$), with the most significant benefit seen in active patients versus retired patients. Recurrence rates were less than 1% in both groups at 12 months. At 1 and 6 months, there was also significantly less pain experienced by the glue fixation group compared to suture fixation as evidenced by less use of analgesics (65.2% vs. 79.7%, $p = 0.0009$). There is no long-term follow-up data available for fibrin sealant mesh fixation. In addition, there may be issues related to cost and availability of fibrin sealant depending on where a surgeon's practice is located.

40.2.1.9 Preperitoneal Approaches

Only TIPP and Kugel preperitoneal approaches have been adequately studied and compared against the Lichtenstein repair to formulate conclusions regarding their efficacy. The other approaches mentioned above do not have sufficient available comparative data to generate an informed opinion. In the most recent HerniaSurge guidelines, three RCTs, one systematic review, and two meta-analyses were identified and used to generate recommendations [62–67]. The best available data come from a meta-analysis in 2013 of 12 RCTs comparing TIPP repairs to Lichtenstein repairs for both primary and recurrent inguinal hernias [63]. In this meta-analysis, "TIPP" referred to the actual TIPP repair, Kugel repair, and Rives repair. There was a reduced risk of chronic groin pain with TIPP repairs (RR, 0.48; 95% CI, 0.26, 0.89; $z = 2.33$; $p < 0.02$) without any change in the incidence of recurrence (RR, 0.18; 95% CI, 0.36, 1.83; $z = 0.51$; $p = 0.61$). Other secondary outcomes such as perioperative complications, duration of operation, and postoperative pain intensity were similar. Despite heterogeneity between the studies, the author of the 2013 meta-analysis concluded that TIPP repair was comparable to Lichtenstein repair. An additional RCT published in 2012 randomized 301 patients to TIPP versus Lichtenstein repair [63]. Primary outcome was presence of chronic pain at 1 year, with assessors and patients blinded to the intervention. The TIPP patients had a chronic pain incidence of 3.1% compared to 12.9% for patients with Lichtenstein repairs ($p = 0.004$). Recurrence rates were similar in the two groups.

40.2.1.10 Suture-Based Open Repairs

Many suture-based open repairs exist, with eponyms such as Bassini, Halstead, McVay, Marcy, Shouldice, Desarda, etc. Of these, the Shouldice has been most studied with recurrence rates as low as 2% in high-volume centers such as the Shouldice Clinic. Eight RCTs with 2865 combined patients have compared the Shouldice technique versus other suture-based techniques, and these were examined in a systematic review published in 2012 [25]. These studies were quite heterogeneous with inadequate randomization methods and insufficient blinding. Recurrence rate was the primary outcome and pain was evaluated in only three of the trials. In addition, there was no rigorous standardization of technique. Recurrence rates were found to be lower with the Shouldice technique (OR 0.62, 95% 0.45–0.85 NNH 40). In addition, these studies found less incidence of chronic pain, less hematoma formation, slightly higher infection rates, and increased hospital stay with Shouldice repair. This review was limited by low-quality RCTs, non-blinded outcome assessments, patient selection bias, loss to follow-up, and bias based on degree of surgeon familiarity with the Shouldice technique. However, it remains the best studied tissue-based technique, and updated guidelines for the European Hernia Society recommend that the Shouldice technique be utilized as the best suture-based repair [12]. At the same time, they acknowledge that the learning curve is substantial for this technique, with 300 cases needed to be considered qualified at expert centers.

The Desarda technique is a novel addition to suture-based repairs with increased interest due to a lower learning curve and applicability in the developing world where mesh is not always readily available. The premise is similar to prior tissue repairs describe by Halstead in the late 1800s.

Early short-term results are encouraging with a reported 1.9% recurrence rate and no differences in complication rates [30]. However, more high-quality studies and longer follow-up are needed before stronger recommendations can be given regarding this type of repair.

40.2.2 Laparoscopic Inguinal Hernia Repair

Transabdominal preperitoneal (TAPP) hernia repairs and totally extraperitoneal (TEP) hernia repairs are generally accepted as the best evidence-based options for minimally invasive inguinal hernia repair [12]. There has been a recent shift to performing TAPP repairs with robotic assistance as opposed to traditional laparoscopy. Data on robotic-assisted TAPP procedures is sparse and will not be addressed in this chapter but in general can be extrapolated to at least reproduce standard laparoscopic TAPP repair.

Systematic reviews and meta-analyses from 1999, 2000, 2003, and 2012 compared TAPP and TEP repairs to all open repairs [68–71]. Comparison to only Lichtenstein repairs was done as a subgroup analysis in a 2005 meta-analysis [72]. There were significant advantages for laparoscopic approaches, including lower incidence of wound infection, less hematomas, less nerve injury, earlier return to normal activities, and fewer incidences of chronic postoperative inguinal pain. There were no differences in urinary retention, bladder injury, vascular injury, visceral injury, and testicular problems. Lichtenstein performed better in terms of operative time, seroma formation, and, most importantly, recurrence (OR 2.00; 95% CI: 1.46–2.74; $p = 0.00001$). This was a significant finding and often used to highlight the weaknesses of laparoscopic repair. However, it was greatly influenced by the Veterans Affairs multicenter trial, which used a 7.6 × 15 cm mesh size for laparoscopic repairs. These are dimensions typically considered inadequate for covering the myopectineal orifice, and when this study is excluded from analysis, there is no significant difference in recurrence rates. The HerniaSurge committee additionally examined results of 1237 TEP and TAPP repairs compared to 1281 Lichtenstein repairs in male patients with unilateral primary hernias [73–82]. They found no differences in intraoperative and immediate postoperative complications. Additionally, there were clear advantages with early postoperative pain, analgesic use, and return to daily activities and work. There was no significant difference in the recurrence rate (TEP vs. Lichtenstein with median follow-up of 5.1 years 2.4% vs. 1.2%; $p = 0.109$ and TAPP vs. Lichtenstein with median follow-up of 52 months 1.3% vs. 1.2%; ns) once surgeons had achieved the necessary cases to complete the learning curve [73–76]. In TEP versus Lichtenstein patients, chronic postoperative inguinal pain occurred in 9.4% and 18.8%, respectively, at a median follow-up of 5 years. In a separate study, TAPP patients had no chronic pain compared to 3.9% of Lichtenstein patients [79–82].

Large population studies from the Herniamed registry corroborate RCT data [82]. A 2015 analysis of 17,388 patients (10,555 with Lichtenstein and 6833 TEP) revealed nonsignificant differences with regard to recurrence rates (estimated OR 0.775 95% CI 0.549–1.093; $p = 0.146$), chronic postoperative pain requiring treatment (estimated OR 1.066 95% CI 0.860–1.321; $p = 0.560$), and complication-related reoperation rates (estimated OR 1.356 95% CI 0.960–1.913; $p = 0.084$). TEP demonstrated better postoperative complication rates, less pain at rest, and less pain with exertion compared to the Lichtenstein repair. From a direct cost-effectiveness standpoint, TEP and TAPP repairs are inferior to the Lichtenstein repair. However, if one factors into account quality of life measures affected by numbness and chronic pain, then TEP and TAPP repairs may be of increased utility.

Studies examining outcomes between TEP and TAPP do exist but are insufficient in determining if one is better than the other due to bias, lack of statistical power, and significant heterogeneity in study design [83–99]. In addition, many of these studies did not control for the learning curve period, though characterizing the trend in

outcomes as surgeons become more experienced is helpful. Over a 20-year period, recurrence rates for TAPP and TEP dropped from 1.33% and 0.6% to 0.77% and 0.54% [100]. This likely reflects improvement in technical performance as more surgeons adopted laparoscopic techniques and became more comfortable. Large population studies also failed to demonstrate any significant difference between the two techniques.

40.2.3 Complications

Complications from open and laparoscopic inguinal hernia repairs include recurrence, chronic postoperative inguinal pain, infection, urinary dysfunction, sexual dysfunction, hematoma, seroma, vascular and visceral injuries, late postoperative complications, and mortality.

40.2.3.1 Recurrence

Recurrence rates after inguinal hernia repair have been reported to be as low as less than 1% to as high as 15% [101]. In most studies, reoperation is used as a proxy for recurrence, with the assumption that recurrences are twice as common as reoperations. A Swedish study from 2011 found 24-month reoperation rates for primary hernias to be 1.7% for primary repairs and 4.6% for recurrent repairs [102]. A Danish study from 2014 found reoperation rates for Lichtenstein repair to be 2.4% and 3.3% for laparoscopic repair, with no significant difference between the two types of repairs [33].

40.2.3.2 Chronic Pain

In 2008, an international consensus conference formally defined chronic postoperative inguinal pain (CPIP) as new or different quality of pain (if there was pain prior to hernia repair) arising as a direct consequence of a nerve lesion or a disease affecting the somatosensory system after inguinal hernia repair [103]. The incidence of CPIP ranges from 0.7 to 75%, depending on the study and the definition of chronic pain used [103]. The various etiologies include neuropathic pain, nociceptive pain, meshoma pain, orchialgia, and other types of non-neuropathic pain and are covered in detail in other chapters. The definitions used in these studies were very heterogeneous. For example, one RCT comparing Kugel versus Lichtenstein repair defined chronic pain as VAS > 0 at 3 months, with incidence of 20.7% and 45%, respectively [104]. Another study conducted in 1992 with tissue repairs found 62% of patients with some inguinal pain at 1 year and 53.6% at 2 years [105]. When further categorized as pain limiting return to preoperative activities (moderate) or incapacitating pain (severe), the incidence dropped to 11.9% at 1 year and 10.6% at 2 years [105].

Long-term follow-up by the Danish Hernia Database found 28.7% of patients with some inguinal pain 1 year after their operation, with 11% reporting work- or daily activity-related impairment and 4.5% receiving medical treatment [106]. Those with pain were then followed for 6 years, with 16.7% having the same pain and 7.5% having increased pain [107].

Meta-analyses of Lichtenstein repairs compared to preperitoneal or TEP repairs demonstrated CPIP rates of 7.1% for preperitoneal repairs, 12.5% for TEP repairs, and 12.3–16.8% for Lichtenstein repairs [72, 108]. These meta-analyses defined chronic pain as pain at 3 months or 6 months, depending on the study. There is some evidence that suggests CPIP occurs less after endoscopic procedures by experienced surgeons compared to open procedures, along with the use of mesh, fine-tuning of surgical technique such as nerve identification, pragmatic neurectomies versus prophylactic neurectomies, and limited mesh fixation [73]. Specific strategies for mitigating and preventing CPIP will be discussed in separate chapters. HerniaSurge estimated that clinically significant CPIP happens to 10–12% of patients undergoing inguinal hernia repair with debilitating CPIP affecting 0.5–6% of patients [103].

Pubic pain and orchialgia are often related to inguinal hernia repair. Tenderness over the medial insertion of the inguinal ligament was reported as the most common exam finding in patients with CPIP in one study [105, 109–112]. Another study found that 12% of non-neuropathic CPIP patients had pain at the insertion of the inguinal ligament

onto the pubic tubercle. Based on these findings, medial fixation of mesh in repairs is recommended to not involve deep sutures to the periosteum [105]. For patients with orchialgia, the suspected culprit is often excess dissection of the spermatic cord, mesh-related inflammation, or trauma to the vas deferens and its associated visceral innervation during hernia repair. Several studies and meta-analyses have differentiated chronic pain to subgroups, including orchialgia. Consistently across these studies, the incidence of orchialgia was around 0.5–1% [113]. These studies did not find any differences in incidence of orchialgia between Lichtenstein and preperitoneal repairs or between heavy- and lightweight mesh.

40.2.3.3 Meshoma and Other Mesh-Related Complications

Implantation of a foreign body inevitably causes foreseen and unforeseen complications. Mesh implantation predictably causes a foreign body reaction, which can scar it in place and help reinforce the repair or cause an exuberant reaction leading to shrinkage, meshoma, or nociceptive chronic pain. Studies of mesh explants have revealed foreign body granuloma with macrophages and foreign body giant cells [114, 115]. This inflammation may occur in varying degrees, from appropriate to exuberant to inadequate inflammation.

Mesh migration is another known risk of mesh-based repairs. The available literature has demonstrated that this phenomenon may happen up to 20 years after the operation [116–120]. Shrinkage and an increase in tensile forces, especially with plugs and small onlay patches, can increase the risk of mesh migration to the skin, into the peritoneal cavity, the bladder, or the adjacent visceral or vascular structures [116–120]. It is uncommon to see flat mesh migrate unless it has shrunken substantially or folded up to become a meshoma. Mesh contraction occurs as it interfaces with surrounding tissues and forms cross-linking fibers as an expected part of the inflammatory process [114, 121]. Small-pore mesh or meshes with three-dimensional profiles have been found to lose up to 90% of the original volume and may contract to become a meshoma [122–127]. Mesh shrinkage, studied by placing metallic clips at the edges and tracking movement over time, have shown average mesh contraction of 20% from the time of implantation, with up to 50% or more contraction with plugs [122–127]. When meshomas occur, patients sometimes feel deep persistent pressure or ache. In addition, if the meshoma is adherent to the cord or any of the nerves, neuropathic pain can also occur.

40.2.3.4 Infections

Infection is always a concern in inguinal hernia repairs especially with implantation of prosthetic material into the body. Studies looking at infection tend to evaluate high-risk or low-risk patients. A meta-analysis found wound infection rates of 2.3% in the low-risk environment placebo group and 1.6% in the prophylaxis group, with no significant difference. Other studies cite even lower rates. The Swedish Hernia Register identified only 5.6% of 14,053 patients receiving perioperative antibiotics with postoperative infection rates in this group ranging from 1.2 to 1.4%. A German study looking at 85,000 patients with 70% receiving antibiotic prophylaxis demonstrated an infection rate of 0.2% in the endoscopic group and 0.6% in the open group [128–131]. Based on these data, HerniaSurge recommended that no antibiotic prophylaxis is needed for normal or low-risk patients before open or laparoscopic repair. High-risk patients or high-risk environments still merit antibiotic prophylaxis.

40.2.3.5 Urinary Retention

The incidence of postoperative urinary retention (POUR) for inguinal hernia repair varies between 1% and greater than 20% in currently published studies [132]. Review of these series demonstrated that use of general or regional anesthesia predisposed patients to POUR. A study that pooled results from 70 nonrandomized studies and two RCTs found the incidence of POUR to be 0.37% with local anesthesia, 2.42% with regional anesthesia, and 3% with general anesthesia. Some series report POUR after

laparoscopic inguinal hernia to be as high as 22%, likely due to the need for general anesthesia with these cases [133]. Other potential causes include overhydration, bilateral repair, increased BMI, use of opioid analgesics, older age, prostatic hypertrophy, and longer operative time. Meta-analyses of laparoscopic and open inguinal hernia repairs have not found any significant evidence of technique choice being related to POUR [133–137]. There is a tendency to place Foley catheters during laparoscopic repairs, which seems to be more a tradition than actually rooted in evidence-based medicine. Surgeons do this to decompress the bladder in an attempt to minimize potential injury. One study evaluated a pre- and post-intervention of no catheter use during laparoscopic repairs. This study found decreased incidence of cystitis, hematuria, and urinary retention once catheters were no longer routinely used [137].

40.2.3.6 Sexual Dysfunction

Sexual dysfunction after inguinal hernia repair is reported in the literature in one of several ways: the presence of pain affecting sexual function, effects of the operation on fertility and gonadal function, and complications stemming from dysejaculation and ischemic orchitis. The Danish Hernia Database surveyed patients after their operation and found that 28% of patients with open repairs had some pain with sexual activity and 11% of patients reported some pain in the laparoscopic group. Pain that moderately to severely impaired sexual activity was reported in 2.8% of open repairs and 2.4% of laparoscopic repairs. Dysejaculation related to trauma or mesh-associated inflammation occurred in 7.6% of the open group and 3.1% in the laparoscopic group [107, 138, 139]. Ischemic orchitis is a complication associated with damage to the arterial and venous plexuses in the spermatic cord. This is often seen with large, adherent sacs and aggressive dissection causing venous thrombosis. Subsequently, the testicle becomes atrophic with absent seminiferous tubules. A meta-analysis of heavyweight versus lightweight mesh for Lichtenstein repairs did not show a significant difference in rates of testicular atrophy [22]. Some clinical studies have provided evidence of mesh placement contributing to testicular hypoperfusion and sperm dysmotility in the short term [140–143]. Operative injury to the vas deferens, or inflammation mediated by mesh, can cause vas deferens stricture, obstruction, or transection [140–143].

40.2.3.7 Hematoma and Other Vascular Injuries

Nine systematic reviews and meta-analyses have addressed in some form hematomas and other vascular injuries [69, 71, 79, 108, 144–147]. In one study, a significant decrease in hematoma formation was noted with endoscopic compared to open repairs. However, in several other meta-analyses, there were no significant differences between open suture-based and Lichtenstein repairs. Several studies did find that cumulative experience and getting through the learning curve did reduce the incidence of complications in TEP repairs. However, no direct comparisons were made regarding hematomas and vascular injuries in these studies.

With regard to patients who are being anticoagulated and the risk of hematoma formation, most studies are dated with variable techniques studied that would not be applicable to present-day practice. However, laparoscopic repair opening the preperitoneal plane, especially with TEP repairs, should be performed in these patients with caution.

40.2.3.8 Seroma

Seromas are a known postoperative occurrence after laparoscopic and open inguinal hernia repairs, especially in patients with scrotal hernias or large direct defects in preperitoneal repairs without plication of the transversalis fascia. The incidence varies between 0.5 and 12%. Some risk factors for seroma formation include coagulopathy, liver disease, and congestive heart failure. Some meta-analyses found a higher incidence of seroma formation after endoscopic repairs, while others were unable to corroborate that finding [71, 146–151]. In the presence of a lax transversalis fascia present in a large direct defect, reduction and fixation of the fascia to Cooper's

ligament or plication with an Endoloop suture can obliterate the dead space where seromas can form [71, 146–151]. Seromas tend to resolve spontaneously over the course of 1–2 months. They should not really be considered a postoperative complication unless an infection were to occur.

40.2.3.9 Late and Serious Postoperative Complications

Serious postoperative complications (bowel, bladder, vascular) occur between 0.1 and 1.4% in the largest reported series and meta-analyses [72, 146, 147]. One Cochrane review found more instances of serious complications with endoscopic versus open repairs and more with TAPP than with TEP repairs [147]. This likely has to do with intraperitoneal entry and working space used in the TAPP repair. Vascular injuries tend to occur with the dissection of the peritoneum off the spermatic cord near the triangle of doom or the corona mortis overlying Cooper's ligament and during fixation of the mesh. Other potential vascular injuries include lacerating the inferior epigastric vessels with preperitoneal dissection. Port-site hernias and small bowel obstructions can happen in up to 8% of patients after TAPP operations [151]. In the Swedish Hernia Register, only 0.3% of patients had intestinal obstruction related to the hernia repair, all of them with laparoscopic TAPP repairs.

Table 40.1 Complications of inguinal hernia repair

Complication	Incidence	Comment
Recurrence (overall)	1–15%	
– Open	2.4%	
– Laparoscopic	3.3%	
Chronic pain (CPIP)	0.7–75%	Range, any reported pain
– Clinically significant	10–12%	
– Debilitating pain	0.5–6%	
– Preperitoneal	7.5%	
– Endoscopic	12.5%	TEP
– Open	12.3–16.8%	Anterior Lichtenstein
Orchialgia	0.5–1%	
Mesh shrinkage		
– Flat	~20%	
– Three dimensional	~50%	Plug
Infection		Low-risk patients, low-risk setting
– Endoscopic	0.3%	
– Open	0.6%	
Urinary retention	1–20%	Range
– Local anesthetic	0.37%	
– Regional anesthetic	2.42%	
– General anesthetic	3%	
Sexual dysfunction		
– Open	28%/2.8%	Any complaint/ moderate to severe
– Endoscopic	11%/2.4%	Any complaint/ moderate to severe
Dysejaculation		
– Open	7.6%	
– Endoscopic	3.1%	
Seroma	0.5–12%	
Port-site hernia	Up to 8%	TAPP
Bowel obstruction	0.3%	TAPP
Serious complication	0.1–1.4%	Visceral/vascular (>endoscopic)

Conclusion

Non-surgeons and lay people often view the repair of an inguinal hernia as "just another small hernia operation." However, serious and life-altering complications, such as CPIP, can happen to patients. The risk of recurrence, chronic postoperative inguinal pain, mesh-related complications, fertility issues, and serious vascular injuries should always be discussed with patients (See Table 40.1). All general surgeons must have a solid grasp of the risks, benefits, and alternative operations and management associated with repairing a hernia. This information must be disclosed in a way that is easy to understand in order to facilitate informed, shared decision-making between patient and their surgeon. For the patients who return with recurrence, CPIP, or other unforeseen issues, the surgeon must know the diagnostic work-up and, more importantly, when to operate versus when to refer the patient to dedicated herniologists.

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41 Aetiology, Pathogenesis and Assessment of Chronic Pain After Inguinal Hernia Repair

W. A. R. Zwaans, M. R. M. Scheltinga, and R. M. H. Roumen

41.1 Definition

Chronic postoperative inguinal pain, abbreviated as CPIP, is currently the most invalidating complication of inguinal hernia repair and often leads to an inability to normally participate in society. It is the most costly adverse event of inguinal hernia surgery and poses a major health issue [1, 2]. CPIP is defined by the International Association for the Study of Pain (IASP) as 'pain beyond three months after inguinal hernia surgery' [3]. Others have suggested to extend this period to 6 months, allowing inflammatory mesh-based responses to decrease [4].

41.2 Epidemiology

Inguinal hernia repair is one of the most frequently performed procedures in general surgery, with approximately 20 million repairs every year worldwide [5]. Pooled incidences of CPIP following open mesh-based repairs such as the Lichtenstein technique may vary between 11 and 17% [6–9]. It is estimated that some 2–6% of inguinal hernia repairs result in significant restrictions in social and daily activities leading to an impairment of health status and marked lower quality of life [10–14]. Laparo-endoscopic techniques for inguinal hernia repair including TAPP and TEP may result in lower CPIP incidences, varying from 6 to 12.4% [9, 14].

CPIP is generally classified as *neuropathic* or as *non-neuropathic* (inflammatory or nociceptive) pain (Fig. 41.1). Neuropathic CPIP covers approximately 50–70% of CPIP, whereas the rest may be thought of as nociceptive or inflammatory pain syndromes [15]. Profiles of both neuropathic and non-neuropathic CPIP following laparo-endoscopic hernia repair are different compared to CPIP after open hernia repair. It must be appreciated that distinction between the two types is often difficult. Moreover, patients may present with a combination of pain characteristics, as CPIP can be considered as a spectrum (Fig. 41.1). To improve our understanding, the various CPIP syndromes are classified into three different entities (neuropathic, nociceptive or combined), and their associated aetiology and pathogenesis are discussed separately. Finally, pain can either be of central origin or more peripherally located. The clinical distinction of these classifications is often very difficult, if not impossible.

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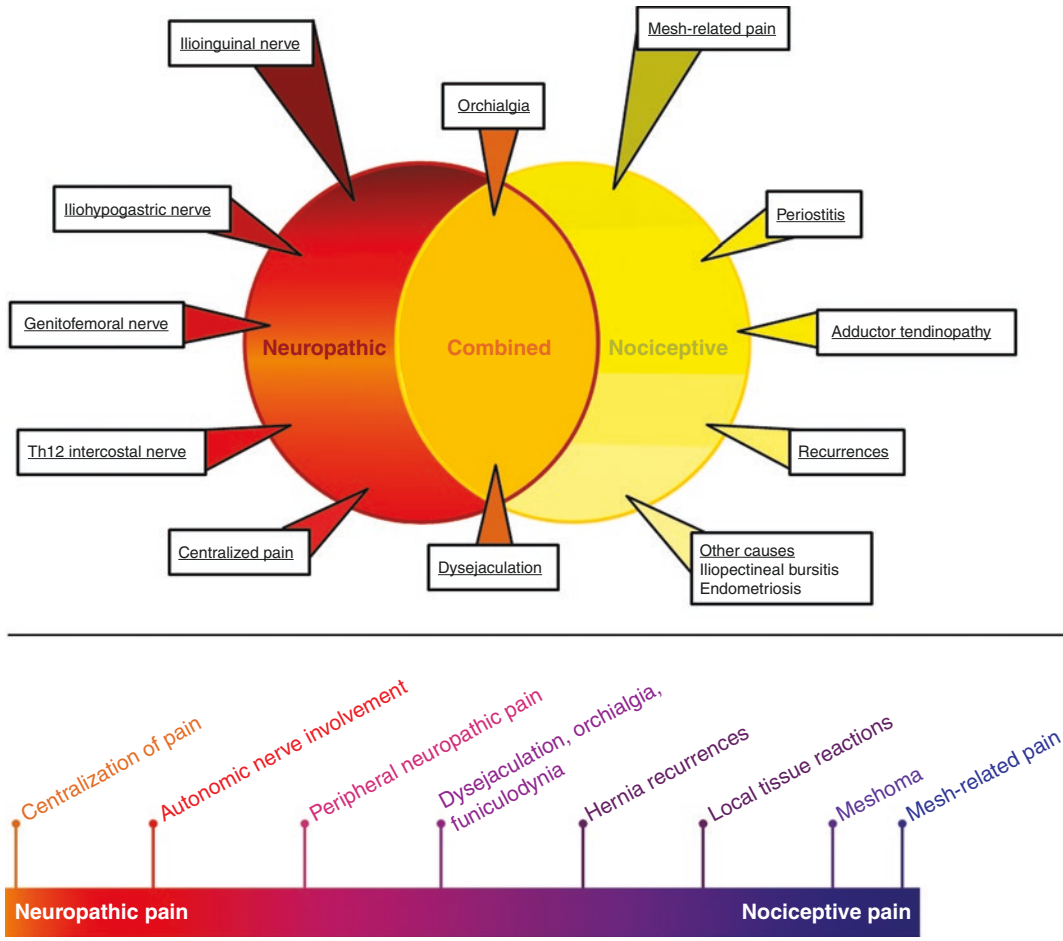

Fig. 41.1 Classification (**a**) and spectrum (**b**) of chronic inguinal postoperative pain following groin hernia repair

41.3 Aetiology and Pathogenesis

41.3.1 Neuropathic Pain Syndromes

41.3.1.1 Inguinal Nerve Involvement

The majority of neuropathic CPIP is due to the involvement of one or more of the inguinal nerves (ilioinguinal nerve, iliohypogastric nerve, genitofemoral nerve or lateral femoral cutaneous nerve, Fig. 41.2). If pain occurs in the early postoperative phase, immediate mechanical effects of the inserted mesh, sutures, staples or other prosthetic materials or direct damage to inguinal nerves during surgery is most likely [6, 15, 16]. Injury to the nerves can vary from complete transections (a so-called neurectomy) to smaller, partial nerve lesions [17]. Partial lesions can vary from neurapraxis (in which the axons and myelin sheath are both intact) to axonotmesis (interruption of the axons but intact myelin sheath) or neurotmesis (interruption of both axons and the myelin sheath) [17]. The consequences of these grades of damage on pain perception are unclear. In case of pain due to surgical disruption of these nerves, one might in fact refer to this situation as postdissection or deafferentation pain (Sect. 41.3.1.4).

The technique of inguinal hernia repair determines which nerves are at risk. Although the inguinal nerves are less frequently affected after laparo-endoscopic hernia repair as they course in another plane between the transverse and oblique muscles, the genital branch of the genitofemoral

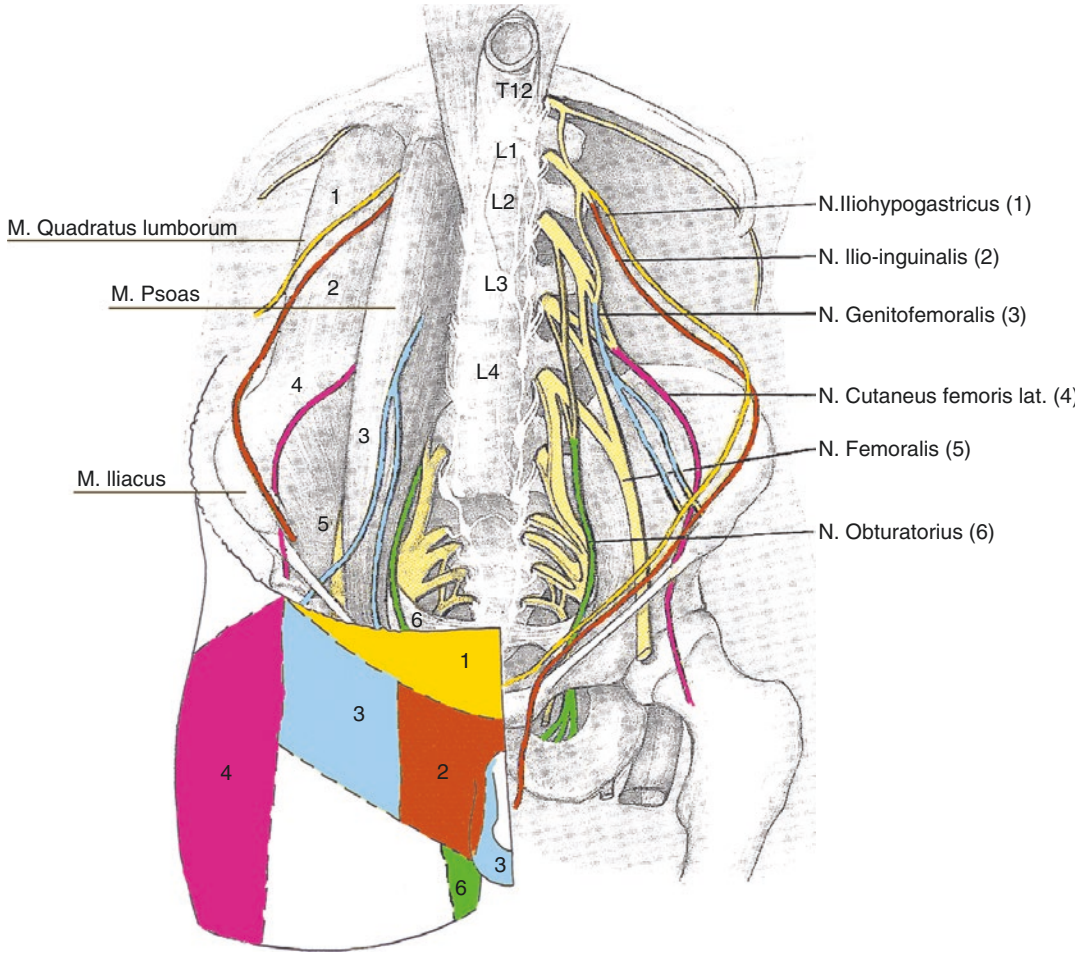

Fig. 41.2 Neuroanatomy of the inguinal nerves

nerve is particularly at risk during a *laparo-endoscopic* procedure, as it runs on the bottom of the operative field. Conversely, damage to ilioinguinal and iliohypogastric nerves is a frequent cause of pain following *open* inguinal hernia repair. Hence, a distinctive diagnostic and therapeutic approach for patients with CPIP is required depending on the repair technique (see Sect. 41.4). The risk of CPIP, however, may be reduced by meticulous identification of groin nerves during the hernia repair [8, 18].

Neuropathic pain caused by inguinal nerve damage, perineural scar tissue development or perineural fibrosis [17] may arise some weeks to months following the inguinal hernia repair. However, immediate postoperative neuropathic pain may also occur, for instance, after a partial damage due to constricting ligatures. The underlying mechanisms of this type of neuropathic pain differ from acute postoperative pain based on tissue damage. Furthermore, if a previous repair was mesh based, an ongoing inflammatory response to the inserted mesh (Sect. 41.3.2.1) may result in CPIP by progressive nerve injury [19, 20]. One rabbit study investigating microscopic inguinal nerve reactions to insertion of a prosthetic mesh found nerve axonal dilation and mild-to-severe loss of myelinated axons in nerve fascicles [21]. Both mechanisms may be responsible for neuropathic CPIP evolving in the long term in patients. On the other hand, due to long-lasting compression, nerves may already have

become damaged by the presence of the hernia for some time, resulting in myxoid histological changes of perineural oedema and an increased ratio of connective tissue to neural tissue [22].

41.3.1.2 Lower Intercostal Nerve

Following a laparo-endoscopic hernia repair, mechanical pressure following insufflation of the preperitoneal space or abdominal cavity may lead to stretched endings of the lower intercostal nerves. Stretched nerves may result in a typical abdominal wall pain syndrome that is also referred to as anterior cutaneous nerve entrapment syndrome (ACNES) [23]. This pain syndrome, which is often overlooked, may occur in patients after a variety of abdominal operations, although it frequently develops spontaneously. The same mechanism of injury may explain ACNES following open inguinal hernia repair, as pulling forces are exerted onto the abdominal wall during surgery. During physical examination, a painful area of altered skin sensation that is often more proximally located, i.e. towards the umbilical area, may be found (Sect. 41.4).

41.3.1.3 Neuroma Formation

A neurectomy or partial nerve lesion may incidentally lead to a traumatic neuroma formation. A neuroma can be intraoperatively recognized as a shiny, white, oval or round, firm-elastic palpable nodule at the proximal cut end of the nerve or at a damaged part along its course (Fig. 41.3). Of note, the location of the neuroma depends on the location of the lesion [17]. Histopathological examination of a potential neuroma is mandatory for verification. A neuroma develops by an inward migration and subsequent proliferation of fibroblasts and perineural cells and outward growth of axons [17]. In theory, inflammation evoked by the inserted mesh may lead to the reactive proliferation of perineural cells in proximity to the mesh [24, 25]. This abnormal benign neural proliferation may result in ectopic excitability of the concerning inguinal nerve, resulting in CPIP.

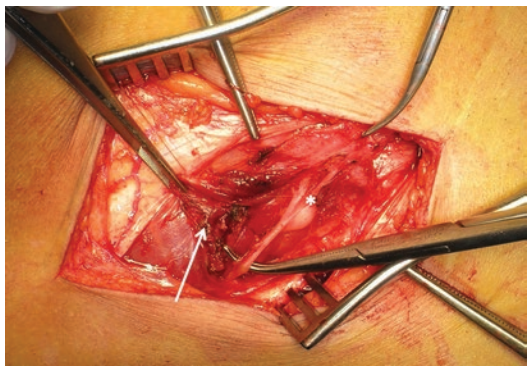

Fig. 41.3 Intraoperative view of a neuroma (*) of the ilioinguinal nerve by compression caused by the placed mesh (arrow) that is elevated by the clamp

The incidence of traumatic neuromas in CPIP patients has been estimated between 12 and 14% [26–28], but proper studies have not been performed to date. The question why some develop a neuroma after surgical nerve injury while others do not is largely unanswered. Earlier research has not fully unveiled its aetiology; hence, more research on the pathogenesis and how to avoid neuroma formation is desirable. When a neuroma is identified and removed, success rates of the remedial surgery may be increased [26].

41.3.1.4 Deafferentation and Centralization of Pain

Another neuropathic CPIP entity is deafferentation or postdissection pain leading to central sensitization [17, 29]. Patients with neuropathic postoperative pain following inguinal hernia repair who are unresponsive to all conservative and surgical treatments in the peripheral field may have developed such type of pain. It can be considered as a type of phantom pain. This sort of pain results from a (complete or partial) disruption of the afferent nerves. As a neurectomy or nerve injury interrupts the normal impulses from the afferent nerves, deafferentation pain is always looming.

Nerve lesions may further lead to molecular changes in nociceptive neurons (C-fibres) and non-nociceptive neurons (Aδ- or Aβ-fibres) by releasing growth factors [30]. These nerve growth factors were found to influence neighbouring uninjured nerves, which react by an upgraded expression of certain receptors such as vanilloid receptors (trpV1 receptors, responding to noxious heat), adrenoceptors (adrenergic receptors,

responding to catecholamines) and upregulated sodium channels [30–34]. By an upregulated expression of these receptors, hyperexcitability of initially normal surrounding nerves may ensue. Furthermore, a hyperexcitable state may result in an ongoing sensitization of the spinal cord dorsal horn neurons by releasing glutamate acting on postsynaptic N-methyl-D-aspartate (NMDA) receptors [30]. Both mechanisms may contribute to ectopic activity of the concerning nerves and consequent spontaneous pain [30, 35]. Since neighbouring, initially uninjured nerves have intact connections to the skin, pain is often experienced at superficial groin areas [36] as also reflected by a painful skin pinching test (Sect. 41.4). Why some patients develop deafferentation pain while others do not is still unclear.

Long-lasting inguinal pain may result in central sensitization that can be extremely difficult to distinguish from other potential sources of pain. Centralized pain is independent of any peripheral drive [37] such as initiated by inguinal nerves and thus is refractory to peripherally directed treatments. Prolonged impulse stimulation along unmyelinated C-fibre afferents may cause transneuronal morphologic changes to peripheral nerves ('neuronal plasticity'). Peripheral nerve hyperexcitability may subsequently be caused by a lower threshold of nociceptor afferent peripheral terminals, a phenomenon termed peripheral sensitization [30]. The extensive quantity and ongoing input resulting from peripheral sensitization may lead to hyperexcitability of the spinal cord and morphological changes more proximal in the central nervous system and thus central sensitization [38–41]. Patients with centralized pain should be excluded from remedial, peripherally oriented surgery [16, 42].

41.3.2 Non-Neuropathic Pain Syndromes

41.3.2.1 Mesh-Related Pain

Non-neuropathic or nociceptive CPIP can be due to a mesh- or suture-induced inflammatory reaction within the inguinal area. Theoretically, any foreign material has a potential of inducing an inflammatory reaction. Locoregional inflammation is assumed critical for strengthening the hernia repair as formation of fibrosis is correlated to the intensity of inflammation [43, 44]. Interestingly, lightweight meshes were found to induce less inflammation and, as a consequence, less formation of fibrosis resulting in more hernia recurrences [44, 45].

The downside of mesh-related inflammation is an occasionally occurring unfavourable effect of ongoing inflammatory responses. Meshes that were explanted after 3 years were still demonstrating active foreign body reactions [46]. These findings support the idea that inflammation may go on for many years.

Inserted meshes may not only lead to an ongoing low-grade chronic inflammatory reaction but may also exert mechanical pressure or irritation possibly contributing to pain. The 'anatomy' of inserted mesh may change as creasing, wrinkling and folding may occur. This slow process increases mechanical pressure and may lead to a foreign body feeling. This feeling is reported by patients as something that is constantly bothering them as if a 'wrinkled handkerchief is sitting in their pocket'. Previous studies suggested that up to half of the patients with a sutured mesh-based hernia repair report some kind of foreign body feeling in the groin [15, 28, 47]. Trials comparing a standard and a lightweight mesh have demonstrated a significantly lower rate of foreign body sensation in the latter group [20, 45, 47, 48]. The lesser formation of fibrosis may correlate with the reduced foreign body feeling. Moreover, adhesions to surrounding structures may contribute to the sensation.

Apart from an uncomfortable sensation, a foreign body feeling may possibly herald mesh-related pain. The results of previous studies that most mesh-related pain develops over a few years following hernia repair [28] support this hypothesis. Of note, not only the natural evolution of mesh-related pain but also insufficient knowledge of hernia surgeons and hesitance to refer patients to specialized centres contribute to this long diagnostic and treatment delay. Whether a foreign body feeling is also directly related to mesh shrinkage needs to be clarified.

Mesh-related pain may occur both after open and after laparo-endoscopic inguinal hernia repairs. In Western countries, laparo-endoscopic repairs such as TEP and TAPP are primarily recommended, providing resources and expertise are available [49]. Approximately 15% of CPIP patients demonstrate a mesh-related pain after an open Lichtenstein repair [28]. The number of patients presenting with mesh-related pain is many times lower following laparo-endoscopic repairs [50]. An explanation for this difference is possibly provided by the position of the mesh in the preperitoneal space. This location is likely beneficial not only in terms of evoking fewer cases of neuropathic pain [14, 51] but probably also for generating less mesh-related pain. It is thought, however, that the mesh may exert comparable mechanical effects irrespective of mode of implantation, open or laparo-endoscopic [50].

Meshoma Formation

Meshes have the tendency to wrinkle, fold and shrink up to 30% over time [52], and if this process proceeds, a so-called meshoma may be formed (Fig. 41.4). A meshoma is defined by the operating surgeon [53]. Different gradations may be present, varying from a mass-like density to more subtle effects of mesh wrinkling or fibrosis [53]. A meshoma results in CPIP by a volume effect or by mechanical pressure on surrounding structures in the inguinal region. Insufficient fixation or insufficient dissection to make adequate room for the prosthesis may increase the risk of meshoma formation [54].

A meshoma is increasingly recognized as an important factor contributing to CPIP [55]. A recent study on CPIP patients after open inguinal hernia repair observed an up to 17% incidence of a meshoma [26]. Interestingly, identification of this unique pathologic finding following laparo-endoscopic hernia repair is less frequently described [50]. It should be appreciated that a meshoma following initial laparo-endoscopic hernia repair looks different compared to open repairs, as subtle effects as wrinkling or small folds of the preperitoneal mesh may create pressure and mass effects. The lower grade of folding of the mesh in the preperitoneal space is possibly related to a relative limited grade of flexing and extending forces when compared to the groin region.

The mesh, being a meshoma or not, may also invade the surrounding structures and organs, resulting in serious damage (for instance, to the vas deferens or bladder). A typical case of invasion of the appendix by a meshoma (Fig. 41.5), leading to chronic visceral pain in epigastrium with nausea, was previously described [56]. After removal of this mesh, visceral complaints (besides the pain) that had been present for many years also disappeared.

41.3.2.2 Adductor Tendinopathy

Inguinal pain following hernia repair may result in a compensatory antalgic gait. If pain persists and an effective remedial therapy is postponed, such an ongoing antalgic gait can lead to a tendinopathy of the adductor muscles of the hip. This

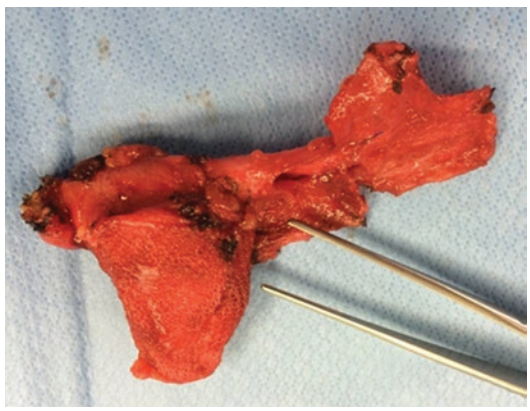

Fig. 41.4 A surgically removed meshoma

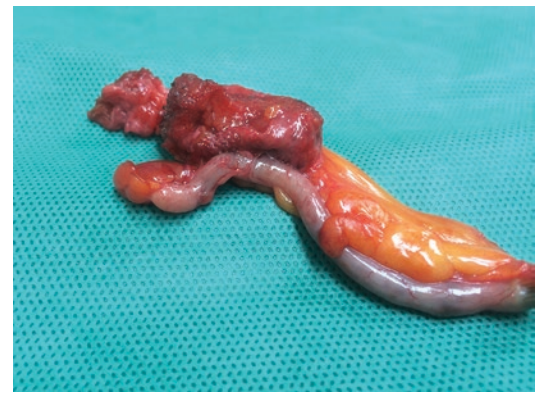

Fig. 41.5 An appendix vermiformis firmly attached to a plug that was previously used for inguinal hernia repair

(possibly latent) cause is not yet properly studied, whereas therapeutic options are limited and experimental. Moreover, persistent groin pain following a successful neurectomy or meshectomy can be due to a persisting adductor tendinopathy. It is imperative that, prior to deciding on remedial surgery for CPIP, these patients should be counselled on the copresence of this pain syndrome. However, to our experience, this is difficult, especially when the groin pain due to a neuropathic entrapment or meshoma is prevailing.

41.3.2.3 Periostitis Pubis

Another CPIP syndrome that is frequently encountered is periostitis of the pubic tubercle (also known as periostalgia pubis or pubalgia). This inflammatory-related pain syndrome can develop after both open and laparo-endoscopic hernia surgeries. Periostitis of the pubic bone can evolve by a long-standing direct mechanical irritation by prosthetic material. Overlap of the inserted mesh onto the pubic tubercle may cause a periosteal reaction, as well as sutures or staples into the pubic bone. It is thought that the vector forces of the rectus and adductor muscle result in this intriguing pain entity. Surgery itself may also cause a painful local inflammatory reaction, but this phenomenon is assumed to be self-limiting.

Apart from inflammation, periostitis is also characterized by sclerosis in the pubic bone [57]. The diagnosis, however, is primarily based on physical examination (Sect. 41.4). The estimated incidence of this underreported cause of CPIP is less than 1% following open inguinal hernia surgery [20]. Together with adductor tendinitis, ongoing periostitis is the most frequent cause of persistent groin pain following successful remedial groin surgery for CPIP after nerve or mesh removal. Therefore, CPIP patients who are planned for a neurectomy or mesh removal must be informed on the issue of persisting periostitis after the operation.

41.3.2.4 Iliopectineal Bursitis

A seldom acknowledged and rare cause of CPIP is iliopectineal bursitis, which can also present spontaneously, that is, without any previous (hernia) surgery. Injury and overstrain are the main causes of this pain syndrome, which results in haemorrhage or fluid retention in the bursa [58]. As a consequence, a sterile inflammation of the iliopectineal bursa may occur. As previously mentioned, pain following CPIP may lead to an antalgic gait which occasionally leads to iliopectineal bursitis. Sometimes an enlarged bursa can be visualized using magnetic resonance imaging (MRI).

41.3.3 Combined Groin Pain Syndromes

41.3.3.1 Dysejaculation

Sexual complaints following inguinal hernia surgery are often ignored. Only a small portion of men spontaneously report sexual dysfunction after a standard mesh repair. Up to 3% of patients have a moderate to severe pain-related impairment of sexual activity following inguinal hernia repair [59]. Therefore, hernia surgeons should always check for the onset of sexual complaints when patients present with CPIP. Ideally, these issues must be discussed prior to hernia surgery.

Dysejaculation (pain just before, during or following ejaculation) is known to profoundly affect a patient's sexual activities [60]. The incidence of dysejaculation is approximately 3–4% following inguinal hernia repair [59–61] and may occur in male patients after both open and laparo-endoscopic repair techniques [60]. In one series of 100 men with CPIP, we encountered this phenomenon in some 30% [60]. The prevalence of ejaculatory pain is lower following laparo-endoscopic repair techniques compared to open repair [61].

The pathogenesis of dysejaculation involves injury to the vas deferens with or without damage to the inguinal nerves [59, 62, 63]. The vas may be compressed by the mesh or may be injured as a consequence of scar tissue. During ejaculation, peristalsis in the vas results in a post-obstructive dilation, triggering a spasm-related pain [64]. Mesh-related inflammatory responses (Sect. 41.3.2.1) may also injure the vas deferens. Previous studies have identified a potential role of the three inguinal nerves at risk in dysejaculation following open mesh repairs [59, 62, 65, 66]. The relative contribution of these separate nerves

regarding dysejaculation remains unknown. Successful effects of remedial surgery on sexual functioning, including a neurectomy (only), mesh removal and funicular release or a combination of these, support this mechanism of CPIP [60]. In one series, two out of three males reported serious improvement or disappearance of dysejaculation after these types of remedial surgery [60].

Mesh migrations due to insufficient fixation or as a result of a foreign body reaction [67] are other etiologic factors contributing to dysejaculation. These reactions may lead to erosion of the surrounding tissue. The grade of erosion highly depends on the biocompatibility of the material [67, 68]. Other factors influencing mesh biocompatibility include the type of material, pore size and rigidity [68]. Irrespective of the mechanism of erosion, invasion of meshes into the vas deferens can cause dysejaculation by the described mechanism.

The analogue of dysejaculation in men is post-orgasm pain in women, seen of course in CPIP, but also after neuropathic pain in the so-called post-caesarean section pain syndrome. It is our experience that a pure neurectomy in these women can result in relieve of this specific sexual problem. Percentages of post-orgasm pain in women after hernia mesh repair are unknown.

41.3.3.2 Orchialgia Versus Scrotal Pain

Another CPIP syndrome with both neuropathic and non-neuropathic characteristics is orchialgia [69, 70]. Orchialgia is defined as an intermittent or constant, unilateral or bilateral testicular pain [69]. Sometimes orchialgia is accompanied by dysejaculation [64]. Its aetiology and innervation of the testis are complex. Pain in the testes and epididymides is mediated by the autonomic nerve fibres that run along the internal spermatic vessels and on the surface of the vas deferens (so-called perivasal nerves), from the pelvic plexus originating in the Th10 to Th12 (testes) and Th12 to L1 segments (epididymides) [69, 70]. Since periprostatic application of local anaesthetics may relieve orchialgia, the idea is supported that the pelvic plexus supplies neural input to the testes [69]. The perivasal nerves may be injured during hernia repair by various ways including dissection of the spermatic cord or entrapment of the vas during open hernia repair techniques [70]. Injury due to the preperitoneal dissection or disruption of the autonomic fibres accompanying the vas can occur during laparo-endoscopic repairs, as well as placement of the mesh or additional fixation materials in proximity to these structures [54, 70–72]. As mentioned before, orchialgia is a combined CPIP syndrome that can include both neuropathic and nociceptive characteristics. The nociceptive causes for orchialgia are diverse and include postherniorrhaphy testicular ischemia, oedema, fibrosis of the spermatic cord and infection [70].

Orchialgia is particularly complicating as a significant overlap with inguinal and scrotal pain is present [70, 73]. However, since the testes themselves lack a somatic nerve innervation, it is essential to differentiate between true orchialgia and scrotal (skin) pain. Scrotal pain is neuropathic in origin and caused by the somatic genital branch of the genitofemoral nerve and/or the ilioinguinal nerve. Localized diagnostic injections with local anaesthetics may help to distinguish between these two types of CPIP (Sect. 41.4.5).

Apart from dysejaculation, orchialgia and scrotal pain, other sexual CPIP syndromes have been described, although less frequently seen. Dyspareunia (pain during sexual intercourse) is one such symptom. Its occurrence ranges from less than <1 to 3%, and literature on this phenomenon is scarce [59, 74, 75]. Pain in the penile shaft or glans is another such rare symptom [59].

41.4 Assessment

Concise history taking and an extensive physical examination provide the cornerstones in diagnosing inguinodynia. Clues for diagnosing the aetiology of CPIP are discussed below.

41.4.1 Patient's History

41.4.1.1 Diagnostic Clues for Neuropathic Pain

First, when a patient experiences excruciating pain immediately after inguinal hernia surgery, an acute reexploration is indicated. If postoperative

pain following a standard hernia repair develops later in the course of recovery or if pain persists after 3–6 months, a concise patient history and physical examination should indicate whether a patient suffers from neuropathic pain, from a nociceptive/inflammatory pain (either mesh related or by other origins) or a combination of these or from pain due to a recurrent hernia. However, the differential diagnosis for groin pain in general is extensive, and not all CPIP does necessarily have to be related to the previous surgery (Table 41.1).

Central in the neuropathic CPIP patient's history is a sharp, burning or shooting (electrical-shock-like) painful sensation which is progressive after repetitive stimulation. Paraesthesia (tingling, crawling ongoing non-painful sensations) and dysaesthesia (spontaneous or evoked unpleasant abnormal sensation) with radiation towards the associated skin area of the involved

Table 41.1 The differential diagnosis of chronic postoperative inguinal pain

Hernia surgery	*Orthopaedics*
Primary hernia	Acetabular labral tears
– Inguinal	Avascular necrosis
– Femoral	Chondritis dissecans
– Obturator	Legg-Calve-Perthes disease
Recurrent hernia	Osteoarthritis
Postherniorrhaphy	Pelvic stress fractures
– Neuropathic (including neuroma)	Slipped femoral capsule epiphysis
• Iliohypogastric	Snapping hip syndrome
• Ilioinguinal	– Anterior
• Genitofemoral	– Lateral
• Lateral femoral cutaneous	Synovitis
• Lower intercostal nerve (Th12)	Iliopectineal bursitis
• Deafferentation pain	Spondylolisthesis
• Centralized pain	Spondylolysis
– Non-neuropathic	
• Mesh related (including meshoma)	*Sports medicine*
• Adductor tendinopathy	Rectus strain
• Periostitis pubis (pubalgia)	Adductor tendinopathy
• Iliopectineal bursitis	Iliopsoas tendinopathy
– Combined (non-)neuropathic	Symphysiolysis/symphitis
• Dysejaculation	Sportsman's hernia (sports hernia)
• Orchialgia	
	Urology
Gynaecology	Postvasectomy pain syndrome[a]
Post-Pfannenstiel	Vas granuloma/fibrosis
– *Neuropathic*	Cystitis or urinary tract infection
• Iliohypogastric	Epididymitis
• Ilioinguinal	Prostatitis
Cervical cancer	Uro–/nephrolithiasis
Endometriosis	Torsion of the testis
– Intra-abdominal	
– Round ligament of the uterus	*Gastroenterology*
– Pfannenstiel incision	Appendicitis
Adnex disorders (including torsion)	Adhesions
Uterus myomatosis	Diverticulitis
	Irritable bowel syndrome
Vascular	Inflammatory retroperitoneal phlegmon[b]
Hematoma	Meckel diverticulitis
Varices	Granulomatous colitis

(continued)

Hernia surgery	*Orthopaedics*
Pelvic congestion syndrome	
Postvein stripping	*Oncology*
Pseudoaneurysm (catheterization)	Retroperitoneal neoplasm
Iliac/femoral artery aneurysm	Osseous metastasis pelvis/hip joint
Iliac/femoral artery stenosis	
Thrombosis	*Infectious disease*
Vascular graft	Herpes zoster
Abdominal aortic aneurysm[c]	HIV/tuberculosis
	Lyme disease
Dermatology	Psoas abscess
Lymphadenitis	
Psoriasis/burn	*Neurology*
Sebaceous cyst	Lumbosacral disorders
Thrombophlebitis	Neurofibromatosis
Cellulitis	Disc disease
Hidradenitis suppurativa	Spinal injuries
	Spinal tumours
Rheumatology	Spinal inflammation
Connective tissue disease	Anterior cutaneous nerve entrapment syndrome (ACNES)
Systemic lupus erythematosus	

[a]Entrapment genital branch of genitofemoral nerve
[b]Pancreatitis
[c]With compression of genitofemoral nerve

(inguinal) nerve are often reported. Depending on the affected nerve, pain may radiate towards the upper medial thigh (ilioinguinal nerve), the suprapubic region (iliohypogastric nerve) or the genitals or ventral upper leg (genitofemoral nerve, Fig. 41.2). Some patients may spontaneously complain of sensory disturbances in the groin area. It is known, however, that in clinical presentation a lot of overlap between these involved areas is possible.

Once it is decided to perform a surgical exploration for CPIP, it is important to consider the type of inguinal hernia repair, as the inguinal nerves at risk depend on the technique. During laparo-endoscopic hernia repair, a detailed exploration of both the 'triangle of doom' and the 'triangle of pain' is essential. Therefore, original operative reports of the primary repair should always be checked in detail, including intraoperative complications and identification of inguinal nerves. As a pragmatic neurectomy is recommended for inguinal nerves if considered at risk [49], the operative report may clarify on this issue. If a previous neurectomy was performed, the occurrence of a traumatic neuroma should be considered. The use of sutures, tackers, staples and other prosthetic materials may indicate whether neuropathic pain is caused by injury from these.

The time after inguinal hernia repair may indicate possible neuropathic aetiologies of CPIP. As stipulated earlier, immediate pain may be due to direct intraoperative nerve injury of mechanical effects to the nerves from surgery, whereas pain manifestation after weeks to months suggests CPIP from scar tissue formation or mesh-based inflammatory responses (Sect. 41.3.2.1). Of note, in patients with acute neuropathic postoperative pain following inguinal hernia repair who are unresponsive to all conservative and surgical treatments, deafferentation pain should be considered.

ACNES patients typically complain of a specific localized pain, within the lateral border of the rectus muscle. In over 90% of the cases, local somatosensory disturbances are present. Compared to groin pain, the pain is often located more proximally, towards the umbilical area

corresponding the lowest Th10, Th11 and Th12 intercostal nerves.

Centralized pain is independent of any peripheral drive. Distinction of centralized neuropathic pain cannot be done based on patient history only. Possibly, a spontaneous burning pain is more often present when pain is due to sensitization [76], but the same symptom may be present in other neuropathic pain syndromes.

41.4.1.2 Diagnostic Clues for Non-Neuropathic Pain

Patients with a non-neuropathic CPIP usually report a throbbing or nagging pain located in a non-neuroanatomical area [77]. Once again, it is important to consider the type of inguinal hernia repair. Fixation methods and the inserted type of mesh are important clues associated with non-neuropathic pain syndromes. Studying previous operative reports is crucial. Moreover, the duration of CPIP may contribute to the diagnosis.

Mesh-related CPIP is suspected when patients complain of a foreign body sensation or feeling of tightness in the groin area [28]. The pain is often aggravated during car driving or leg crossing (pressurizing the groin), whereas a supine position relieves mesh-related pain [28]. The same set of nociceptive pain characteristics are present in patients with a meshoma.

When patients or their partners notice an abnormal gait, musculoskeletal origins such as adductor tendinopathy or periostitis pubis (pubalgia) should be considered. Adductor tendinopathy typically relieves during rest and increases during physical activity when using the hip adductor muscles (in particular climbing stairs). The chance on these syndromes increases with the duration of CPIP. Excluding other disorders may lead to the diagnosis of more rare pain syndromes such as iliopectineal bursitis.

On the other hand, sexual complaints including dysejaculation are solely diagnosed on the basis of patient history taking since no physical findings can be noted. An intense burning, painful sensation that occurs just before, during or after ejaculation [64] confirms the diagnosis of dysejaculation. Orchialgia is experienced as an intermittent, squeezing, deep ache in the testis 'like the sensation the day after you got kicked there' [69, 78]. Sometimes the patient reports that it feels as if the testicle is pinched in the crotch of the underwear but trouser readjustment does not help. The onset of pain is commonly related to particular activities such as long car journeys or unsupported seating posture [69, 78].

41.4.1.3 Diagnostic Questionnaires

The French Neuropathic Pain Group developed a questionnaire (DN4) discriminating between neuropathic and non-neuropathic pain syndromes [79]. The DN4 questionnaire consists of both sensory descriptors and characteristics during physical examination [79]. This questionnaire was tested in a variety of neuropathic pain syndromes and demonstrated to be valid. Whether the questionnaire is also usable for distinguishing neuropathic from non-neuropathic CPIP patients needs to be investigated.

41.4.2 Physical Examination

41.4.2.1 Tests for Diagnosing Sensory Disturbances

All of the CPIP pain syndromes are characterized by distinct clinical signs and symptoms that can be used to differentiate between them. First, the presence of sensory disturbances is a key diagnostic feature for neuropathic CPIP and generally lacking in non-neuropathic pain.

An area of sensory deficit can be assessed by touching the skin of the alleged painful area with a cotton swab or gauze (Fig. 41.6). If the patient experiences a normal sensation in the area of pain, as compared to the contralateral side, neuropathic pain becomes less likely. Hypoaesthesia (reduced response to non-painful stimuli) is present if a reduced perception or numbness is experienced. This by itself can of course be present in any groin scar after hernia surgery. Nevertheless, patients with groin pain and hypoaesthesia experience this type of numbness as (very) annoying. Conversely, hyperaesthesia is present when an increased sensation to non-painful stimuli is reported. Allodynia can be tested likewise, but the stimulus evokes severe pain. When a sharp,

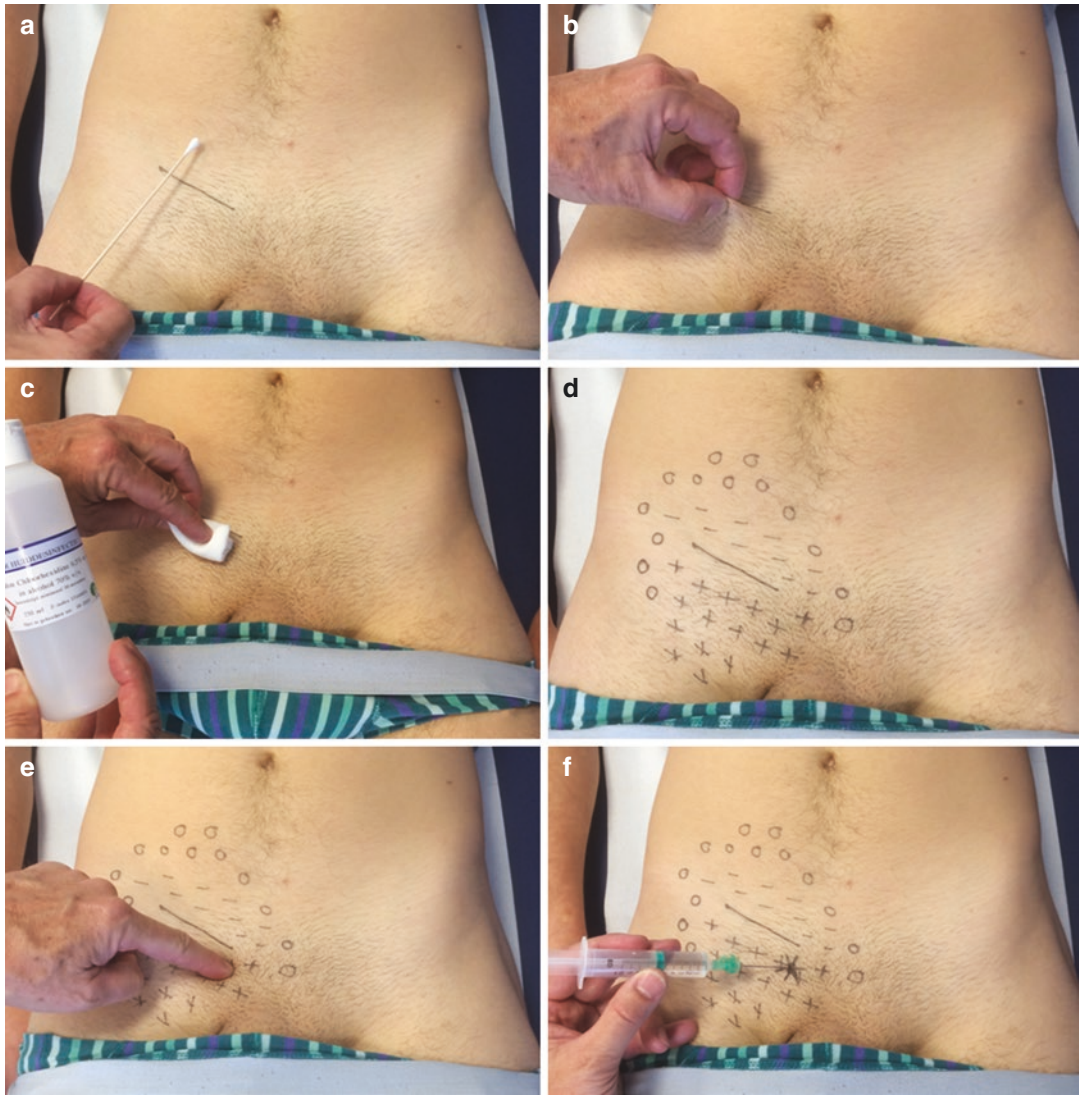

Fig. 41.6 Physical examination for sensory disturbances and identification of trigger points. Testing of sensory dysfunctions by touching the skin with a cotton swab (**a**), pinching of the skin (**b**), altered cold sensation assessed by a gauze soaked in liquid disinfectants (**c**). Results of the sensory mapping by these tests as illustrated by the drawing (**d**): decreased sensation (−), increased sensation (+), normal sensation (0). Identification of circumscriptive pain points using the index finger (**e**). End result of the sensory mapping in the inguinal region with a diagnostic local nerve block with 5 cc lidocaine 1% placed at the point of maximum pain (**f**)

burning and superficial pain in the primary affected zone is spreading into unaffected skin areas, allodynia is likely [30].

Pain sensation following pinching of the skin (Fig. 41.6) may be disproportionally painful (hyperalgesia). Positive sensory abnormalities such as hyperalgesia and hyperpathia (abnormally painful reaction to a stimulus, especially a repetitive stimulus, as well as an increased threshold) can both point towards at neuropathic CPIP [30]. Moreover, negative neurophysiologic phenomena including hypoaesthesia and hypoalgesia (diminished pain in response to a normally painful stimulus) also contribute to the picture [30].

Cold sensation can be assessed by the response to a gauze soaked in ethanol or other liquid disin-

fectants (Fig. 41.6). Responses as obtained during assessment with the cotton swab are graded as normal (0), decreased (−) or increased (+) to determine whether negative or positive sensory phenomena are involved. An altered cold perception is a characteristic of neuropathic pain syndromes. Of note, these can be both peripheral and centralized!

Tinel's test provokes the neuropathic pain by tapping the skin. If the ilioinguinal or iliohypogastric nerve is the suspected cause for CPIP, the pain can (occasionally) be reproduced by tapping medial to the anterosuperior spine of the iliac bone [17]. In case of other nerves, the test can be performed over an area of localized tenderness [17]. These simple investigations can be done during physical examination. A more sophisticated form is provided by quantitative sensory testing (QST), which may reveal various patterns of somatosensory disturbances (Sect. 41.4.5.2).

Differentiating between peripheral neuropathic and centralized pain is difficult as both are associated with somatosensory skin abnormalities. Patterns of complaints that cannot be explained by regular neuroanatomy may point some more towards central sensitization. Regarding physical examination, allodynia and hyperalgesia are more common in (spinal cord) centralized pain [76]. Since these somatosensory abnormalities do not exclude peripheral neuropathic pain, more definite diagnostics are needed. Specifically, when a point of maximum pain (trigger point) is found, peripheral origin is more likely. The response to a peripherally administered diagnostic injection using a local anaesthetic to this end can be very helpful in distinguishing from central pain and should be included in the standard work-up of CPIP patients (Sect. 41.4.5).

41.4.2.2 Localization of Pain

Peripheral neuropathic pain following inguinal hernia repair is associated with an inguinal area of sensory abnormalities. Within this affected inguinal skin area, a point of maximum pain can often be identified by palpation (Fig. 41.6). Typical 'trigger points' (circumscriptive pain point about one fingertip in diameter) are often found when an inguinal nerve is affected as the cause of the CPIP. Carnett's test can be performed by putting a finger (or a cotton swab) on the trigger point. Whereas the finger remains positioned onto the painful spot, tenderness increases when abdominal muscles are tensed as the patient lifts his/her head. Of note, centralized pain often lacks any of these specific trigger points. Pure non-neuropathic pain syndromes do not demonstrate any of these neuropathic characteristics also.

Additional clues for mesh-related pain during physical examination are a painful deep palpation along the inguinal ligament over a ≥5 cm length or over the mesh itself. The mesh-related pain is more diffuse but follows the contours of the mesh. Sometimes the mesh as an actual meshoma is palpable in nonobese patients [28].

When pain is not localized in the inguinal canal and sensory disturbances are not present, both periostitis pubis and adductor tendinopathy are possible causes for the non-neuropathic CPIP. It is critical to differentiate between the two. Periostitis pubis (pubalgia) can be diagnosed by exerting local pressure on the pubic tubercle. Local pain increases if pressure is applied to the affected side of the pubic bone [15]. Adductor tendinopathy is characterized by pain at the origin of the adductors muscles on the inferior side of the pubic ramus. Subtle flexion and exorotation of the hip exert tension on these muscles and help to identify the origin. Palpation along the tendons and muscle is particularly painful, especially when performed against resistance following hip endorotation.

The point of maximum pain in iliopectineal bursitis can be found halfway between the anterior superior iliac spine and the pubic tubercle, just distal from the middle portion of the inguinal ligament. Provocation by leg endorotation with a flexed hip and knee may worsen the pain.

Patients with dysejaculation may demonstrate maximum pain along the spermatic cord or at the superficial ring of the inguinal canal. A recent study demonstrated pain at this external inguinal annulus in all of the studied dysejaculation patients, but not in CPIP controls without sexual dysfunction [62]. Other locations of ejaculatory pain have been described, including the inguinal region, testes/scrotal region and lower abdomen, thigh, penile

shaft and anal region [61]. Nonetheless, dysejaculation may be present without any specific maximum pain points.

Orchialgia can be provoked by light compression of the testis or epididymis. Depending on the aetiology (Sect. 41.3.3.2), sometimes enlargement or atrophy of the testicles can be seen during physical examination, or epididymal swellings are present during palpation [70]. However, as in dysejaculation, most patients have no abnormality during physical examination [69].

41.4.2.3 Musculoskeletal Examination

Hip movement examination is particularly helpful in non-neuropathic pain syndromes. Flexion of the hip typically increases pain if mesh related [28]. If pain can be provoked by adduction of the leg against resistance, the presence of an adductor tendinopathy is likely. Iliopectineal bursitis results in pain after pressure on or stretching of the bursal wall during provocation tests [58]. These provocative tests can be performed by active movement and include the maximum range of flexion, extension, abduction as well as endorotation and exorotation of the hip joint. Of note, a full range of motion is present, and passive movements are not restrained, in contrast to diseases of the hip joint such as osteoarthritis. Mounting a male bicycle that requires abduction, extension and exorotation of the affected leg is particularly painful for patients with iliopectineal bursitis [58].

41.4.2.4 Spine Examination

A small number of patients suffer from CPIP that is originating from the back. Therefore, a standard examination of the lumbar spine should be performed when evaluating these patients. When pain is provoked during spine movement or by paravertebral palpation of the lumbosacral spine, further evaluation of the spine's role is mandatory, ideally by a neurologist.

41.4.3 Pitfalls

It is of utmost importance to note that experience with these pain syndromes is conditional. The authors are aware of their own learning curve, while analysis from own collected data over time appeared very helpful to this end. It is difficult to explain to other than hernia specialists the more subjective aspects of examining of patients, while recognizing specific patterns of complaints in the daily clinical setting becomes more and more important over time.

It must be appreciated that the anatomy of the inguinal nerves can vary widely [80]. A thorough knowledge on the complex groin anatomy and these anatomic variations is critical in understanding the characteristics of CPIP. Peripheral communication between the inguinal nerves, overlap of their sensory innervation and involvement of more than one nerve in CPIP make the identification of specific injured nerves even more difficult [17, 81]. Furthermore, secondary hyperalgesia (a spread of hypersensitivity to initially unaffected nerves) as detected during a physical examination can also trick the physician [41]. This symptom sometimes results in contralateral segmental changes, clinically demonstrated by projection of pain on the contralateral side (also called 'mirror pain'). Hence, an examination at mirror sites might not necessarily represent a true control [30]. Another rare phenomenon is the observation that patients with peripheral nerve injury can suffer from an almost pure hypersensitive syndrome, in which sensory deficits may be absent [76].

Do not overlook causes for inguinal pain other than following an inguinal hernia repair! Endometriosis (i.e. growth of uterine mucosa outside of the uterine cavity) may cause pain in the female inguinal region. Especially when a Pfannenstiel incision was previously performed, endometriosis of the abdominal wall may be present. Typically, females complain of a pain that varies in intensity throughout the menstrual cycle and/or of dysmenorrhoea (pain increasing during the menstruation period). Dyspareunia and sometimes adhesions with subsequent fertility problems may direct towards endometriosis.

Apart from CPIP pain characteristics, questions regarding gastrointestinal complaints should also be asked. Nausea and tendency to vomit may occasionally be present in CPIP via a reflex mechanism. This phenomenon is a type of central somatovisceral integration which can

result in this specific type of referred visceral pain. These complaints may typically mimic, for instance, a stomach ache, although the pain is resistant to stomach-protecting medications. Such discomfort is a characteristic example of a segmentally related complaint. Removal of the trigger continuously supporting this afferent input can result in an immediate relief of the visceral discomfort (Fig. 41.5). Caution is warranted as a 'true visceral component' should be excluded. On the other hand, visceral pain may also demonstrate altered skin sensations [82] that are similar as observed in neuropathic CPIP. This is possibly an expression of segmental phenomena as originally described by Head [83]. Sensory disturbances may also be present in iliopectineal bursitis. An inflamed iliopectineal bursa may compress adjacent tissues including the genitofemoral nerve and funiculus. As a consequence, the right diagnosis is often not suspected if one focuses just on these irradiating pains [58]. Similarly, retroperitoneal tumours and aneurysms may exert pressure on groin nerves leading to pain that is experienced in the groin or upper leg.

As stated earlier, original operative reports of the primary repair should always be checked in detail since consecutive steps of hernia repair may not always have been followed during the index operation [84]. If a procedure is not performed lege artis, CPIP may be an immediate consequence. A typical example illustrating a faulty order of steps is a case in which the spermatic cord was split during a Lichtenstein repair, while the mesh was placed over the medial portion causing severe inguinodynia by compression of the genital branch of the genitofemoral nerve over the pubic bone [85].

If postherniorrhaphy visceral complaints develop over the years following a mesh-based repair, migration of the prosthetic material compromising the viscera should be considered in the differential diagnosis. Plugs in particular have a greater tendency to migrate when compared to flat meshes [49]. Migration of prosthetic material can also cause a foreign body reaction [67]. These reactions may lead to erosion of the tissue surrounding the plug (or mesh, in a similar configuration called a meshoma). Irrespective of the mechanism of erosion, invasion of plugs (or meshes) into the viscera of the gastrointestinal tract, urinary bladder or even vessels is a potentially devastating long-term complication. Although rare, previous cases of intestinal obstruction and/or perforation due to migration of meshes have been described [67].

41.4.4 Imaging

41.4.4.1 Ultrasonography

It is imperative to appreciate that imaging techniques often fail to contribute to a proper diagnosis in CPIP. Ultrasonography is a simple and fast method and is only useful in excluding diagnosis such as an occult hernia recurrence. When a patient is presenting with orchialgia, this imaging technique is helpful to exclude occult testicular neoplasms, epididymal cysts or varicoceles [86]. However, these clinically occult radiological abnormalities are usually coincidental and are often not the cause of orchialgia [69].

41.4.4.2 Computed Tomography

Computed tomography (CT) scan can be a valuable tool for diagnosing non-neuropathic origins of CPIP. When a meshoma is suspected, this imaging technique may confirm the diagnosis and provide a road map for the operating surgeon for the exact location of a meshoma in relation to critical anatomic structures including the iliac vessels [52]. However, the attending radiologists must be familiar with this phenomenon. Otherwise, images are usually interpreted as non-specific postsurgical changes, non-specific tissue densities or lymph nodes [52]. CT scanning can be helpful to exclude or show other entities within the differential diagnosis such as retroperitoneal tumours or aneurysms.

41.4.4.3 Magnetic Resonance Imaging

In rare cases, MRI may reveal a neuroma as a cause of neuropathic CPIP, but the clinical value of this finding is unclear. For non-neuropathic CPIP, MRI may have an additional value for periostitis, since the T2-weighted MRI may indicate bone marrow oedema [57]. However, one study demonstrated that abnormal MRI findings were

also common in asymptomatic athletes, which decreases its specificity [87]. MRI can also be very helpful in the case of endometriosis.

MRI may confirm the presence of a flat non-wrinkled mesh, but specific causes of CPIP are not identified [88]. A meshoma can be seen on MRI, but again, radiologists only establish an accurate diagnosis when they are familiar with this phenomenon [52]. Furthermore, its presence does not bear a relationship with the presence of CPIP, and low interobserver agreements for pathologic alterations following inguinal hernia repair were previously demonstrated [89]. Furthermore, MRI does not contribute to elucidating the underlying pathology in CPIP as it is not specific, whereas differences in images of painful and pain-free operated groins were also not observed [89, 90]. A recent study on mesh removal showed that previous reports of MRI scans in patients who intraoperatively had a meshoma never mentioned a meshoma [28]. In conclusion, imaging is only helpful in ruling out other pathologies and should only be performed on strict indication with specific inquiries.

41.4.5 Other Diagnostics

41.4.5.1 Diagnostic Injections

Local Anaesthetic Agents

A diagnostic local nerve block with a local anaesthetic agent (e.g. 5–10 mL lidocaine 1%) may aid in distinguishing neuropathic from non-neuropathic causes of CPIP [91, 92]. Theoretically, if pain is truly peripheral and purely neuropathic of origin, local nerve blocks should relieve the pain, at least temporarily. The underlying mechanism involves the downregulation of specific subtypes of voltage-gated sodium channels, associated with an increased electrical excitability, which are upregulated in damaged peripheral nerves [76]. It is hypothesized that the nerves involved in neuropathic pain syndromes may express a unique profile of these sodium channels [93], and abnormal profiles are reset by a peripheral nerve block.

The diagnostic injection should be preferably placed at the point of maximum pain (Fig. 46.6f), instead of a standard 1–2 cm superior and medial to the anterior superior iliac spine, as demonstrated by two trials using ultrasound-guided nerve blocks [94, 95]. Besides its diagnostic value, local anaesthetics may also have a therapeutic potential. Interestingly, a recent randomized controlled trial demonstrated that 22% of patients benefitted from these injections in the long term (i.e. 6 months) [96]. An explanation may be that lidocaine decreases sensitization and therefore acts beyond its pharmacological duration of action, as mentioned above.

Corticosteroids

Corticosteroids are known for their anti-inflammatory actions and are utilized for almost all chronic pain syndromes [97]. In CPIP, the addition of corticosteroids may theoretically enhance and prolong the treatment effect [98, 99]. The addition of corticosteroids may seem logical if CPIP is based upon an entrapment mechanism associated with inflammation and ischemia [100, 101]. A previous systematic review studying the effect of addition of corticosteroids compared to a local anaesthetic agent alone in compression neuropathies demonstrated an additional benefit of steroids, despite the low quality of the analysed studies [99]. Preclinical experiments suggest that corticosteroids may reduce neuropathic pain, but paradoxical increasing pain has also been shown [102].

Since steroids are almost always standardly combined with local anaesthetics, there is just no simple way of determining which of the two agents exerts the beneficial effect. Inflammatory pain syndromes such as periostitis pubis and mesh-related pain may be treated and diagnosed by combined injections of steroids with local anaesthetics that are deposited at the pubic bone or at the site of the mesh, respectively [103]. However, this and other uses of additional corticosteroids are rather based on alleged mechanisms of action than clinically demonstrated with a high level of evidence. The pathophysiological basis underlying a pain syndrome will probably determine whether steroids are a valuable addition to injection therapy [101].

41.4.5.2 Quantitative Sensory Testing

Altered groin skin sensation is quite common following (open) inguinal hernia repair and may become more prevalent over time [20]. These somatosensory disturbances vary from negative to positive neuropathic signs. Most simple and reliable tests can be done during physical examination, as explained in Sect. 41.4.2. A more sophisticated neurophysiological technique is quantitative sensory testing (QST), which may reveal various patterns of somatosensory disturbances. QST uses a battery of standardized mechanical and thermal stimuli. When present, allodynia or hyperalgesia can be quantified by measuring intensity, threshold for elicitation, duration and area [30].

The information from QST, however, does not change the clinical outcome of information nor shows typical predictive patterns recognized in literature up till now. Furthermore, patterns of QST and potential correlations with treatment modalities and outcomes are still unclear.

41.4.5.3 Other Imaging Techniques

Other imaging techniques for CPIP include a technetium bone scan for periostitis, which may reveal an enhanced isotope uptake of pubic bone [57]. Magnetic resonance (MR) neurography, a new technology based on the water content of the nerve fibres, has been described as a diagnostic tool for neuropathic pain. However, the exact role of this technique regarding nerve involvement is not yet fully established [17].

Conclusion

In this chapter, pain syndromes are classified as neuropathic or non-neuropathic. However, differentiation between neuropathic and non-neuropathic pain is often difficult, if not impossible, as entirely objective diagnostic measurements are currently lacking [4]. A combined pain syndrome entailing neuropathic and nociceptive elements is not uncommon following hernia repair. As illustrated in Fig. 41.1, CPIP syndromes are all part of a spectrum rather than distinct entities. A work-up by hernia pain experts is mandatory for correct interpretation and for suggesting a tailored treatment.

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42 Postoperative Chronic Pain Assessment and THOPA Philosophy

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42.1 Clinical Assessment

PCP (postoperative chronic pain) was formally defined in 2008 as a new or different quality of pain (if pain existed before hernia repair) arising as a direct consequence of a nerve lesion or disease affecting the somatosensory system after inguinal hernia repair [1].

For this reason, when a patient complaining of PCP comes to our attention, it is important to collect a thorough clinical history and ensure if the onset of the pain is prior to the inguinal hernia repair or it is subsequent to surgery, and the same is done when assessing for the type and quality of pain.

If pain was preexisting inguinal hernia repair, did it have typical features of pain related to a real hernia with discomfort associated with prolonged walking and/or upright position and did it decrease and disappear with lying position? Or perhaps, patient is suffering since the beginning from a pain related to physical and/or sport activity and he did not refer the presence of a real swelling?

In fact, patients with unusual preoperative inguinal pain in an imperceptible hernia (typically 0.5–10 mm at ultrasound) should be evaluated with attention, and often a proper physical examination and clinical history investigation should have revealed a different cause for their pain: back disease, hip pathologies, pubic bone or tendon injuries, etc.

Among all these pathologies that can cause inguinodynia, the so-called pubic inguinal pain syndrome (PIPS; see Chap. 38) [2] or sportsman hernia is often wrongly labeled inguinal hernia and treated like it were. We would strongly underline that PIPS is a situation that cannot only occur in sportsmen but also even in population with normal physical activity and that it absolutely is not a real hernia. This has to be deeply kept in mind when we deal with a case of PCP: indeed, this could be the results of a misdiagnosis and an incorrect treatment.

Sometimes, a preexisting PIPS can be complicated by nerve lesion or disease affecting the somatosensory system during the surgery, and a PCP complicates and makes worse the preoperative PIPS symptoms.

Just considering the etiology of both syndromes, we can try to resolve the symptoms.

So, once the diagnosis of PCP is done, we proceed with the review of history and performed exam (US, CT, etc.) and the surgical report: type of anesthesia, approach (anterior, posterior, open, laparoscopic), type of hernia isolated and treated

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(medial, lateral, or both), type of mesh (synthetic, absorbable, non-absorbable, biological, flat and/or plug, or 3D), placement of the mesh and fixation (suture, glue, staple), identification and preservation or neurectomy of the three nerves of the region, and, if open approach, the placement of the cord at the end of the procedure (subaponeurotic or subcutaneous space).

Etiology of PCP includes non-neuropathic and neuropathic causes, visceral and somatic pain. Non-neuropathic causes include hernia recurrence, muscle strain, and mechanical pressure of rolled-up or wadded mesh and folded prosthetic material (the so-called meshoma [3]) or of excessive scar tissue on the adjacent tissue including the vas deferens and nerves. Neuropathic pain can be caused by (a) compression of one or more nerves by "perineural fibrosis," suture material, staples and tacks, and prosthetic material or (b) actual nerve injury caused by partial or complete transection of nerves due to accidental cutting or excessive traction of the nerves.

Hernia recurrence with intestinal involvement, incarceration, or mesh adherence to the intestine can contribute to visceral pain. Additionally, involvement of the spermatic cord (funiculodynia), periurethral structures, venous congestion of the spermatic cord, dyssynergia of the ejaculatory effector muscles, stricture of the vas deferens, or twisting of the spermatic cord can cause visceral pain [4].

The most commonly and well-described pain syndrome to fall under somatic pain is periostitis pubis. This is commonly caused by deeply placed anchoring sutures or actual periosteal anchoring of the mesh to the pubic tubercle [5–7]. Evidently, a mix of causes (neuropathic, non-neuropathic, visceral, and somatic) can be present.

Distinguishing between neuropathic and non-neuropathic or visceral pain is complicated by excitatory coupling between sympathetic and afferent nociceptive nerve fibers, neuroplasticity, deafferentation, hyperalgesia, pain centralization, and socioeconomic, genetic, and patient-related factors [4].

Some questionnaires have been proposed to value neurophysiological assessment and personality, and these include the Short-Form McGill Pain Questionnaire, Neuropathic Pain Questionnaire, Douleur Neuropathique 4 Questions, 36-Item Short-Form Health Survey, Activity Assessment Scale [8], Dermatome Mapping Test (DMT), and MMPI-2® (Minnesota Multiphasic Personality Inventory-2® test) [9], but today none of these is recognized to be able to identify the real cause of pain, address to a specific treatment, or predict the therapy outcome.

A thorough physical examination is predicated on in-depth knowledge of the groin neuroanatomy. An understanding of the anatomic course of the three inguinal nerves and their dermatomes and the presence of hernia recurrence or meshoma is crucial. Tinel test (tapping skin medial to anterior superior iliac spine or over the area of maximal tenderness) can reproduce neuropathic pain along the sensory distribution of the affected nerves.

Distinguishing between individual inguinal nerves is often more difficult because of overlapping sensory innervations, peripheral communication, and common routes of origin [8, 10].

Normally a patient with PCP undergoes various radiologic evaluations, often without getting to the cause of the pain.

While pain-generating complications like hematoma or abscess formation are likely to be visible with any modality (ultrasound, computed tomography, magnetic resonance), most other complications are subtle in nature. Excluding frank recurrence, mesh abnormalities such as migration, meshoma, or mesh reaction are outside the scope of ultrasound (US) evaluation and may be of indeterminate significance on computed tomography (CT). Inappropriate nerve division, in particular, requires magnetic resonance (MR) imaging, as neuroma is currently beyond the capability of CT. MR neurograms are specifically protocoled non-contrast MR images that allow for high-resolution evaluation of the peripheral nervous system but suffer from low signal-to-noise ratios and should ideally be performed with a 3 T magnet if available. Osteitis pubis can be diagnosed on MRI based on signs of inflammation at the pubic symphysis. For patients with histories consistent with sports injuries, osteitis pubis, or hip joint injury, MR of the groin

and/or hip is likely to provide the most high-yield information. Moreover, a MR of lumbar-sacral column and pelvis is useful to identify a different cause of pain, other than postoperative pain: hip joint injury such as stress fractures, labral tears, femoroacetabular impingement, and iliopsoas bursitis. As such, MR should be considered as both the definitive and first-line modality for the most specific evaluation of the PCP. However, this modality is radiologist dependent [11].

42.2 Treatment

Data in the literature are poor and inconsistent due to limited information on the preoperative demographics, differences in definition and evaluation of pain degree, and limited follow-up, so comparison among different strategies and their results is very difficult.

As previously written, PCP is a product of neuropathic and nociceptive pain and is also influenced by socioeconomic, emotional, cognitive, and genetic factors. So, a multimodal, multidisciplinary approach to PCP is therefore necessary. Early involvement and cooperation with pain management specialists are important for the optimal management of these patients.

Initial acute postoperative pain treatment should be as effective as possible, and standard pharmacological pain treatment (gabapentanoids, tricyclics, etc.) [12] for neuropathic pain should be instituted earlier in patients with severe pain. The question of whether this may reduce development of chronic pain is debatable in the absence of any conclusive data [13].

It has been proven that analgesic patches (lidocaine patch (5%) and capsaicin (8%)) do not reduce summed pain intensity (at rest, during movement, and during pressure) [14].

Nerve infiltration with anesthetics is a minimally invasive technique for treating peripheral neuropathy after inguinal surgery [15, 16]. Varying success rates have been reported, but the relative ease of application is a main advantage [17, 18]. Several studies [19–27] reported the use of diagnostic blocks presurgery. The use of ultrasound-guided regional anesthesia has increased in the last decade and enables direct visualization of peripheral nerves, facilitating the success rate of the blocks [17]. However, there is no scientific evidence of any short-term or long-term analgesic efficacy of local anesthetic blocks in PCP following inguinal hernia repair.

If nerve blocks do provide short-term relief, the patient should subsequently benefit from neurolytic or neuroablative techniques. These include chemical neurolysis with alcohol or phenol, cryoablation, or pulsed radiofrequency ablation. Several different techniques of neuromodulation have been proposed. Pulsed radiofrequency (PRF) is an invasive pain treatment technique that employs electromagnetic energy deposited in or near nerve tissue [28, 29]. An insulated needle with an active tip is inserted at the vertebral level or at the peripheral level. Paresthesias are then elicited in the painful area, by electrical stimulation as an indication of adequate positioning of the needle tip. The voltage applied to the treatment needle is rapidly raised and lowered, with voltages typically alternating between 0 and 40 V with a frequency of 300–500 kHz. The temperature is held below 42 °C avoiding structural damage to the nerve tissue. The moderate heating of the nerve tissue is believed to temporarily block the nerve conduction.

Conventional continuous radiofrequency (CRF) produces temperatures at the tip of the treatment needle of 45–80 °C leading to irreversible thermocoagulation of nerve structures and has proven to be considerably more efficacious than PRF in various chronic pain states [28]. A recent retrospective uncontrolled study reported a longer duration of pain relief in the CRF group than in the local anesthetic block group at 12-month control [30].

Peripheral nerve stimulation utilizing a transperitoneal laparoscopic approach with selective implantation of quadripolar electrodes at the genitofemoral nerve (anterior surface psoas major muscle) or ilioinguinal nerve, iliohypogastric nerve, and femoro-cutaneous lateral nerve (anterior surface quadratus lumborum muscle) has recently been presented with promising result [31].

Although preliminary reports with neuromodulation techniques are enthusiastic and promising, the evidence is still of low quality, and the strength of recommendation is weak to moderate [29]. The scientific rigor is generally not considered adequate, and study designs should be improved in regard to control groups, randomization, blinding procedures, and adequate sampling sizes [32].

Patients who are refractory to a conservative regimen can be considered for operative intervention. However, successful surgical management is entirely dependent on selecting patients with discrete, neuroanatomic problems that can be corrected with previous surgery [33].

The working group of the international guidelines for prevention and management of PCP following inguinal hernia repair decided to consider reasonable surgical treatment only after 1 year postoperatively, when the inflammatory response has decreased and only when pain intensity curtails activity and conventional treatment has failed (L.E. 5, G.R.D) [33].

Neuropathic pain not present before the operation, isolated to the inguinal distribution, with demonstrated improvement from diagnostic and therapeutic nerve blocks is most likely to benefit from operative neurectomy [4].

Surgical options proposed in literature for the treatment of PCP are various and include selective neurolysis or neurectomy alone or along with removal of mesh and fixation material with revision of prior hernia repair [9, 10, 19–25, 32, 34–47]. Most of the studies reported an open surgical approach, few studies reported a laparoscopic approach, and only three studies reported a combined approach. Consistently satisfactory results in the majority of patients are reported.

Selective neurolysis or neurectomy may improve a small subset of patients with PCP [19, 25, 26, 40, 43]. However, electron microscopy of grossly normal nerves resected during triple neurectomy for CPIP demonstrates ultrastructural damage contributing to PCP but unseen to the naked eye [7, 19, 25, 40, 43]. There is also significant variation and cross innervation of the inguinal nerves in the retroperitoneum and inguinal canal, resulting in an overlap of their sensory innervation, that make selective neurectomy less reliable [19, 33, 48].

For these reasons, we always prefer triple neurectomy.

About follow-up, it is important to remember that nerve transection is known be associated with delayed onset of neuropathic pain symptoms, from months to years, so extended follow-up times are suggested [32].

Data on surgical management clearly demonstrate that neurectomy with or without mesh removal may provide long-lasting analgesic effects in most patients with severe PCP following inguinal hernia repair.

Open anterior approach involves re-exploration through the prior operative field, and it permits the removal of mesh and fixation placed in the previous surgery but could be frustrating and challenging to proceed in a scarred field to identify nerve, and so the approach could become unreliable.

Endoscopic access in the retroperitoneum allows for the identification of the ilioinguinal nerve (IIN) and iliohypogastric nerve (IHN) at the L1 nerve root overlying the quadratus lumborum and the genital and femoral branches of the genitofemoral nerve (GFN) exiting from the psoas muscle [21–23, 27]. The advantage of this operation is the proximal access to potential sites of peripheral neuropathy safety and separation from the scar tissue of any prior inguinal hernia repair, but mesh or plug removal is not feasible in this way [21–23, 27].

After a clinical experience of more than 100 patients with PCP, we drafted and normally adopt the Total Hope Pain Solving Approach (THOPA.): in this approach, we try to operate "against" all the possible causes of pain in order to improve the patient's chance to fix his painful symptoms.

So, we propose a total simultaneous double anterior-posterior open approach to the inguinal region: through a 6–8-cm-long suprapubic transverse lateral incision, 2 cm below the anterior superior iliac spine (Fig. 42.1), we first approach the preperitoneal space, and we identify IIN and IHN on the quadratus lumborum (Fig. 42.2) and the genital and femoral branches of the GFN running on the psoas muscle (Fig. 42.2) or along the

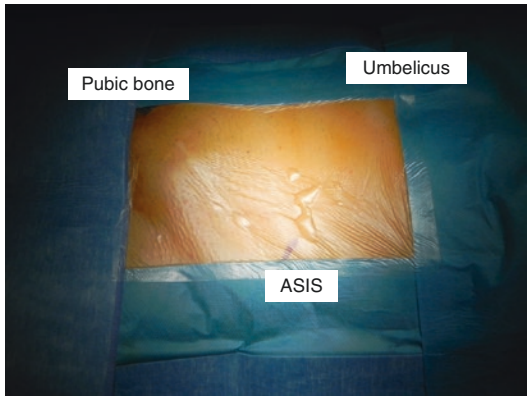

Fig. 42.1 Left inguinal region, the incision line (dotted) is 2 cm below the anterior superior iliac spine (ASIS)

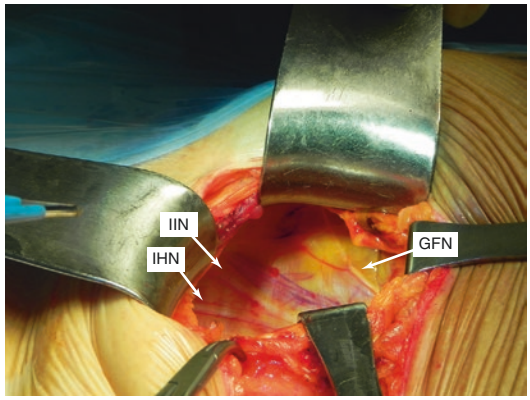

Fig. 42.2 Right side, approach to the preperitoneal space and identification of iliohypogastric nerve (IHN) and ilioinguinal nerve (IIN) running on the quadratus lumborum muscle and of the genitofemoral nerve (GFN) running on the psoas muscle

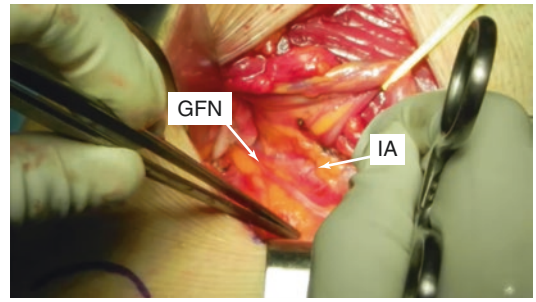

Fig. 42.3 Right side, genitofemoral nerve (GFN) running along the iliac artery

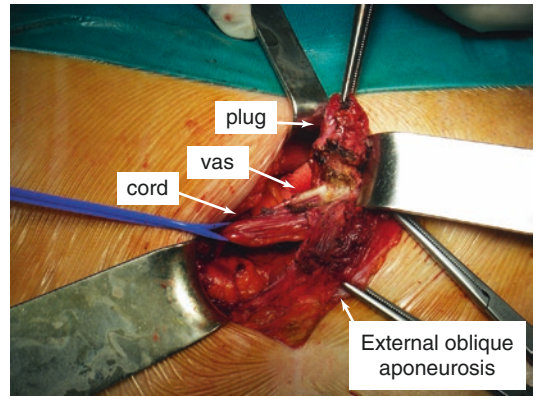

Fig. 42.4 Plug previously placed is carefully divided from the cord and removed during the preperitoneal approach

iliac artery (Fig. 42.3) and proceed with triple neurectomy.

Proceeding with a blunt dissection at retropubic level, the Retzius space is reached and Cooper's ligaments are identified. Going from the pubic symphysis toward the psoas muscle, the Bogros space is approached, and the external iliac vessels, the cord, and the recurrent hernia sac, if present, are identified.

If a plug has been placed during previous surgery, it can be safely removed now (even if not always easily) (Fig. 42.4).

If a mesh has been placed in the preperitoneal space during the previous surgery, blunt dissection and its removal can be challenging: in this case, we suggest to open the peritoneum, access the abdominal cavity, and, after the viscera have been safely reduced, cut the peritoneum all around the mesh previously implanted. The peritoneal cavity can be closed then with a running suture or with a bridged vicryl or biological mesh, in case of loss of substance. Only in this way, then it is possible to focus on the mesh and remove it safely.

Then, through the same incision, after the dissection of the skin and subcutaneous space toward the pubic bone, the anterior region is approached (Fig. 42.5), the external oblique aponeurosis is open, and the meshoma or mesh and suture or stitches placed can be completely removed (Fig. 42.6). It is important to remember that the cord may be found below the fascia

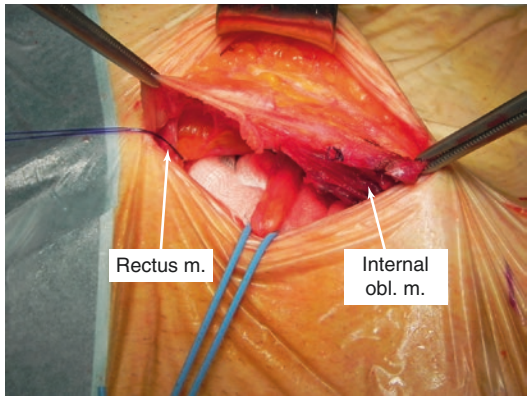

Fig. 42.5 The drawing shows the double (anterior and posterior) approach through the same incision in the right inguinal region

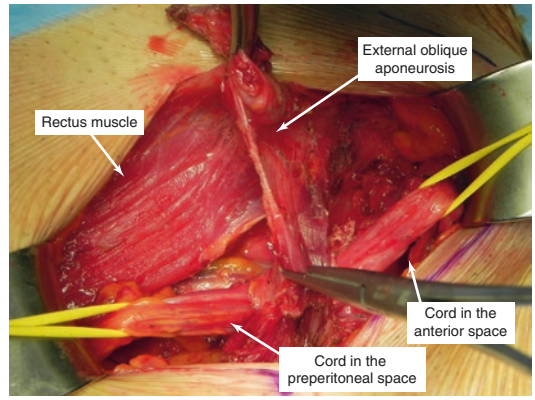

Fig. 42.7 Left inguinal region after posterior and anterior approach and removal of mesh previously placed. The cord is isolated in both approaches

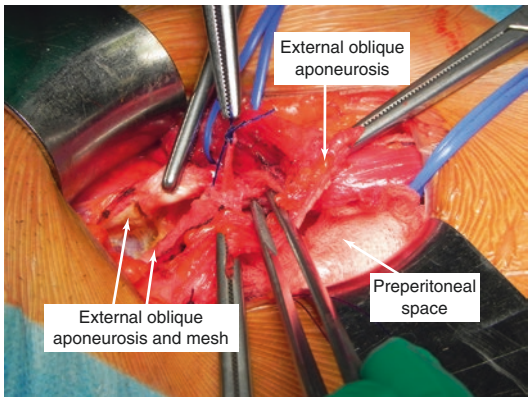

Fig. 42.6 Left inguinal region, the anterior region is approached and the external oblique aponeurosis is open: one nerve, probably the ilioinguinal, is isolated enclosed in scar tissue and mesh previously placed

but also above the fascia, in the subcutaneous space, depending on the technique used in the previous surgery. So, a prudent dissection is required to identify and preserve the cord. The IIN and IHN and the genital branch of GFN can be sometimes reidentified and resected once again (even if in scar tissue it is not reliable) (Fig. 42.7).

If, during preoperative evaluation of the patient, we understand that a PIPS was likely misdiagnosed and treated like an hernia and the patient is still suffering from PIPS, we complete the surgery with a partial calibrated tenotomy of the abdominal rectus muscle and longus adductor muscle, like we usually do in PIPS treatment (see Chap. 38) [49]. Both tenotomies can be feasibly achieved during the anterior step at the approach.

Finally, a new reinforcement is done with an ultralight or biological mesh in the preperitoneal space fixed with glue [9].

We remove always the mesh previously placed because the real reason of pain (neuropathic or non-neuropathic) cannot be surely detected. The choice of placing a new mesh in the preperitoneal space is due to the fact that, even if at the moment of surgery no recurrence is present, the removal of mesh previously placed should make the posterior inguinal wall weak. For this reason, an ultralight mesh is normally implanted.

In our experience (follow-up ranges between 6 and 108 months), 80% of patients are free of pain at 1 year after surgery. As previously written, the late evaluation (almost 1 year) is important because nerve transection can be associated with delayed onset of neuropathic pain symptoms.

In patients who underwent also a double partial calibrated tenotomy, a physio-kinetic program is established.

We wonder often what the reason of persisting pain could be in some patients (20%), even if all patients suffered with similar preoperative symptoms and underwent the same surgical procedure. We think that psychological attitude should be investigated, and we included the MMPI-2® test in the preoperative evaluations, but, until now, no clear connection has been found.

We strongly believe that more attention should be paid to identify a test that can determine the real cause of pain and optimize nonsurgical and surgical options.

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43 Laparoscopic Approaches to Chronic Postoperative Inguinal Pain

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Inguinal hernia repair continues to be one of the most commonly performed operations, with an estimated 20 million cases performed worldwide and 800,000 in the United States per year [1–3]. The introduction of mesh and refinement of tension-free techniques have markedly reduced recurrence rates and improved patient outcomes. However, chronic postoperative inguinal pain (CPIP) remains a significant complication. This is defined as a new or different quality of pain persisting 3 months after the hernia has been repaired. Up to 63% of patients are affected by some degree of chronic pain, with 6–8% experiencing significant interference with quality of life and activities of daily living [3–6].

CPIP can happen for multiple reasons. Hernia recurrence must be ruled out. The patient can also experience neuropathic pain associated with injury to the ilioinguinal, iliohypogastric, genitofemoral, and lateral femoral cutaneous nerves. These injuries can happen during dissection, tissue handling, mesh fixation, or scarring. Nociceptive pain is another culprit, associated with tissue injury and inflammation caused by tissue handling and trauma or foreign body inflammation due to meshoma [3–12]. Management of CPIP is difficult as there is often not a discrete distinction between nociceptive and neuropathic pain. Diagnosis is also often complicated by psychosocial factors.

Most patients are successfully treated with multimodal pharmacologic, interventional, and behavioral therapies through a multidisciplinary approach involving surgeons, pain specialists, radiologists, psychiatrists, and primary physicians [3]. Some patients, however, will require remedial surgery. With regard to neuropathic inguinodynia, the most definitive of these surgeries is a triple neurectomy of the ilioinguinal, iliohypogastric, and genitofemoral nerves. This was first described as a two-stage operation approached through the inguinal and retroperitoneal fields but was refined by Amid into a single-stage, open operation in 1995. Recent technical modifications have yielded response rates of 85–95% [13].

With the evolution of mesh-based, tension-free repairs, recurrence rates declined, and pain became the more relevant clinical outcome of inguinal repair. Surgical options for chronic post-inguinal hernia repair pain have also progressed and evolved to utilize minimally invasive operative approaches. The guiding principle is identification of the involved or at-risk inguinal nerves with division proximal to the area of the repair. However, identifying the three nerves in the scarred re-operative field is difficult, and the neuroanatomic variation increases along the course of the nerves especially within the inguinal canal [15–17].

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In the last three decades, use of the extraperitoneal space has become ubiquitous as a part of endoscopic transabdominal preperitoneal (TAPP) repairs, totally extraperitoneal (TEP) repairs, and open preperitoneal repairs [18–20]. However, inguinodynia that arises after preperitoneal operations and those that cross both the anterior and posterior planes pose a more complex challenge. Nerve injuries associated with these operations are often too proximal to reach through an open anterior inguinal approach, and addressing preperitoneal mesh through an open incision is also difficult [19–21]. Orchialgia resulting from vas and spermatic cord injury proximal to the internal ring is also a technical challenge. These aforementioned challenges make an endoscopic approach, either retroperitoneally or transabdominally, a desirable alternative [21–23].

Patients with CPIP should be offered surgical intervention if there are appropriate targets for remediation (meshoma, neuropathic pain, recurrence, orchialgia) after attempting and failing conservative therapies for a minimum of 3 but optimally 6 months after the initial repair. CPIP is traditionally defined by this 3-month chronicity, but the timing of mesh integration and resolution of normal postoperative scarring with mesh-based repairs make 6 months a more conservative time frame. The preoperative workup needs to be thorough and methodical as successful intervention and the minimization of secondary complications are primarily predicated on proper patient selection. Characterization of symptoms, assessment of prior pharmacologic and interventional treatments, as well as cross-sectional imaging to identify recurrence, meshoma, or other anatomic abnormalities should be done. A plain film of the pelvis or scout films from a CT scan may determine whether metallic fixation tacks were used and where they were placed. Prior operative reports should be reviewed to determine the type of operation, use of mesh, location of mesh, fixation, identification, and handling of nerves as all these factors can influence the most appropriate type of remedial operation. Dermatosensory mapping should be used during the preoperative assessment to help determine if neuropathic pain is present and which nerve distributions are implicated. Quantitative sensory testing when available is also useful in characterizing neuropathic inguinodynia but is often too time and labor intensive for daily clinical practice. All patients considered for neurectomy should undergo diagnostic and therapeutic blocks of the ilioinguinal, iliohypogastric, and genitofemoral nerves.

A thorough discussion of risks, benefits, and expectations should be carried out with the patient undergoing remedial surgery [24, 25]. These include but are not limited to failure to identify or resect all three nerves, persistent pain, permanent numbness, bulging of the lateral abdominal wall muscles due to motor denervation of the lower oblique muscles, labial numbness, testicular atrophy or loss, loss of cremasteric reflex, injury to the spermatic cord, and deafferentation hypersensitivity. If the patient has nociceptive pain caused by tissue injury, meshoma, or other factors, their pain will not be alleviated with triple neurectomy alone, and mesh-, hernia-, or tissue-based causes must also be addressed. Similarly, isolated orchialgia is unlikely to resolve with inguinal neurectomy alone.

43.1 Surgical Techniques

43.1.1 Endoscopic Groin Exploration

Endoscopic groin exploration should be considered a part of the diagnostic evaluation and can be used as an adjunct (with hybrid approaches to the inguinal canal) or primary means to address many of the pathologies associated with CPIP. It is appropriate for patients with a prior history of laparoscopic inguinal hernia repair (TEP or TAPP) with evidence of meshoma and use of lateral penetrating fixation or for patients with anterior or preperitoneal approach, equivocal imaging, and unremitting pain that is mesh-related or neuropathic on physical exam. Diagnostic laparoscopy is the first step, as it allows for identification of interstitial hernias, recurrent hernias, mesh migration, and intra-abdominal adhesions that could be contributing

to the patient's symptoms. Offending tacks or other types of fixation can also be identified and often removed from the intraperitoneal working space without violating the preperitoneal space.

Exploration of the preperitoneal space and myopectineal orifice, whether through a transabdominal or totally extraperitoneal approach, is an important next step. Developing the preperitoneal view of the myopectineal orifice helps to rule out occult causes of pain including recurrence, retained lipoma, and mesh migration and allows for subsequent preperitoneal mesh repair of the resultant or recurrent hernia if desired. This allows for visualization of the cord structures and hernia spaces and identification of the lateral femoral cutaneous nerve and genitofemoral nerves. The peritoneal flap should be initially separated from the mesh and preserved; however, this is sometimes not possible. If the main issue is recurrence and the mesh is otherwise flat, it may be left in place with creation of a larger dissection space, and additional mesh is placed. Alternatively, recurrence may be addressed with an anterior Lichtenstein repair avoiding the preperitoneal plane altogether. However, if recurrence is not the only factor leading to pain, hernia repair alone is unlikely to remediate the problem.

Neuropathic pain that arises with laparoscopic preperitoneal repair without traumatic fixation should by anatomy and mechanism be isolated to the genitofemoral or lateral femoral cutaneous nerves. Similarly, cases with dermatosensory mapping suggestive of an isolated neuropathic distribution involving the genital or lateral femoral cutaneous nerves can be addressed in the preperitoneal space without involvement of the ilioinguinal and iliohypogastric nerves. The genital and femoral branches of the genitofemoral nerve may be identified over the psoas and iliac vessels as they pass toward the internal ring and iliopubic tract. The lateral femoral cutaneous nerve can be identified lateral to the psoas passing over the iliacus muscle toward the lateral thigh. Neurectomy of these two nerves may be safely and effectively performed during endoscopic groin exploration with minimal morbidity in this location (Fig. 43.1).

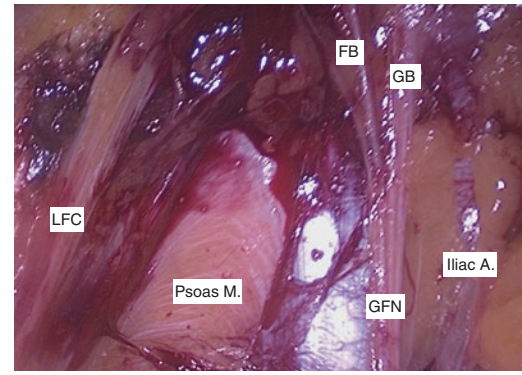

Fig. 43.1 Left preperitoneal inguinal neuroanatomy. Lateral femoral cutaneous (LFC) nerve over iliacus. Genitofemoral nerve (GFN) with its genital (GB) and femoral (FB) branches passing over the psoas medial to the iliac vessels

43.1.2 Meshoma

Meshoma pain after laparoscopic preperitoneal repair may require mesh removal. Laparoscopic mesh removal is difficult and fraught with potential dangers. However, compared to open mesh removal, laparoscopic dissection and visualization allow for a broad assessment of mesh position and configuration, involvement of surrounding visceral structures, and potential mechanisms of pain. Laparoscopic dissection also provides a controlled approach to removal of the mesh especially with regard to adherence to vascular structures. In the case of an isolated preperitoneal laparoscopic mesh (TEP, TAPP) (Figs. 43.2 and 43.3), open preperitoneal mesh placement (TIPP, Kugel, TREPP), or plug (Fig. 43.4a), removal may often be accomplished entirely through a laparoscopic approach. With repairs that traverse the anterior and posterior plane (plug and patch and bilayered meshes), laparoscopic mesh removal can address the posterior mesh component alone or may be used as an adjunct to facilitate the posterior dissection as part of a hybrid open inguinal and laparoscopic preperitoneal approach (Fig. 43.4).

Meshoma is typically scarred, fixated, or contracted around the epigastric and iliac vessels along with the cord structures. Occasionally the bladder is adherent to the mesh as well. Preoperative counseling must include discussion

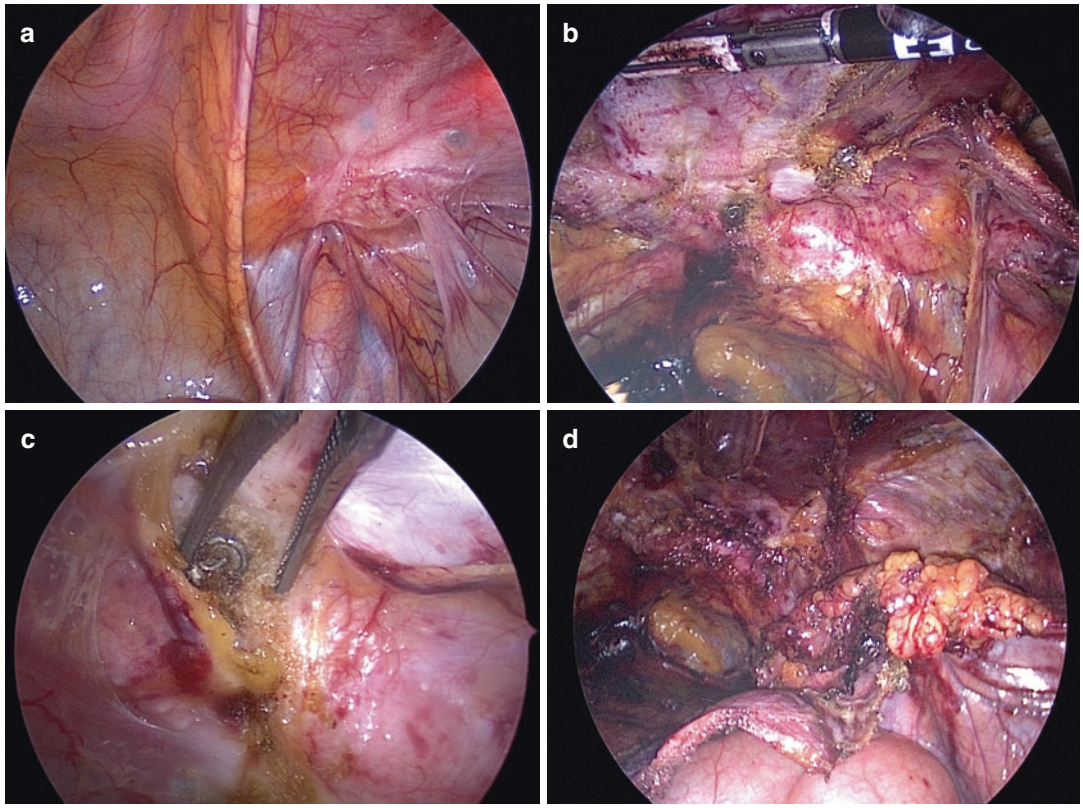

Fig. 43.2 Laparoscopic removal of tack-fixated preperitoneal mesh. (**a**) Intra-abdominal view (**b**) Preperitoneal view with mesh and tacks (**c**) Tack removal (**d**) Mesh and tacks dissected off cord and vascular structures

about injury to these structures and contingency plans to control bleeding and repair any potential damage carefully thought out before starting the operation. When separation from the vessels, the viscera, or the spermatic cord is difficult, it is often prudent and safer to leave a cuff of mesh behind to minimize injury to these structures especially in cases of fixation with tacks and suture. With meshoma pain, patients typically are affected by the amount of mesh present and its three-dimensional configuration and bulk. Reduction in the mass of the meshoma can potentially alleviate symptoms with decreased morbidity and risk by leaving small adherent areas of mesh behind. Bladder decompression for laparoscopic mesh removal operations is recommended to maximize the operative field and facilitate mesh removal or repair in the case of bladder erosion. Robotic-assisted groin exploration, following the same operative principles of laparoscopic surgery, may be helpful for complex cases as the added range of motion, superior optics and visualization, and increased operative dexterity may facilitate more precise mesh dissection and minimally invasive vascular repair.

43.1.3 Fixation

Penetrating fixation with tacks or permanent suture may cause nociceptive symptoms at the point of fixation or neuropathic injury with distal dermatosensory effects. Tacks or other penetrating fixation devices can be removed if they correspond to areas of targeted pain on preoperative exam. Tack removal may be accomplished intraperitoneally or extraperitoneally. Isolated tack pain can occasionally be addressed with simple cutdown over the site of pain. However, laparoscopic removal is recommended for multi-

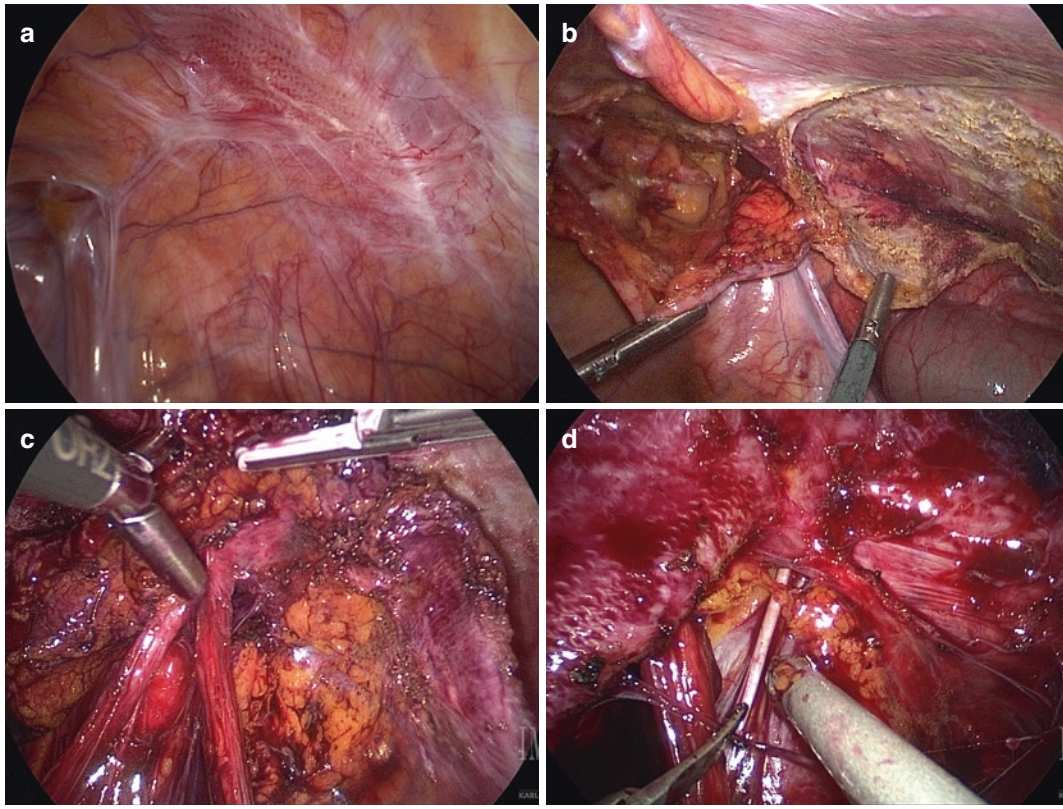

Fig. 43.3 Operative approach to laparoscopic removal of preperitoneal mesh. (**a**) Intra-abdominal view (**b**) Cephalad dissection from abdominal wall and epigastric vessels (**c**) Caudal dissection from cord structures and vessels (**d**) Genital nerve neurectomy with mesh removal

ple problematic locations and coexisting pathology, and removal is typically less traumatic from a posterior approach (Fig. 43.2b, c). Intraoperative fluoroscopy may be a useful adjunct to localize metallic tacks, clips, and devices.

43.1.4 Recurrent Hernia and Retained Cord Lipoma

With laparoscopic repairs, symptomatic recurrences tend to occur due to a retained cord lipoma, incomplete dissection of the preperitoneal space, or incomplete coverage of the myopectineal orifice. Adherence to the recently proposed critical view of the myopectineal orifice by Felix and Daes may minimize these recurrences and sets a technical standard for performance of a laparoscopic repair. Retained cord lipomas may be reduced posterior to the mesh. The existing mesh can remain flat and adherent to the flap without need for removal. If it is folded or clamshelled, this mesh should be removed if feasible to allow for placement of new mesh.

43.1.5 Orchialgia

Patients with orchialgia after inguinal hernia repair may occasionally have isolated or coexisting orchialgia. True testicular pain must be distinguished from scrotal pain or referred pain extending to the testicle. Scrotal pain is mediated by the genital branch of the genitofemoral nerve and is discrete from orchialgia. Testicular pain may arise from nociceptive and neuropathic causes. Nociceptive testicular pain may be caused by direct parenchymal compromise, trauma, or isch-

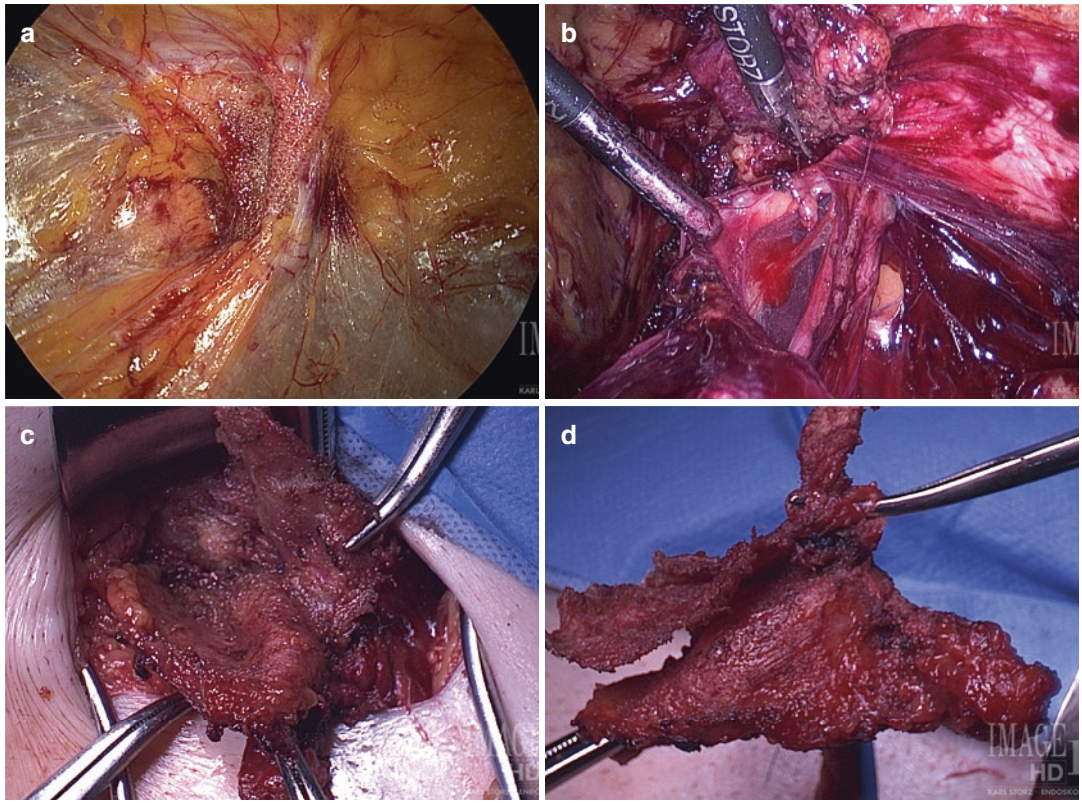

Fig. 43.4 Hybrid approaches to mesh removal. (**a**) Laparoscopic plug removal (**b**) Laparoscopic bilayer mesh removal (posterior layer meshoma) (**c**) Anterior view of anterior and posterior fold after laparoscopic dissection of posterior fold (**d**) Hybrid removal of bilayer mesh

emia. In CPIP, this is typically caused by compromised arterial inflow with injury or scarring to the spermatic vessels or obstructed venous outflow with mesh, scarring, or constriction from the repair. Neuropathic orchialgia is mediated by the autonomic nerve fibers that envelop the cord structure as a plexus and then coalesce to travel within the cord (Fig. 43.5). The majority of these fibers travel along the vas deferens. After preperitoneal repair with plug, plug and patch, bilayered mesh, and laparoscopic and open preperitoneal mesh, these nerves and the vas deferens may be involved. Laparoscopic exposure of the preperitoneal plane allows for paravasal neurectomy of these autonomic fibers taking the tissue between the skeletonized vas and spermatic vessels (Fig. 43.5b, c). This procedure must be performed proximal to the injury and scarring and may alleviate orchialgia in patients with neuropathic testicular symptoms.

43.1.6 Endoscopic Retroperitoneal Triple Neurectomy

Neuropathic pain refractory to conservative measures with pathology proximal to the inguinal canal may be approached via a laparoscopic retroperitoneal operation within the lumbar plexus. This single-stage procedure allows access to the main trunks of the ilioinguinal, iliohypogastric, and genitofemoral nerves. The retroperitoneal approach allows nerve resection proximal to any potential sites of neuropathy from either anterior or preperitoneal approaches. The neuroanatomy of the inguinal nerves is less variable in the region increasing the reliability and success of nerve identification. However, this technique also increases the distribution of numbness and causes some oblique muscle denervation and bulging due to the proximal nature of this neurectomy. It is

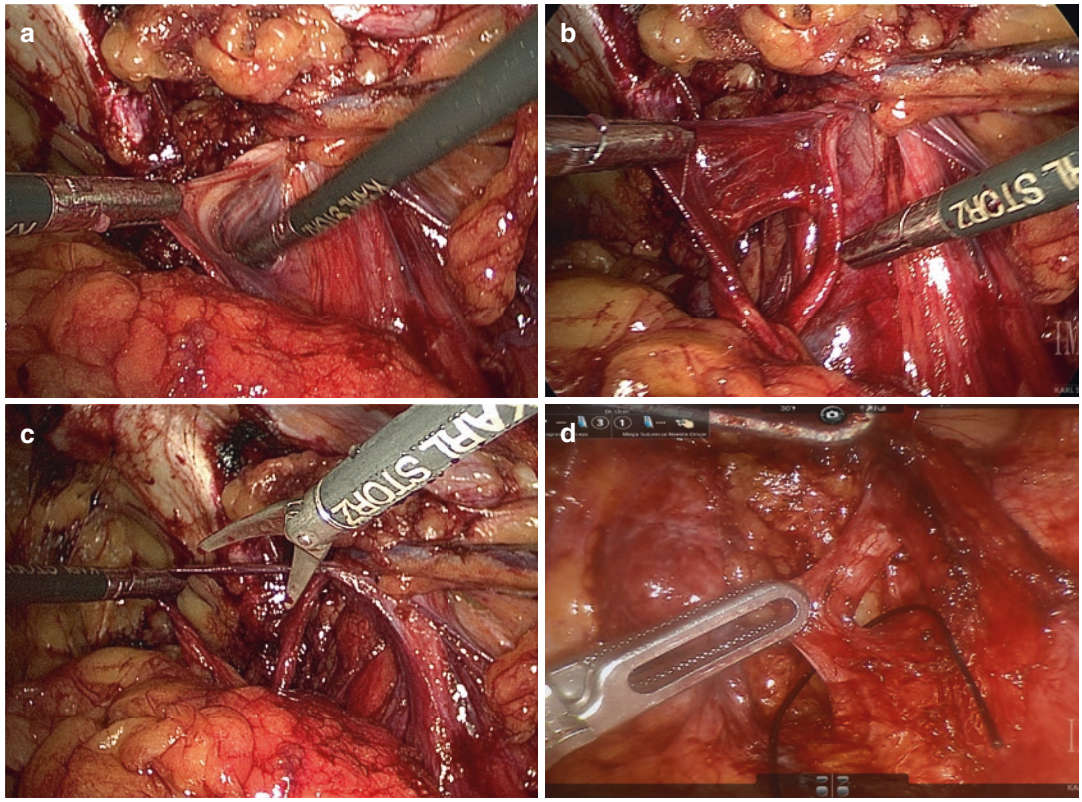

Fig. 43.5 Paravasal neurectomy. (**a**) Paravasal autonomic nerve fibers enveloping vas (**b**) Isolation of fibers from vas deferens (**c**) Division and neurectomy of paravasal nerve fibers proximal to prior preperitoneal mesh (**d**) Robotic approach to paravasal neurectomy

most effective and appropriate for patients that have neuropathic pain with nerve symptoms originating proximal to the inguinal canal, after multiple prior open inguinal operations or infection, or after failed anterior inguinal neurectomy where an anterior approach is unlikely to be successful.

43.1.6.1 Operative Technique

1. Position the patient in lateral decubitus position. Flex the table to open the space between the iliac crest and costal margin.
2. Identify and mark the midaxillary line. A 12 mm transverse incision is made anterior to the midaxillary line 3–4 cm above the iliac crest through the lateral aspect of the oblique muscles.
3. Incise the external oblique fascia, and spread the muscle fibers of the external oblique, internal oblique, and transversalis until the retroperitoneum is accessed.
4. Insert an oval dissecting balloon into the potential space and inflate under direct visualization. This should rotate the peritoneum and viscera medially exposing the retroperitoneal space.
5. Remove the dissecting balloon, place a 12 mm balloon-tipped trocar, and insufflate to 15 mmHg.
6. Insert a 5 mm trocar 2–3 cm medial to the initial incision under direct vision.
7. Dissect and mobilize the retroperitoneal fat pad medially with laparoscopic dissector or vessel-sealing device to expose the psoas and quadratus lumborum muscles.
8. Define the lumbar plexus prior to taking any nerves. The cephalad extent of the dissection

is identified by the subcostal nerve at T12 costal margin (Fig. 43.6).

9. Identify the iliohypogastric and ilioinguinal nerve trunks, which can often share a common trunk, over the quadratus muscle at L1 (Fig. 43.6).
10. Identify the lateral femoral cutaneous nerve originating from L3 and coursing lateral to the psoas, crossing the iliacus muscle below the iliac crest.
11. Dissect medially toward the groin and identify the genitofemoral nerve trunk running over the psoas muscle. Identify and protect the ureter and iliac vessels, which run medial to the psoas muscle. Areas of caution include these structures immediately medial to the psoas and the femoral nerve running immediately lateral to the psoas muscle. The genitofemoral nerve will run over the psoas itself between these two areas (Fig. 43.7).
12. The genital and femoral nerve trunks exhibit considerable variability. Depending on preoperative examination, the femoral branch can be preserved if there is no evidence of its dermatome being affected and if two separate trunks exist.
13. Neurectomy should only be performed once all the aforementioned nerves have been identified.
14. In the cephalad field, clip or ligate the iliohypogastric and ilioinguinal nerves proximally and distally over the quadratus prior to division to close the neurolemma. Divide the intervening segment, and submit to pathology for confirmation. Clips may also serve as markers for future intervention if proximal nerve blocks are needed. In the caudal field, clip and resect the genitofemoral nerve over the psoas muscle in a similar fashion.
15. If the peritoneum is ripped or retroperitoneal access is difficult, the operation can be performed transabdominally with medial rotation of the viscera.

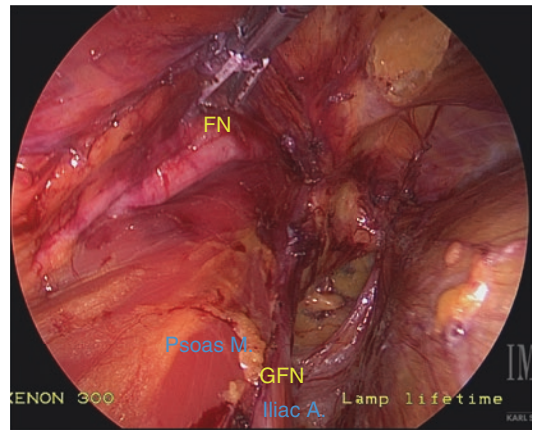

Fig. 43.7 Caudad view of lumbar plexus with genitofemoral nerve (GFN) identified over psoas muscle

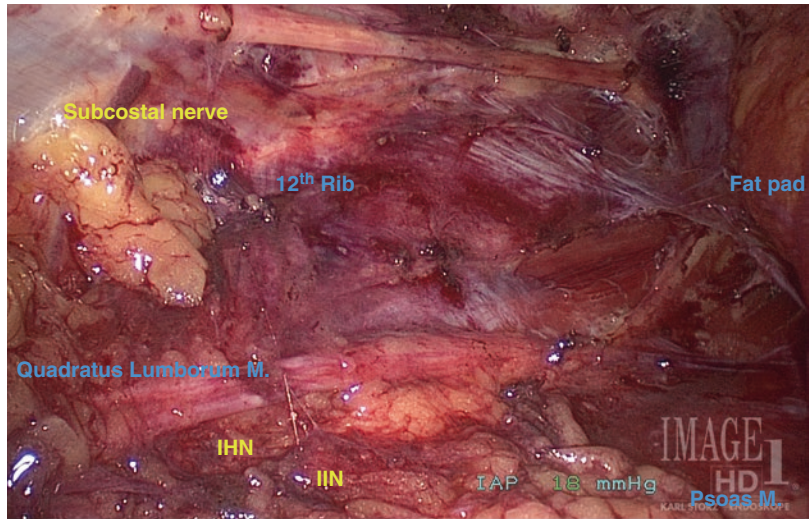

Fig. 43.6 Cephalad view of lumbar plexus with iliohypogastric (IHN) and ilioinguinal (IIN) nerves identified over quadratus lumborum muscle

43.2 Results

The efficacy of pain intervention surgery is challenging to directly compare and quantify given the heterogeneity of inguinodynia. Treatment is truly a tailored process using information from symptoms, anatomy, dermatomal mapping prior operation type, prosthetic material involved, and response to prior interventions to formulate a logical operative plan (if one exists) that may remediate or alleviate the causes of pain and correct identifiable pathology. Diagnostic experience is as crucial as operative experience to maximize the potential for successful outcomes and minimize morbidity. Much of the reported data on inguinodynia has focused on the role of operative neurectomy which can be more directly compared. These studies do not separately factor the type of mesh, role of mesh removal, treatment of orchialgia, and coexisting groin and hip pathology all of which confound the data. The distinction between neuropathic and nociceptive pain is important with most series addressing the neuropathic aspect alone. However, these are often inseparable making objective pain studies complex and challenging.

The Lichtenstein Amid Hernia Clinic recently published prospectively collected long-term data on the efficacy of retroperitoneal triple neurectomy [26]. Data were collected over a 3-year study period, during which time 567 CPIP patients were evaluated. Of these patients, 62 met inclusion criteria and underwent retroperitoneal triple neurectomy after extensive preoperative workup and non-operative management. Exclusion criteria included non-neuropathic pain, low severity of pain, meshoma pain, inadequate non-operative treatment/evaluation, pain limited to area of anterior repair, isolated dermatomal involvement, pain outside of inguinal distribution, multifocal pain, recurrence, unrelated pain, fixation pain, primary orchialgia, prior retroperitoneal surgery, high American Society of Anesthesiologists (ASA) score, and prior histologically confirmed neurectomy. All patients had significant self-reported pain with an average of 8.6 (range, 6–10).

Postoperatively, appropriate numbness was found in all patients within 24 h of the operation and at all subsequent visits with an average follow up of 681 days. Subjectively reported numeric pain scores decreased significantly from a mean of 8.6 to 3.6 on postoperative day 1 to 1.8 by postoperative day 360. After 90 days there were no continued significant decreases in score, but there was durable and consistent efficacy up to 3 years out. Fifty-nine out of 62 patients (95%) had a successful intervention, defined as a decrease in pain intensity to manageable levels below 7. Quantitative sensory testing was also used in a subset of patients to validate the efficacy of the triple neurectomy, with significant increases in sensory and pain detection thresholds. Narcotic and neuropathic pain medication use were eliminated in 44 patients. Twenty patients did experience some degree of deafferentation hypersensitivity. This typically resolved within 6 months, but five patients continued to have some symptoms after 1 year. Nineteen patients experienced some lateral abdominal laxity due to partial denervation of the oblique muscles from loss of the iliohypogastric and ilioinguinal nerves.

In our experience of over 800 patients operated on for inguinodynia, some generalities can be extrapolated. Triple neurectomy for generalized inguinal pain with overlapping dermatomal distribution is more effective than selective neurectomy. This may come at a cost of increased numbness, but the difficulty of reoperation and declining efficacy, neuroanatomic variability, and increased morbidity with subsequent operations make this a negligible consideration. Dermatosensory mapping and correlation to mechanism may help to identify patients that will benefit from selective neurectomy with preservation of obviously unaffected nerves. Nociceptive pain arising from meshoma should be addressed either simultaneously or in staged fashion with complete or partial mesh removal. Orchialgia is a separate and discrete cause of pain with its own intrinsic diagnostic and operative challenges. Recurrence is an independent cause of pain. There are several options for repair, each with their own consideration and risks. In general, removal of mesh or recurrence from an anterior repair is best approached posteriorly and vice

versa with prior open or laparoscopic preperitoneal repair. However, in pain remediation, it may be preferable to not enter another plane and confound the causes of an already challenging diagnostic problem. Repeating an anterior repair with a lightweight anterior mesh repair or replacing a posterior meshoma with a non-fixated flat laparoscopic mesh may be the best option in certain cases depending on the final inguinal anatomy after mesh removal and neurectomy. Patients that decline a subsequent mesh operation should be appropriately counseled on recurrence especially with large (>M2/L2) hernia defects but should be offered a Shouldice repair if possible as the best available tissue option if mesh is declined. Referral to or collaboration with dedicated hernia specialists that routinely treat pain is appropriate for challenging cases.

Conclusion

Chronic postoperative inguinal pain refractory to medical management is a challenging condition with significant costs and impact on a patient's quality of life. There are limited options for remediation and pain relief. Open groin exploration and triple neurectomy remain the standard but can be difficult or ineffective due to postsurgical changes, distorted anatomy, and neuropathy that is proximal to the inguinal canal. In addition, cross-innervation and unpredictable distal branching of the nerves can contribute to the challenges of an open neurectomy. Laparoscopic approaches to inguinal neurectomy are a valuable, highly effective adjunct in dealing with neuropathic postoperative inguinal pain. Safe and effective mesh removal may be facilitated by laparoscopic or hybrid techniques that allow for greater visualization and dissection of mesh from the posterior wall. Orchialgia may be improved with laparoscopic paravasal neurectomy. As with all remedial surgery for inguinodynia, the goal is to identify the least morbid and most effective approach to providing significant pain relief. There is no one size fits all, as each approach needs to be tailored to the patient's initial repair, pain symptoms and distribution, physical exam, imaging, and shared decision-making. A solid understanding of the anterior and posterior anatomy, mechanisms of injury, and laparoscopic and open routes to access pathology provides a broad range of options to tailor treatment and improve outcomes.

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Part III

Femoral

Anatomy of the Femoral Region

44

Jérôme Loriau

The femoral region shouldn't be considered as a separate area.

It has to be considered as the lower part of the inguinal region.

Fig. 44.1 Henri Fruchaud. Commander of The Legion of Honor, member of the French order of the Libération, among other distinctions

Would you drive in a foreign country without the help of a GPS?!

That's the reason why a perfect knowledge of the anatomy of the femoral region is mandatory for a surgeon who'd like to "explore" this beautiful but hazardous region.

Moreover, knowing and understanding the anatomy of this region are a prerequisite to establish the best surgical strategy to treat inguinal hernias.

That's why our aim will be rather to provide a "surgical'" approach to the anatomy of this region than a pure descriptive approach. We'll try to focus on the anatomic key points that a surgeon must always keep in mind in his practice, a kind of surgical GPS!

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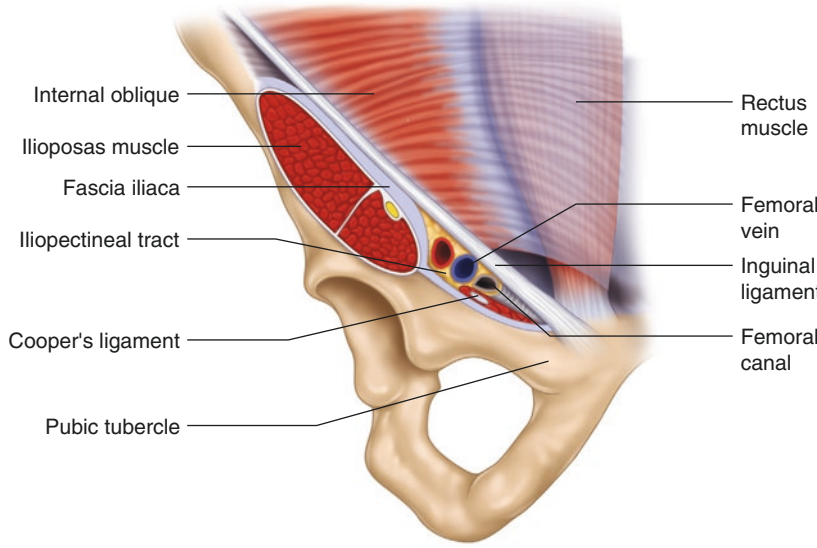

Fig. 44.2 Myopectineal orifice with femoral vessels. (Reprinted from H. Fruchaud *Anatomie chirugicale des hernies de l'aine*. G. Doin; 1956, Fig. 195, p. 341, with permission

This conception of a single entity has been proposed by Henri René Fruchaud [1], who named this anatomic area as the "myopectineal orifice" (Fig. 44.2).

He emphasized we should consider only one single orifice the myopectineal orifice divided in different parts by ligaments. This myopectineal orifice is bounded by the pelvic bone and its surrounding ligaments at the bottom and at the top by the superficial (external oblique muscle) and the deep layer (internal oblique muscle and transversus abdominis) of the abdominal wall muscles forming the conjoint tendon.

The lateral and medial borders of the orifice are, respectively, the psoas muscle and the rectus muscle. In some cases the rectus muscle can end on the pubic tubercle including a lateral extension called Henle's ligament.

As the inguinal region has to be a rampart to abdominal viscera, there are three sites of possible weakness in the myopectineal orifice. The two physiological channels, the inguinal canal and the femoral canal, create two "doors" in the rampart that the peritoneum and the viscera might forcefully open. In addition the medial inguinal fossa can also be an area of weakness representing the third door of the inguinal rampart.

It is important to consider all these areas as a single entity because of the proximity of all their elements. These three "doors" are separated by shared components and as we'll see later, the weakness of those shared components can be responsible for combined herniation. The weakness of the different parts of the fascia transversalis is a key point in hernia formation.

The femoral region is the lowest of those exits and the entrance to the leg. It is separated from the upper part of the inguinal region by the inguinal ligament which is the termination of the aponeurosis of the external oblique muscle.

The femoral region itself must be also divided in different parts in which only one, the femoral canal, is of "surgical interest" for us.

Looking caudal to the inguinal ligament and lateral to medial, we must distinguish the muscular lacuna from the vascular lacuna. The muscular lacuna contains the iliopsoas muscle,

the femoral nerve, and the lateral femoral cutaneous nerve (arising from lumbar plexus L2 to L3). Damage or entrapment of this nerve close to the anterior superior iliac spine is responsible for meralgia paresthetica also know as Bernhardt-Roth syndrome [2].

This syndrome including pain and various sensitivity disorders on the outer side of the thigh,

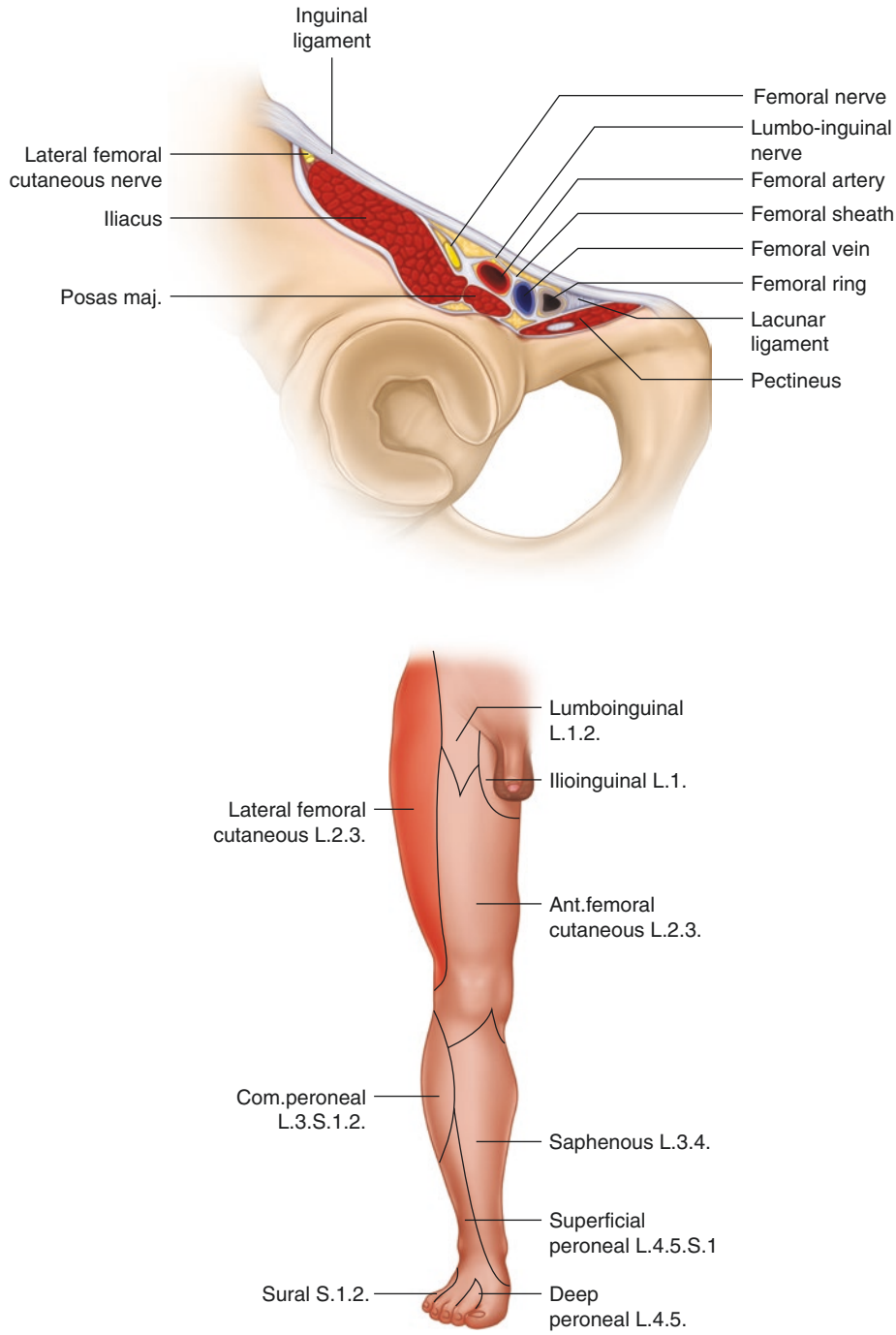

Fig. 44.3 (**a**) Sectional view of the femoral region. (**b**) innervation of the skin (territories) from the inguinal region to the foot

occasionally extending to the outer side of the knee, has to be known by the herniologist. In the earlier experience of laparoscopic inguinal hernia repair, some papers have reported complications due to dissection and fixation laterally resulting in damage of the lateral femoral cutaneous nerve [3, 4].

Knowing that the nerve crosses the inguinal ligament laterally close to the anterior superior iliac spine, stapling or stitching all around should mandatorily be avoided. As shipmen we could state: **"no anchor around the anterior superior iliac spine!"**.

Moving medial, the iliopectineal arch separates the muscular lacuna from the vascular one. It contains lateral to medial the femoral artery (on its anterior face runs the femoral branch of the genitofemoral nerve), the femoral vein, and lymphatic vessels. Those vascular elements can be approached as "medial components" of the region. Since hemorrhage complications are dreaded, this medial part of the region is well known, and injury to its components is most of the time not a result of a lack of anatomy knowledge.

The femoral vein delimitates the external frontier of the topic of interest of the femoral region for the hernia surgeon: the femoral canal.

The femoral canal is the most medial area. Its entrance is known as the "femoral ring." As stated earlier its lateral limit is the femoral vein, and it contains Cloquet's lymph node. Due to the location of the node he described, J. Cloquet (French anatomist and surgeon (1787–1840) who gave his name to that lymph node advised that regarding the position of the node he described, close to the femoral canal, one should be able to discriminate lymph node inflammation from strangulated hernia symptoms.

The other limits are anterosuperiorly the inguinal ligament, posteriorly Cooper's ligament (pectineal ligament), and medially Gimbernat's ligament (lacunar ligament). Except its lateral limit which is a vascular structure, all the other are ligaments and bones. The strength and rigidity of those structures have to be taken into account in case of incarceration because of the inability of the ring to be enlarged (compared to other hernia sites) and of the increased stricture effect this might have to the trapped structure. Its dimensions have been described as ranging from 8 to 27 mm for its transverse diameter and from 9 to 19 mm for its anteroposterior diameter. Nevertheless in more than two thirds of the patients, all the diameters approximate about 10 or 12 mm [5].

As the only smooth limit of the ring is the femoral vein, one must keep in mind during femoral hernia repair that any tension applied to the ring might result in a direct increased pression on the vein. Postoperative phlebitis in those circumstances is a known complication [6].

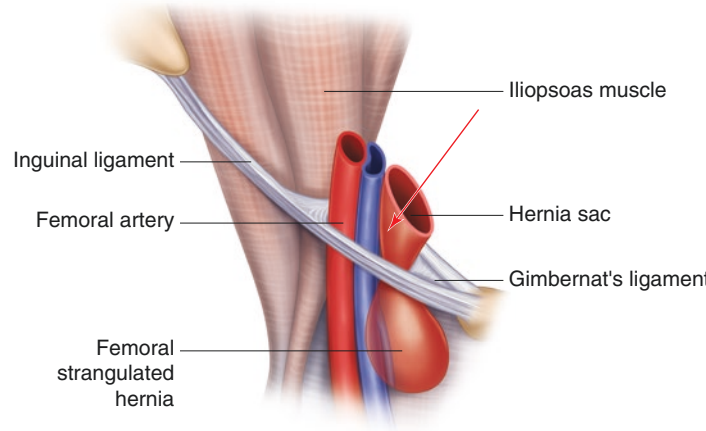

Fig. 44.4 Passage of a femoral hernia. *1* Inguinal ligament, 2 femoral artery, *3* femoral strangulated hernia, *4* iliopsoas muscle, *6* hernia sac, *7* Gimbernat's ligament

The femoral ring as the other "doors" of the "ramparts" is normally closed. The door is constituted by connective tissue called septum femoral crossed by numerous small lymphatic vessels. The septum femoral is the lower and most medial part of the fascia transversalis. Therefore it is important to consider as coming from a common mechanism of frailty of the fascia transversalis both direct inguinal and femoral hernias. This joins Fruchaud's "myopectineal orifice" concept.

Surgical Take-Home Message About the Anatomy of Femoral Region

- It is the lower part of the myopectineal orifice of Fruchaud.
- The purpose of surgery will be to reinforce a lacking fascia transversalis.
- Nerve danger lies laterally close to the anterior superior iliac spine on the iliopsoas muscle: lateral femoral cutaneous nerve.
- Vascular danger concerns iliac artery and vein.
- Hemorrhage can occur in this setting but also phlebitis in case of vein compression.

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45 Primary Femoral Hernia: Open Anterior Treatment

Stefano Mandalà, Camillo La Barbera, Cosimo Callari, Antonino Mirabella, and Vincenzo Mandalà

45.1 Introduction

A femoral hernia is an acquired hernia and is classified as a direct hernia; its path is constituted by the crural or femoral canal.

Nyhus [1] classifies it as an IIIc form, a special kind of defect of the posterior wall; in the EHS classification [2], it is classified as "F 1,2,3,x" depending on the size of the defect. It is an insidious hernia generally asymptomatic, where a small dimension inside the inguinal femoral area justifies a late diagnosis up to 30% of patients [3].

Even if this hernia is rarer than the inguinal hernia (1–2% repairs undertaken at the Shouldice Hospital in 1 year) [3], it has however a higher mortality rate, more than 25% [3, 4], because the diagnosis is often difficult (it is relatively small and harmless), and therefore there is a late, incorrect diagnosis which frequently occurs at the moment of complications [5].

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Therefore, strangulation of a femoral hernia determines a misunderstood and delayed emergency, which could even put an expert surgeon on the wrong track [3–6].

Since the beginning of the last century, three main types of open approach have been used (Table 45.1).

The ideal treatment of a femoral hernia is up to today object of great discussion, and there is a lack of evidence: prospective trials are still not definite for strategy of early diagnosis, surgical techniques and mandatory prosthetic use, for the choice of approach and finally for outcomes, recurrences, pain, complications, etc.

The femoral access (low approach) represents the classical way undertaken in the past, as being simple and reliable, but in tissue repair techniques, this results in an unacceptable rate of recurrence [3], even if subsequent report showed a recurrence rate of 3.1%, at the Shouldice Hospital, in case of high approach, [7] selecting the use of low approach only after an inguinal intervention.

To be thorough, it is necessary to underline that between the preperitoneal access [8] and the laparoscopic one, the latter has gained considerably in its indication over the last two decades. In fact, it is a technique using the posterior approach, a total closure of the myopectineal orifice with a large prosthesis. It also represents a diagnostic technique by evaluating the type and dimension of the hernia defect and the type and vitality of the content after the

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Table 45.1 The main types of open approaches and techniques

Anterior
• **Femoral approach** (low)
– Bassini—inguinal ligament →pectineal sheet
– Bassini-Kirschner—inguinal Thompson ligament→Cooper's ligament
– Lichtenstein—plug repair
– Trabucco—plug T2
– Gilbert "cone-shaped plug"
– Rutkow—PerFix plug
– Bendavid—femoral umbrella
– Wantz—infrainguinal GPRVS
• **Inguinal approach** (high)
– Ruggi—Cooper to Poupart
– Moschowitz—inguinal Thompson ligament→Cooper's ligament
– Lotheissen—McVay—transversus abdominis fascia→Cooper's ligament (rectus fascia release)
– Rives—preperitoneal prosthesis by anterior inguinal approach
Posterior
• **Preperitoneal approach**
– Nyhus-McEvedy
– Trabucco
– Wantz
– Rives
– Stoppa
– Ugahary
– Kugel

reduction. Even more, it allows a simultaneous evaluation of contralateral hernia or associated inguinal or abdominal wall ventral hernias, and it is indicated in atypical varieties [9–11]. However, a superiority in the results is uncertain in some recent studies [12, 13], although other ones show initial guidelines that recommend the use of laparoscopy in femoral hernias in election [14, 15].

Among the various methods used over the last 20 years, we have performed, after an initial experience with "rolled-plug" technique, an anterior approach using a technique called "mesh-plug" repair with several types of a double disc prosthesis (PHS, 3D patch, UPP, UHS—Ethicon).

In our opinion, this prosthetic repair is extremely adaptable to resolve the technical and tactical problems of this particularly insidious hernia [16, 17].

45.2 Anatomic Characteristics of the Femoral Canal and the Femoral Fascia

The femoral canal is conical shaped, and his anatomy requires an appreciation of its three-dimensional characteristic [18]. There is a femoral ring (entrance to canal) and a femoral orifice (canal exit). In the typical variety, the femoral canal is located in the medial position with respect to the femoral vein (Fig. 45.1); there are also various atypical varieties (Fig. 45.2). The fossa ovalis, the opening for the great saphenous vein, is at its apex inferiorly. Thus, a femoral hernia may appear as a bulge of the skin over the fossa ovalis.

The characteristic rigidity of the osteo-fibrotic-fascial structures of this canal predis-

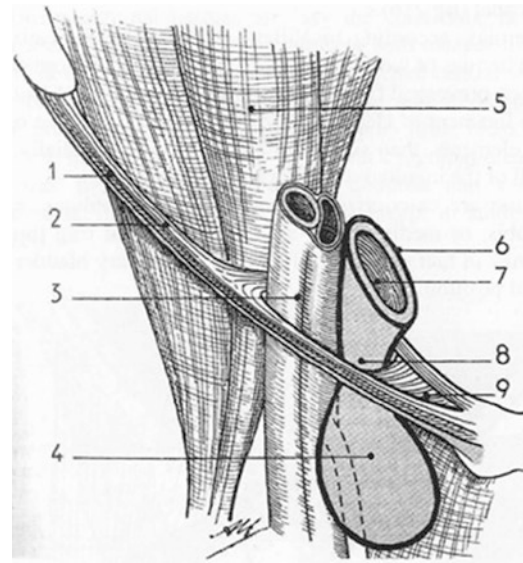

Fig. 45.1 Femoral hernia—typical variety (reproduced from *The Surgical Anatomy of Hernias of the Groin* by Henri Fruchaud—translated and edited by Robert Bendavid, 2006)

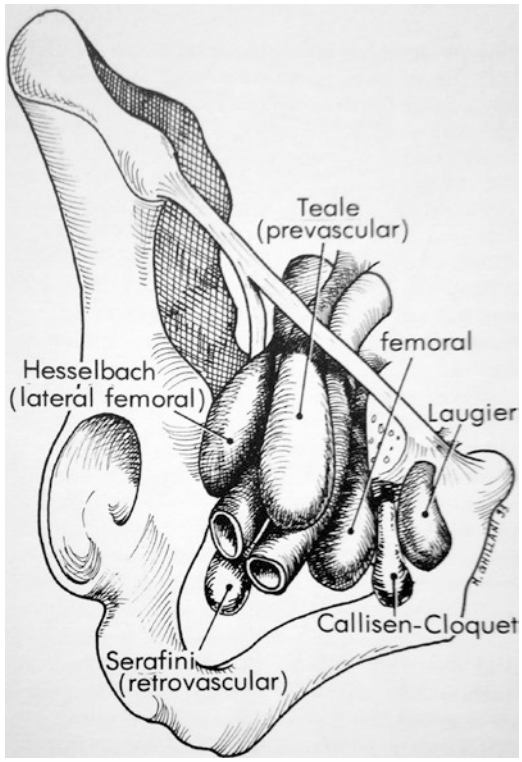

Fig. 45.2 Femoral hernia—atypical varieties (from Bocchi P, Paravascular hernias. In: Bendavid R, editor. *Prostheses and abdominal wall hernias*, Austin: R.G. Landes Company; 1994)

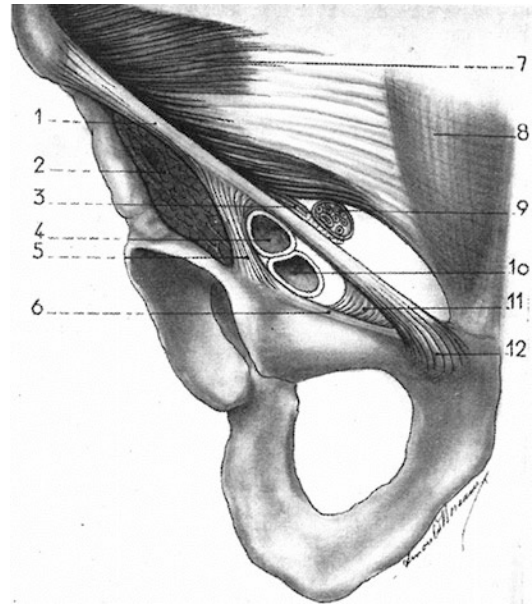

Fig. 45.3 Myopectineal orifice of Fruchaud (reproduced from George Wantz's *Atlas of Hernia Surgery*, Raven Press, 1991, NY)

poses this one towards strangulation. The "less rigid" edge is the lateral one, consisting of the femoral vein and connective tissue. The posterior border is Cooper's ligament. The inguinal ligament and ileo-pubic tract form the anterior limit. The transversalis fascia and aponeurotic insertion of the transversus abdominis muscle and, principally, the lateral edge of the lacunar ligament constitute the medial border. The importance of the femoral ring is equal to the internal inguinal ring; the former represents a second weakness in the lower part of the myopectineal orifice, which is covered only by the transversalis fascia. This assumes a particular disposition in the femoral canal (Figs. 45.3 and 45.4).

It is very important to underline the limits of transversalis fascia funnel:

The anterior limit is the fascia lata, the posterior limit is the pectineus fascia medially and the fascia lata laterally, the medial limit is the lacunar ligament, and the lateral limit is the femoral vein.

The difficulty in closing the femoral ring without tension is due to the lack of elasticity of anatomical structures; in fact, it is difficult to approximate the inguinal ligament to Cooper's ligament.

For this reason, all the femoral hernia tissue repairs presented high recurrence rates, mainly in the cases of a very large femoral ring (> 2 cm) (Fig. 45.5) and after a surgical inguinal hernia repair [9, 19, 20].

A dilated femoral ring can be due to the repeated increase of intra-abdominal pressure (i.e. coughing, pregnancy in women, etc.) but also in the case of degenerative changes and weaknesses of the structures in the subinguinal region with the deterioration of the descending aponeurotic fibres of the transversus abdominis (elderly) [21].

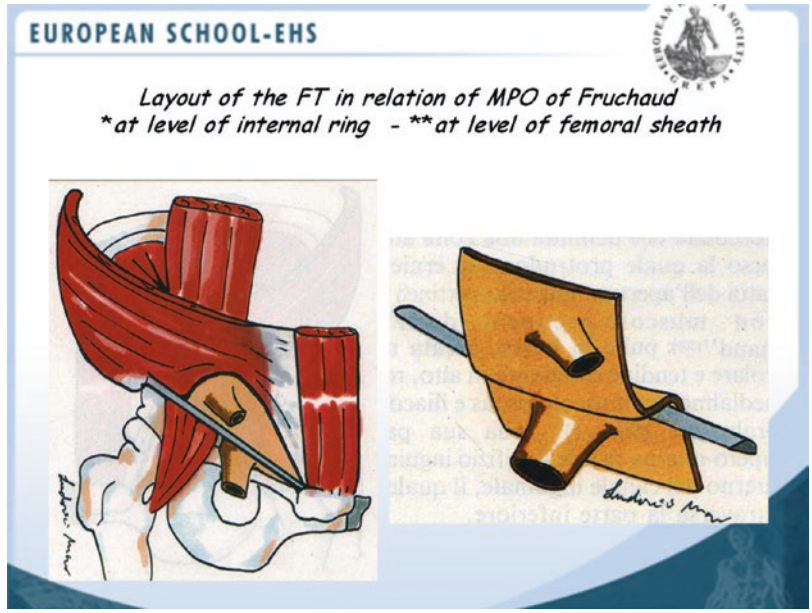

Fig. 45.4 Transversalis fascia and myopectineal orifice of Fruchaud (reproduced from Francesco Ruotolo)

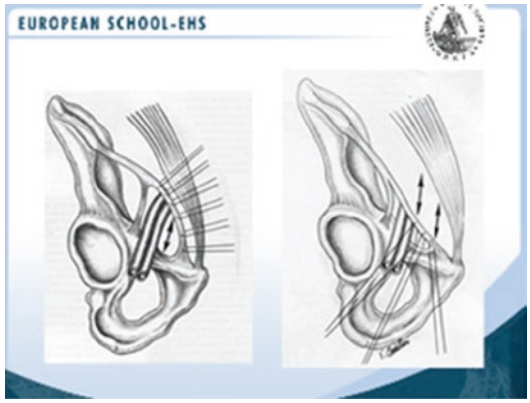

Fig. 45.5 Groin hernia tissue repairs: risk of femoral hernia after inguinal herniorrhaphy and vice versa (from Nocentini et al. Piccin Editore 1981)

45.3 Materials: Important Element for a Rational Use

At the end of the 1980s, on the base of several techniques and the results of dedicated surgeons, the plug technique has become widely used: Lichtenstein's "rolled plug" [22], Gilbert's "cone-shaped plug" [23], Trabucco's "dart-shaped plug" [24] and Rutkow's "PerFix plug" [25] (all made in polypropylene).

In fact, evidence showed and documented a large number of recurrences using the tissue repair techniques even in a dedicated hernia centre with a numerous amount of admissions for non-prosthetic treatment (Shouldice technique). For this reason, in that hospital in 1989, Bendavid proposed a prosthetic repair by positioning a preperitoneal umbrella [3, 26, 27] (Fig. 45.6). This enabled a reduction of the important number of recurrences sustained after the tissue repair technique [3, 28].

In 1995, our proposal was born. We have used the double disc polypropylene prosthesis, PHS mesh much used by Gilbert in United States [29], shaped into dimensions in order to fit the anatomical characteristics of the femoral canal. This technique has allowed us to achieve interesting and progressive results with an improvement of outcomes. These results, concerning especially the rate of recurrences and chronic pain, have been obtained thanks to the use of more modern prosthetic materials, partially absorbable and macroporous bilayer device, in recent years. These have different sizes and diameters and can be shaped according to the anatomical characteristics of the hernia and the femoral canal achieving a prosthetic tailored surgery:

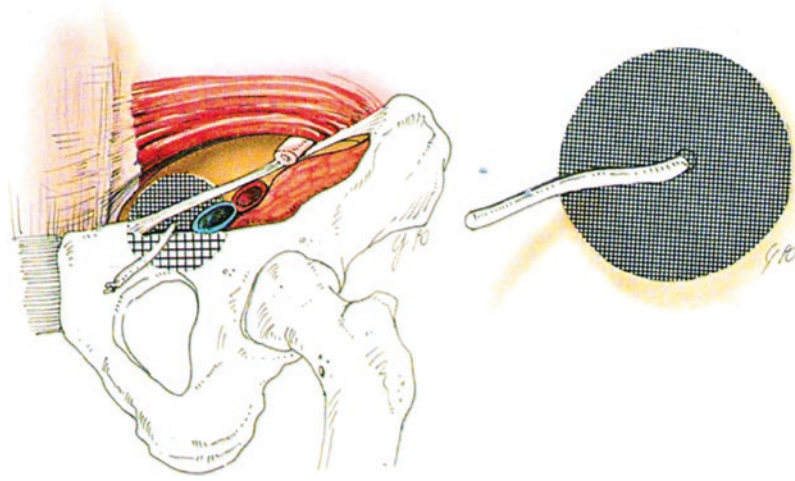

Fig. 45.6 Femoral hernia: Bendavid's umbrella technique (reproduced from G. Valenti—*Le Ernie Inguinali*—Utet 1992 Milano)

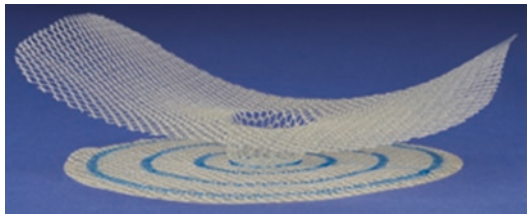

Fig. 45.7 UHS

Fig. 45.8 UPP

- UHS: it represents the technological evolution of PHS (Fig. 45.7).
- UPP: the plug is soft and easy to handle, allowing an easy and fast positioning (Fig. 45.8).

Both are composed of Prolene (macroporous polypropylene) and Monocryl (poliglecaprone 25).

The rational use, as mentioned above, implies the positioning of a reduced amount of prosthetic material because:

- They are light meshes, principally containing less prosthetic material.
- They have a large amount of absorbable material.
- The inner disc of the prosthesis of different sizes lies deeply in the Bogros space, an indispensable condition for the optimal prevention of recurrences without an excessive separation of the space.
- A softer device fills the femoral canal by a mechanism of auto fixation of the two discs. This not only avoids recurrences but also discomfort, numbness and chronic pain. Fixation is limited to a few sutures in order to distend the prosthesis and to avoid migration.

45.4 Anaesthesia

We perform, if possible, preferably a step-by-step local anaesthesia or an ultra-thin needle epidural anaesthesia (over recent years, the latter has been our preference).

The general anaesthesia is realized only if strictly necessary.

45.5 Surgical Techniques

Double disc mesh-plug technique—surgical steps (Table 45.2).

Table 45.2 Step-by-step technique

Step	Description
1	An anterior groin incision, in the shape of a golf club, retracted to expose the femoral region
2	Wide dissection of the femoral hole
3	The femoral sac is opened to assess the content
4	The sac is cut and narrowed, but, if it is possible, it is better to put it back without excision (to avoid pain)
5	The double disc prosthesis is tailored using a personal technique reducing the anterior sheet to a small border
6	Cleavage of the Bogros space using the finger for inner prosthesis
7	The prosthesis is made as a mesh plug
8	The double disc prosthesis is inserted into the femoral canal with a long clamp until the connector fills the canal, and the circular internal sheet of the prosthesis spreads open like Bendavid's umbrella prosthesis
9	The mesh is secured to the femoral canal with only three sutures (Prolene n2–0)
10	The first suture at the level of inguinal ligament
11	The second suture between the prosthetic connector and the Gimbernat ligament
12	The third suture at the level of the pectineal sheet
13	Other sutures are made to extend the anterior edge of the prosthesis in the pectineal fascia

45.5.1 UHS: Ultrapro Hernia System

(Figs. 45.9, 45.10, 45.11, 45.12, 45.13, 45.14, 45.15, 45.16, 45.17 and 45.18)

45.5.2 PHS: Prolene Hernia System

(Figs. 45.19, 45.20, 45.21, 45.22 and 45.23)

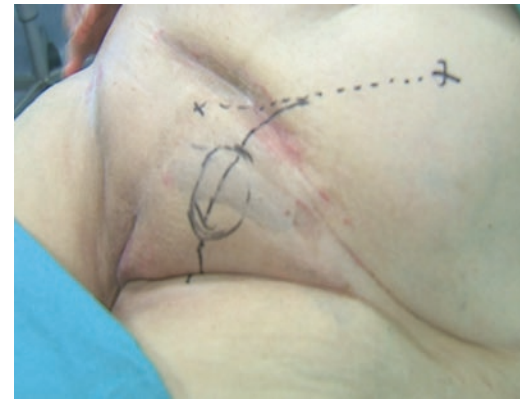

Fig. 45.9 Anatomic landmarks

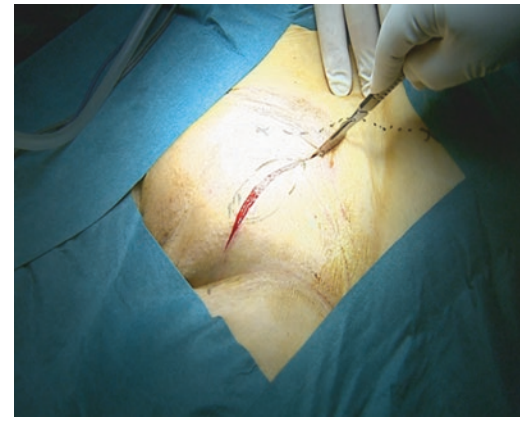

Fig. 45.10 An anterior groin incision, in the shape of a golf club, retracted to expose the femoral region

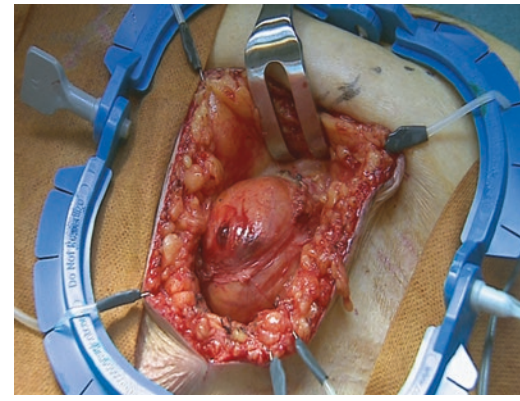

Fig. 45.11 Wide dissection of the femoral sac and hole

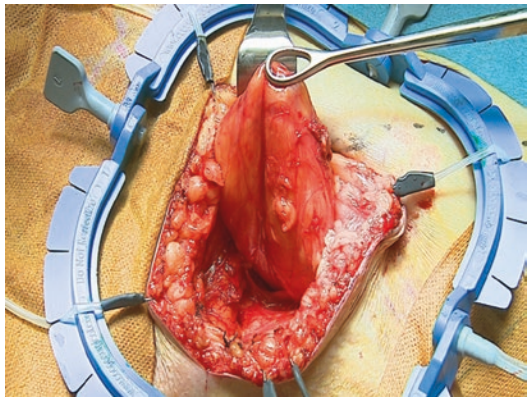

Fig. 45.12 Wide dissection of the femoral sac and hole

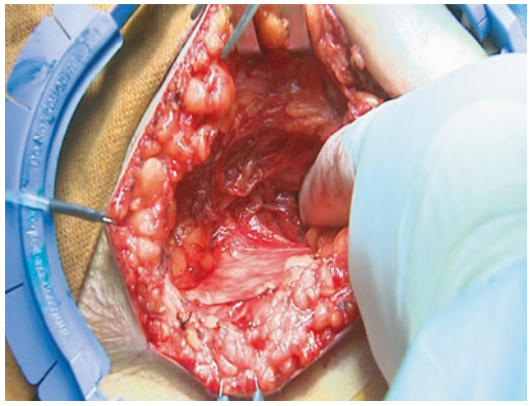

Fig. 45.13 Digital evaluation of crural orifice after hernia sac reduction (without excision)

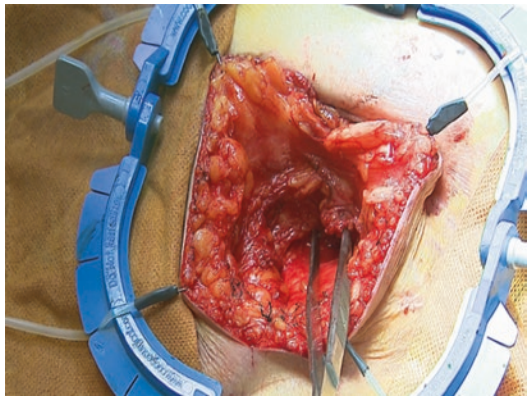

Fig. 45.14 The clamp holds inside the reduced hernia sac

Fig. 45.15 UHS prosthesis is tailored reducing the anterior sheet to a small border

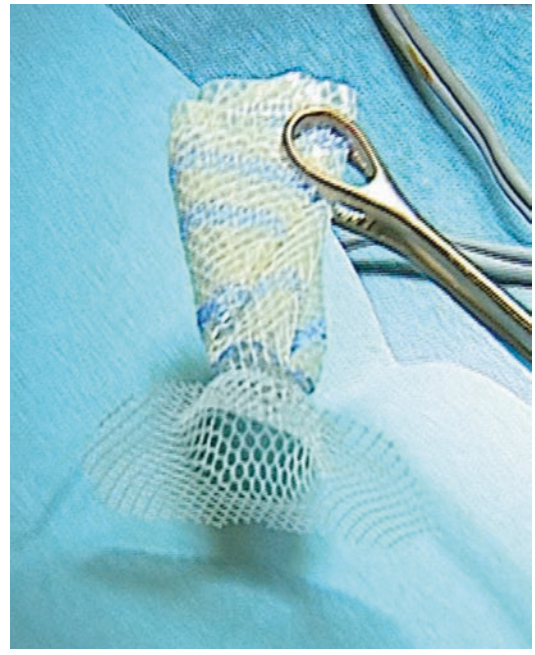

Fig. 45.16 UHS prosthesis is made as a mesh-plug

45.5.3 UPP: Ultrapro Plug

(Figs. 45.24, 45.25, 45.26, 45.27, 45.28, 45.29, 45.30, 45.31, 45.32 and 45.33)

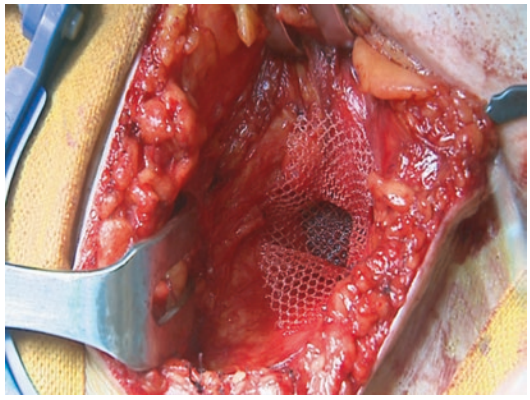

Fig. 45.17 Final position of UHS mesh plug; we can see the small ring of the anterior sheet

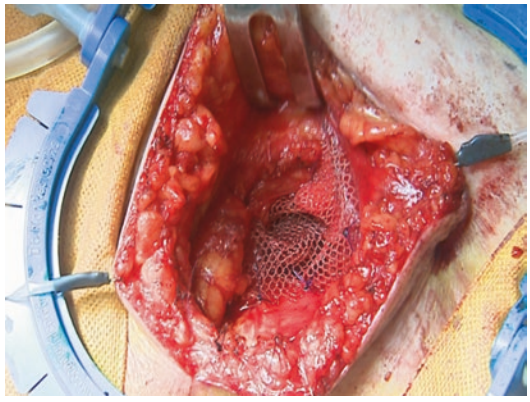

Fig. 45.18 Final view with three cardinal points and a few sutures to extend the anterior edge of the prosthesis in the pectineal fascia

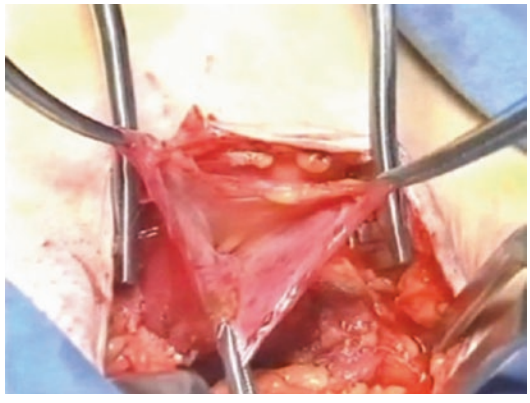

Fig. 45.19 The femoral sac is opened to assess the content

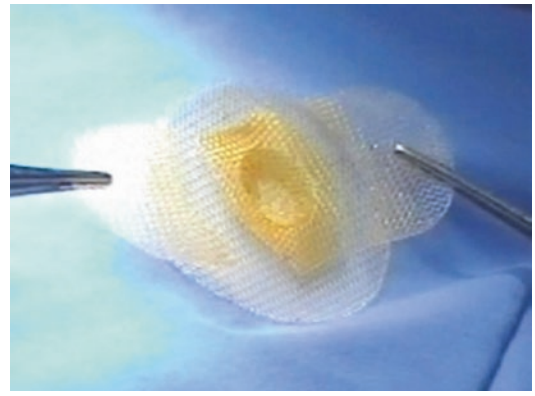

Fig. 45.20 PHS prosthesis used for femoral hernia

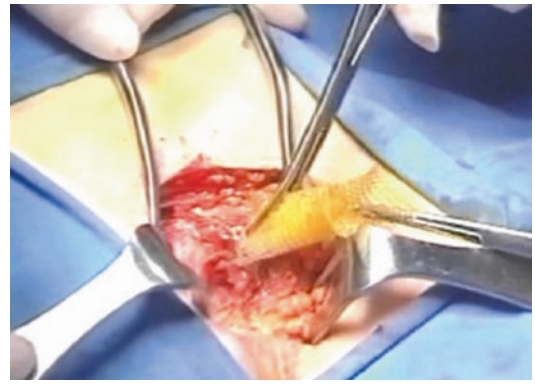

Fig. 45.21 PHS prosthesis before the positioning

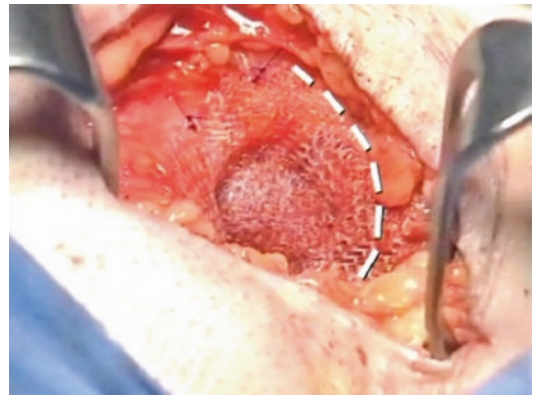

Fig. 45.22 The dotted line close to femoral vein

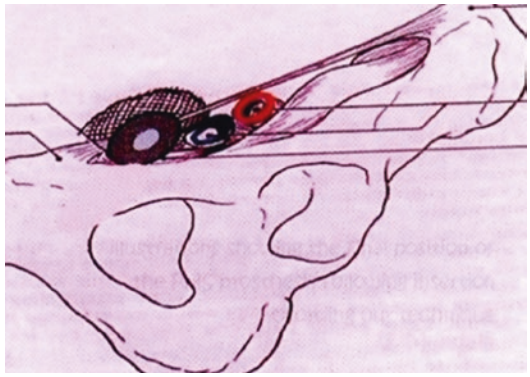

Fig. 45.23 Illustration of final position of the prosthesis

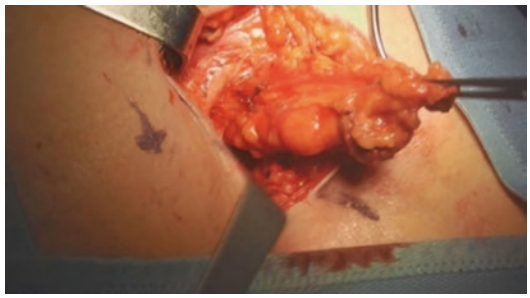

Fig. 45.24 Wide dissection of the femoral sac

Fig. 45.25 The sac is not cut and it is put down without excision to avoid pain

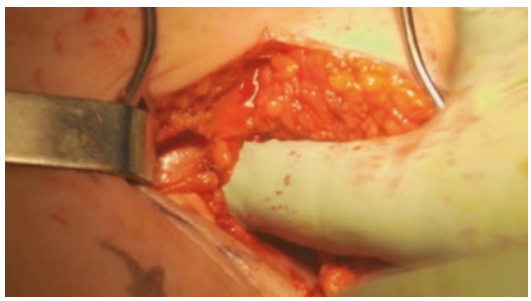

Fig. 45.26 Cleavage of the Bogros space by finger accomplished for inner prosthesis

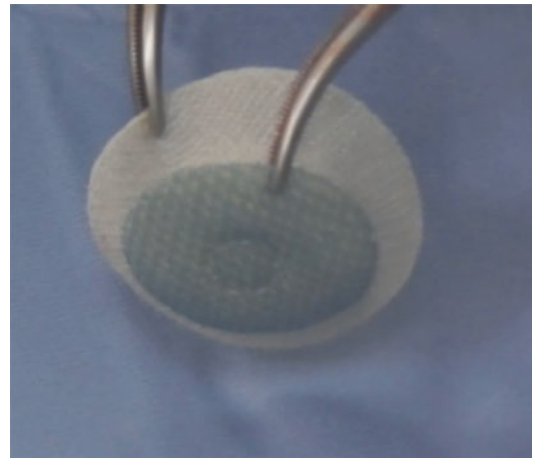

Fig. 45.27 The UPP Ultrapro prosthesis is a light mesh

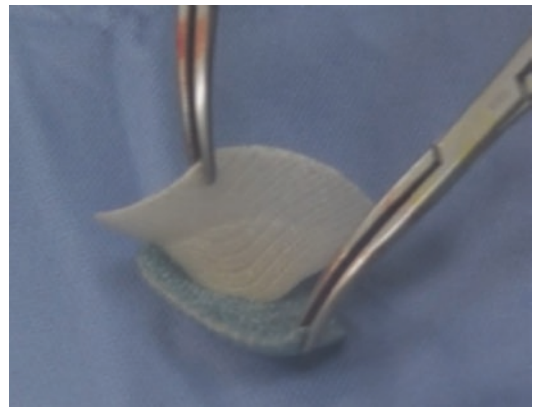

Fig. 45.28 The UPP Ultrapro prosthesis is partially re-absorbable

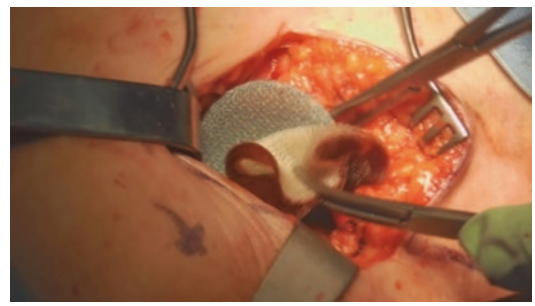

Fig. 45.29 The UPP mesh plug is inserted into the femoral canal with a long clamp

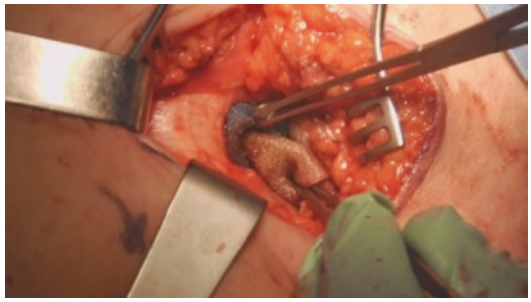

Fig. 45.30 The circular internal sheet of the prosthesis spreads open like Bendavid's umbrella prosthesis

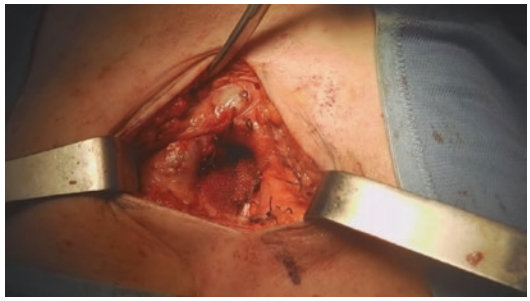

Fig. 45.31 Final position of the UPP mesh plug; we can see the small ring of the anterior sheet

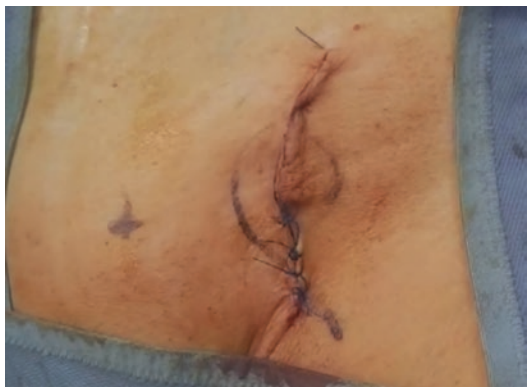

Fig. 45.32 Final appearance of sutured skin

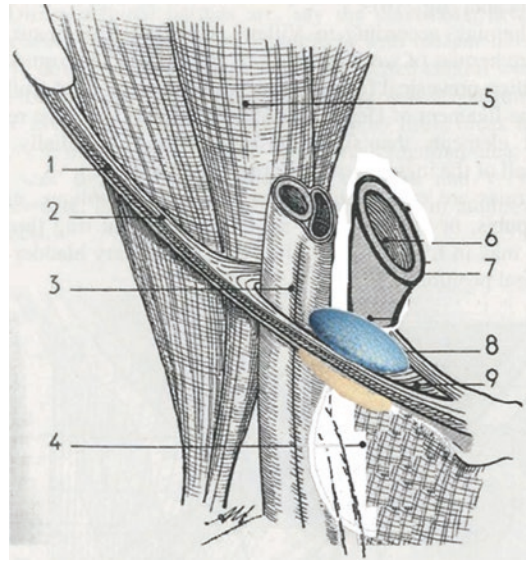

Fig. 45.33 Diagram showing the position of the UPP double disc prosthesis according to our technique (From Fruchaud modified)

45.6 Emergency Femoral Hernias: The Surgical Technique

"…… Are the most treacherous of all hernias. When incarcerated, they outnumber all other forms of incarcerated abdominal hernias combined". (R. Bendavid).

Groin examination must always be part of an abdominal examination.

In many cases, in emergency, the reduction of an incarcerated femoral hernia is impossible without incising the lacunar ligament and the medial femoral sheath to widen the defect (Fig. 45.34).

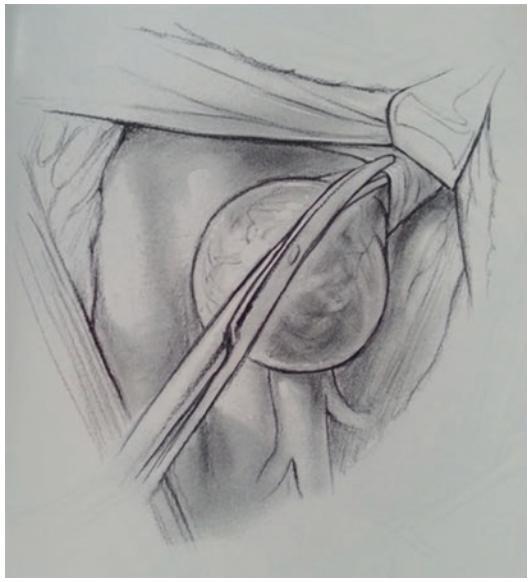

Fig. 45.34 (reproduced from George Wantz's *Atlas of Hernia Surgery*, Raven Press, 1991, NY)

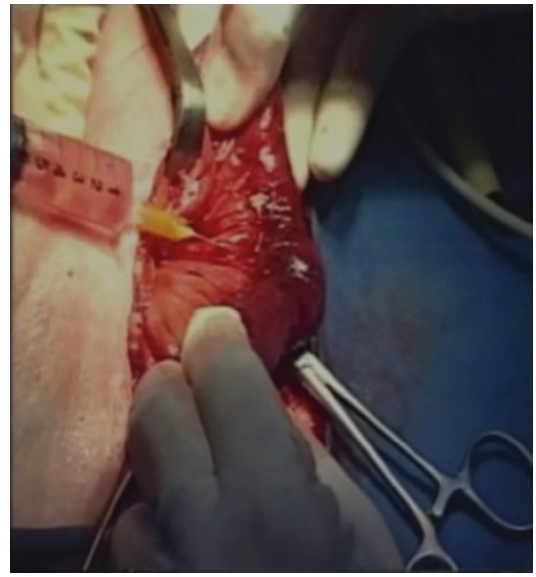

Fig. 45.35 Strangulated Richter's hernia

45.7 Personal Technique in Emergency

CASE I Richter hernia (Figs. 45.35, 45.36, and 45.37).

CASE II Femoral epiploic strangulated hernia – Combined repair (Figs. 45.38, 45.39, 45.40, 45.41, 45.42, 45.43, 45.44, and 45.45).

CASE III Strangulated small bowel femoral hernia – Combined repair (Figs. 45.46, 45.47, 45.48, and 45.49).

In several cases, (12 cases), there was an indication to carry out our technique in a combined procedure (open/laparoscopic approaches) [17].

In our opinion, this technique is indicated in selected cases of complicated femoral hernias, e.g. the elderly and the frail patients with other comorbidities thanks to the collaboration with the anaesthesiologists, for different reasons:

- A "short" general anaesthesia.
- A rapid low-pressure pneumoperitoneum (a few minutes).

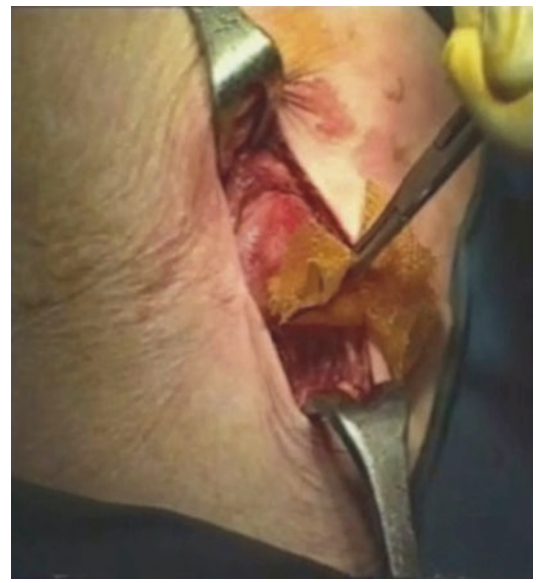

Fig. 45.36 Prosthesis insertion

- Diagnostic aim of laparoscopy: only to explore the type and vitality of the contents after reduction and the evaluation of the size of the femoral ring.

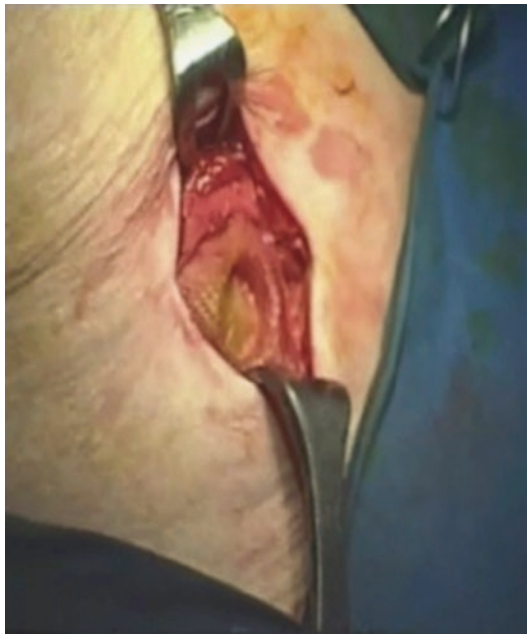

Fig. 45.37 Final position

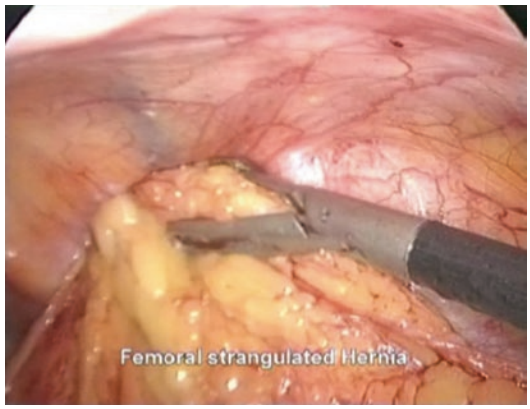

Fig. 45.38 Femoral epiploic strangulated hernia

- The combined technique (laparoscopy and a simple infrainguinal low approach) permits the reduction of the sac into the peritoneal cavity, and it represents a great advantage in avoiding contact between the prosthesis and the hernia content (infections) as well as the intraperitoneal fixation of the sac and, most importantly, the late evaluation of the viability and possible ischemic troubles of the contents.
- The combined technique avoids a negative prognostic factor: an associated laparotomy [30, 31], the latter was carried out in 11 patients, in our case series.

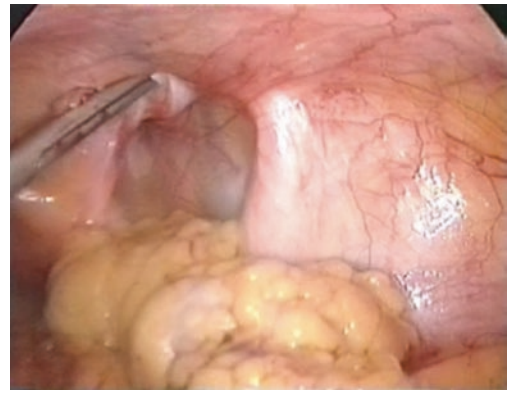

Fig. 45.39 Femoral epiploic strangulated hernia. The internal femoral ring after epiploic reduction

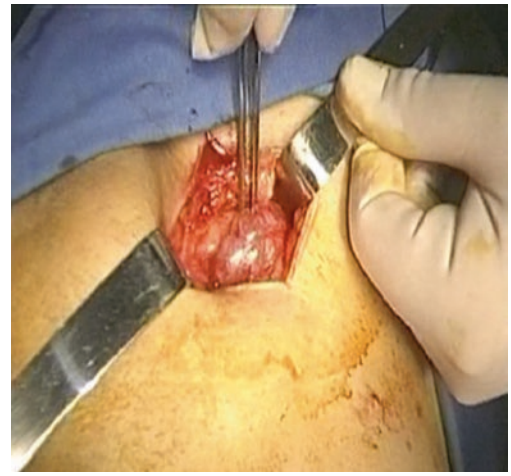

Fig. 45.40 The femoral sac is dissected and reduced into the abdomen by anterior approach ...

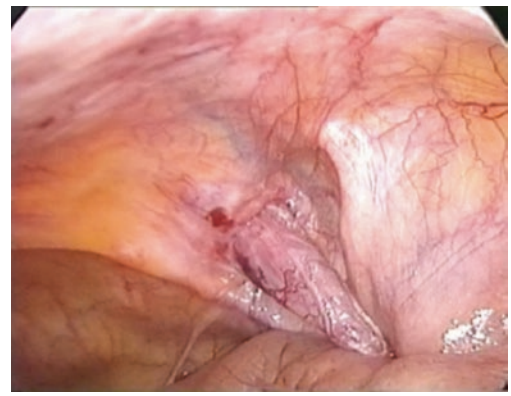

Fig. 45.41 ... under laparoscopic control

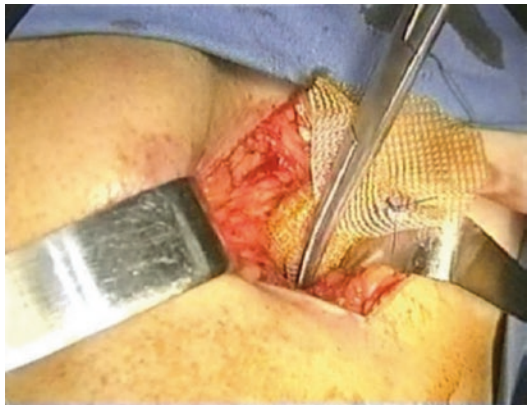

Fig. 45.42 The 3D patch mesh plug is inserted into the femoral canal with a long clamp

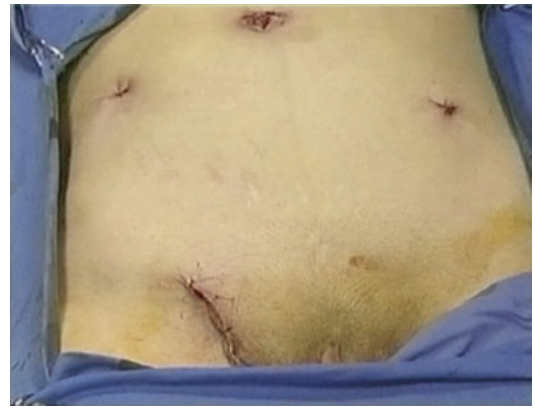

Fig. 45.45 Final view of the abdomen with incisions

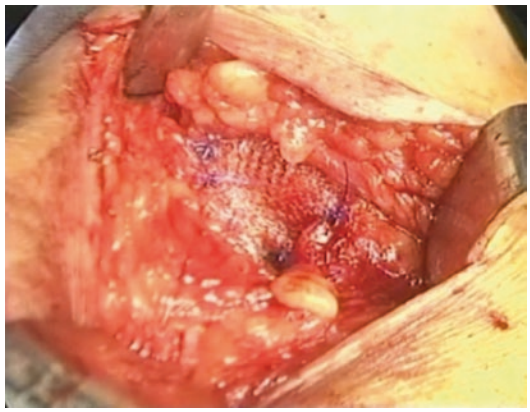

Fig. 45.43 Superficial disc is anchored with three cardinal sutures

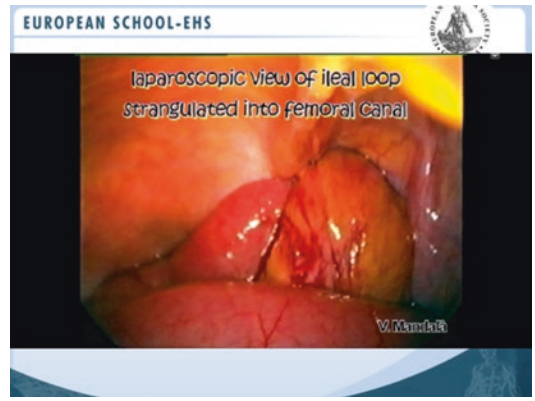

Fig. 45.46 Strangulated small bowel in femoral hernia. Laparoscopic view

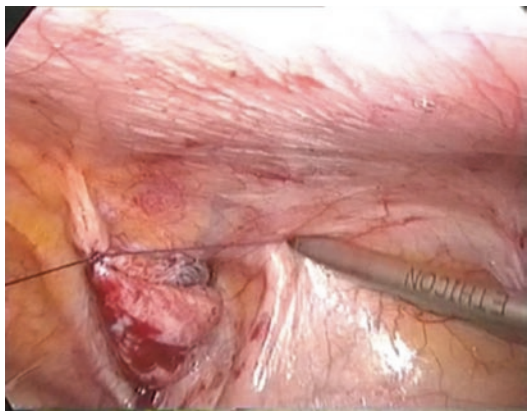

Fig. 45.44 The femoral sac inverted is anchored to the peritoneum

Fig. 45.47 Reduction of the content into the abdomen by laparoscopic approach

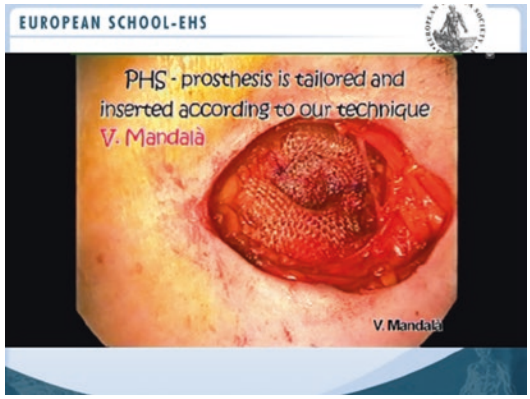

Fig. 45.48 PHS prosthesis is shaped and inserted, according to our technique, by anterior approach

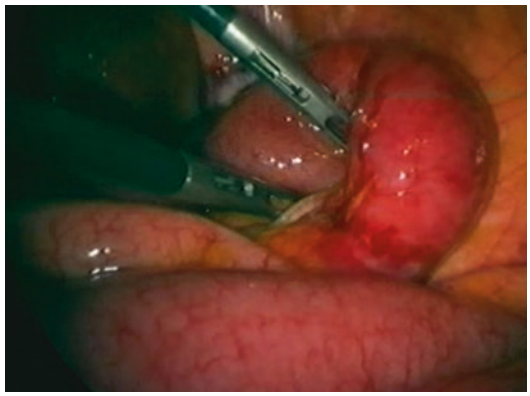

Fig. 45.49 Final view for late evaluation of the bowel integrity

- An alternative technique is the hernioscopy (hernia sac endoscopy) [32, 33]; moreover it is achievable in case of inguinal strangulated hernia, and, in our opinion, it is not possible in femoral one, in consideration of the femoral canal anatomy.

45.8 Personal Experience (1996–2015)

Over a period of 20 years, we have performed 244 surgical procedures using the plug technique, 68 on men and 176 on women; 129 (52.9%) patients underwent emergency surgery and 115 (47.1%) were elective cases. We have performed only 11 laparotomies and the recurrence rate was 2%. This percentage can be underestimated because a great number of elderly patients have been operated on having complications in an emergency setting (dedicated emergency department, patients lost in follow-up). The overall mortality rate was 2% (five patients). The mortality (3.9%) occurred only in strangulated femoral hernias, associated with a bowel resection (three cases) and laparotomy (three cases). Therefore, there was no mortality in elective cases.

45.9 Consideration on Personal Case Studies from 1996 to 2015

45.9.1 Type of Prosthesis

- Rolled plug *n* 56 (22.9%)
- Umbrella plug *n* 45 (18.4%)
- Mesh and plug *n* 11 (4.5%)
- PHS *n* 62 (25.4%)
- 3D plug *n* 22 (9.1%)
- UPP *n* 21 (8.6%)
- UHS *n* 27 (11.1%)

45.9.2 Anaesthesia

- Local: 123 cases
- Local + neuroleptanalgesia: 24 cases
- General 18: cases
- General (conversion): 20 cases
- Epidural: 59 cases

45.9.3 Local Complications *n*. 41 (16.8%)

- Serohaematomas 20
- Wall's oedema 4
- Lymphorrhea 2
- Infection 5
- Recurrence 5
- Pain discomfort 5
- Deep vein thrombosis 0
- Major vascular injury 0
- Major vascular bleeding 0
- Retroperitoneal haematoma 1
- Removal prosthesis 4 (pain—infection)
  - Rolled plug 2
  - 3D patch 1
  - PHS 1

45.9.4 Abdominal Complications

- Adynamic ileus 3 (NOM—nonoperative management)
- Obstructive ileus 2 (redo laparoscopic surgery)
  - Littrè hernia (ileal resection)
  - Single adhesion by plug (adhesiolysis)
- Upper digestive bleeding 1 (NOM—nonoperative management)

There is a great difference of pathway in election (preventive surgery in young people) and in emergency (mandatory therapeutic surgery in elderly patients), as in our case studies that report an acceptance of patients in an emergency surgical department of a third-level hospital. In these complicated cases, a quick and easy intervention, if possible, is the first choice for these elderly patients.

As referred by other surgeons [31], there are several limitations (bias) also in our experience:

- Retrospective design
- Lack of randomization and blinding
- Single-centre experience
- Inconsistency in follow-up schedule
- A lot of patients lost
- Many patients with early mortality (elderly patients with several comorbidities)
- Lack of standardized hernia surgery database, in the past
- With underestimating:
  - Late hernia recurrence
  - Late chronic pain
  - Long-term complication rate

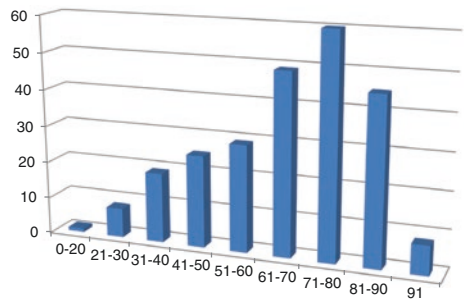

Fig. 45.50 Femoral hernias - Incidence by age (V. Mandalà)

Also in our experience, this disease is correlated by age (elderly people).

"…The older the patient, and the longer the delay in diagnosis, the higher the mortality rate…". (R. Bendavid) (Fig. 45.50).

45.10 Tactical Considerations: Tips and Tricks

45.10.1 The Choice of Materials and Shape: UHS Mesh and UPP Plug

- Does not expand the preperitoneal space (flat disc prosthesis)
- Three-dimensional characteristic shape:
  - Little fixation
  - No plug migration
- Lightweight prosthesis:
  - Large pore and partially absorbable
  - Increased flexibility
  - Reduction in foreign body sensation

→
- Low rate of recurrence
- Low rate of chronic pain

- The rational use of double disc prosthetic device according to our technique:
  - Crural orifice <2 cm → UPP Plug—3D Patch
  - Crural orifice >2 cm → PHS—UHS meshes

45.10.2 Advantages of the Infrainguinal Approach

- Can be performed under local or epidural anaesthesia (high-risk surgical patients)
- Has been proved to be convenient [34] (direct approach to femoral canal)
- Shorter operative time vs laparoscopic procedures
- Easy to learn and teach

45.10.3 What Does a More Minimally Invasive Approach Mean?

- A direct approach to the femoral canal.
- It is not necessary to dissect the inguinal canal.
- Spermatic cord and nerves within the inguinal region are protected.
- Decrease of chronic postoperative pain.

45.10.4 Infrainguinal Open Approach in Emergencies

- Incarceration and obstruction.
- Strangulation.
- Irreducible hernias.
- It is easier to partially cut the inguinal ligament using the infrainguinal approach rather than an inguinal one [34].

45.11 Conclusion: Low Approach Double Disc Prosthesis

- Rapid and straightforward execution
- Suitable for the elderly, frail and "complicated" patients
- Treats both the mechanical and biological problems (prosthetic use)
- Allows short hospitalization, even in emergency cases
- Low recurrence rate
- No increase in chronic postoperative pain
- Applicable in all presentation patterns

45.12 Femoral Hernias: General Key Points

- Lack of evidence.
- Need of multicentric RCT, international registers and consensus conferences.
- A thorough imaging analysis (CT scan) especially in an emergency is mandatory.
- Tailored surgical procedure according to anatomy.
- Several technical options and approaches sometimes combined.
- Mandatory use, if possible, of prosthesis.
- Surgeons should perform the technique they are most confident with.
- No delay surgery.

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Open Posterior Approaches for Femoral Hernia Repair

46

Frederik Berrevoet

46.1 Introduction

Approaches to the groin to treat femoral hernias began in 1876 with the report by *Annandale* [1]. Thereafter, *Cheatle* described the posterior open preperitoneal approach to the groin in 1920 [2], in which he introduced the transabdominal paramedian approach to the space of Bogros. His operation was ignored until 1936, when *Henry* [3] used it to also treat a femoral hernia, while operating extraperitoneally on the pelvic ureter for stones.

In 1950 *McEvedy* [4] reported an oblique lateral incision, dividing both the rectus sheath and transversalis fascia with medial retraction of the rectus muscle, and in that way he used the lateral transverse incision to reach the preperitoneal space. Ten years later, Lloyd Nyhus used a transverse incision placed 2 fingerbreadths cephalad to the superior border of the pubis and exposed the femoral by a preperitoneal approach [5]. He also recommended this procedure for incarcerated or strangulated femoral hernias, in which bowel resection is necessary.

Using the open preperitoneal approach to repair hernias facilitates entry into the retro-fascial transversalis space, providing direct access to the posterior inguinal and femoral structures. Hernial protrusions are exposed along with the myopectineal orifice of Fruchaud.

By using a mesh in this preperitoneal space, a strong barrier is created against the continuous intra-abdominal pressure. *René Stoppa* [6] introduced his giant prosthetic reinforcement technique of the visceral sac (GPRVS) initially for bilateral complex inguinal and femoral hernias. The preperitoneal space was reached by a transverse incision extending from the midline laterally for 8–9 cm. It is made 2 or 3 cm below the level of the anterior superior iliac spine and should be well above the deep ring and any hernias that might present. Incising the transversalis fascia along the border of the rectus muscle frees the muscle, permits entrance into the preperitoneal space, and exposes the inferior epigastric vessels. Performing this dissection, the femoral canal will be fully exposed for evaluation, and reduction of femoral hernia components is facilitated.

In recent years and most probably influenced and stimulated by the introduction of the laparoscopic hernia repair techniques, the open posterior techniques have their revival. Currently, several techniques are being used worldwide, all of them following the anatomical and surgical descriptions of our predecessors and each using their own specific type of mesh (Fig. 46.1). Accordingly, the Kugel™ mesh repair, the transinguinal preperitoneal mesh repair (TIPP), and the transrectus sheath preperitoneal mesh technique (TREPP) will be described and discussed.

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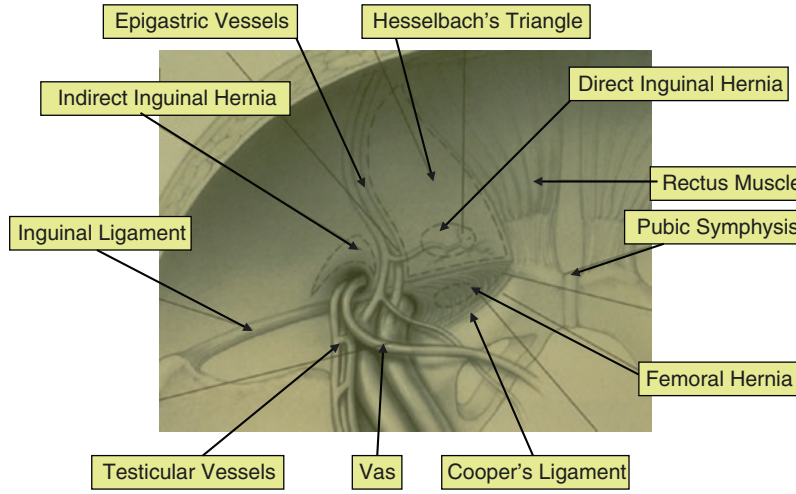

Fig. 46.1 View on the overall posterior anatomy

46.1.1 Indications and Contraindications

It should be clear that in any of the described techniques using an open posterior/preperitoneal approach, the technique *intrinsically implies* identification, reduction, and treatment by mesh coverage of any femoral or obturator hernia present. Without reduction of an unexpected femoral hernia, adequate mesh placement to reinforce the groin is not possible.

All patients, male and female, with an elective or urgent femoral or obturator hernia (next to inguinal hernias) are eligible for these open posterior techniques. In case of previous preperitoneal surgery, e.g., open prostatectomy with lymphadenectomy, bladder surgery, and pelvic trauma surgery, or in case of previous inguinal hernia surgery using the preperitoneal space for the location of the mesh, these techniques might succeed in only 50% of cases. Strangulated hernias are eligible for these techniques as well, even in case a bowel resection is needed. The open approach allows for an adequate reduction of the strangulated content, will easily identify the complete hernia sac, and allows for inspection and treatment of the involved viscera. Whether mesh can still be used in these potentially (clean-)contaminated areas should be evaluated by the surgeon.

46.1.2 Anesthesia

The procedure can in all elective cases be performed under local anesthesia (with sedation) or using spinal anesthesia. In cases of strangulation, general anesthesia is mandatory. Straining and coughing might help to spread the different types of devices and enable the surgeon to check the correct position of the mesh at the end of the procedure. Spinal anesthesia, using ropivacaine 0.2% without admixture of opioids, does not induce unacceptably high urinary retention rates leading to unplanned admissions. An additional local incisional block with ropivacaine 0.2% can be very useful, especially in day-care treatment. In other situations general anesthesia might be the option of choice.

46.1.3 Surgical Techniques

46.1.3.1 The Kugel Approach

A comparable lateral incision is made at a point estimated to be about 2–3 cm above the internal ring. This point is located approximately halfway between the anterior superior iliac spine and the pubic tubercle as described by *Robert Kugel* [7]. The 3–4 cm incision (in an average-sized patient) is made one third lateral and two thirds medial to an imaginary line drawn between these two struc-

tures. The dissection is then carried down to the external oblique aponeurosis, which is opened a short distance parallel with its fibers. The underlying internal oblique muscle is bluntly separated exposing the transversalis fascia deep to it.

The cord structures are carefully evaluated, as well as the femoral canal and its content. Using blunt and limited sharp dissection, an oval-shaped pocket is created in the preperitoneal space just barely large enough to accept the mesh patch. The pocket created sits between the peritoneum, superior and posterior, and the internal ring, cord structures, femoral canal, and Hesselbach's triangle, inferior and anterior. This pocket should extend from behind the pubic tubercle medially to a point about 3 cm beyond the transversalis incision laterally and roughly paralleling the inguinal ligament.

The specifically designed Kugel patch™ for this procedure should be sufficiently large to cover and overlap the hernia defect, including Hesselbach's triangle and the femoral canal, and lie parallel with the inguinal ligament. About three fifths of the mesh should sit above (anterior) the level of the inguinal ligament and the other two fifths below (posterior) the ligament. Two separate oval-shaped sheets of mesh material (small-pore polypropylene) are attached to each other near the outer edge of the smaller piece while leaving a 1 cm "apron" free at the outermost edge of the larger piece. A transverse cut is made in the midportion of the anterior layer of mesh. This transverse cut allows insertion of a single digit or instrument between the two layers of mesh and greatly facilitates positioning of the patch (Fig. 46.2). Inserting a single finger between the layers of mesh will allow placement of the patch into the preperitoneal space. The fingertip should be directed toward the superior aspect of the pubic bone. The finger is then removed from the mesh and a narrow malleable retractor inserted, if needed, to complete placement of the medial edge of the patch behind the pubic bone. The lateral edge of the mesh can then be tucked into the lateral portion of the preperitoneal pocket. The mesh lies between the cord structures (or round ligament) and the peritoneum and does not surround the cord structures. The posterior edge of the patch should fold back under the peritoneum and onto the iliac vessels. This edge must extend well below (posterior to) the level of the inguinal ligament.

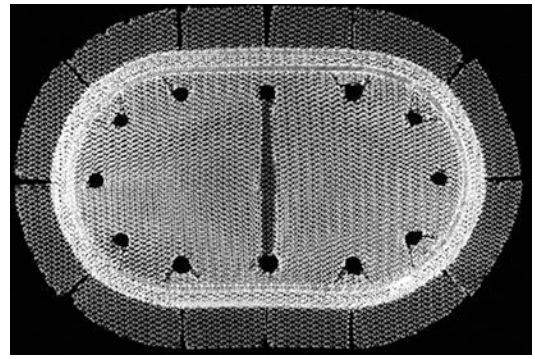

Fig. 46.2 Double-layered Kugel patch™

46.1.3.2 The Transinguinal Preperitoneal Technique (TIPP)

As the traditional anterior approach is the most commonly known and therefore best reproducible by many surgeons, the transinguinal preperitoneal repair is a good alternative to approach the preperitoneal space through the deep inguinal ring or through the medial inguinal defect by incising the transversalis fascia [8]. This type of mesh repair is facilitated by the use of a memory-containing prosthesis. The memory ring offers, in contrast to some other techniques, an easy deployment of the patch in the preperitoneal space under good visualization of the groin structures.

Halfway the line between the pubic tubercle and the anterior superior iliac spine, we start the incision and proceed medially for 3 cm in an angle of approximately 30°. By doing so, the incision is precisely centered over the deep inguinal ring and the epigastric vessels. The iliac vessels will then always be just at the lateral edge of the incision and serve as an important reference point at the time of mesh introduction. The external oblique aponeurosis is opened, taking caution not to harm the ilioinguinal nerve, and the inguinal canal is exposed. This may only increase the

harm done to the inguinal nerves. The preperitoneal space will be entered through the internal ring, and after palpation of both Cooper's ligament and the pubic bone to ensure the dissection will be done in the right avascular preperitoneal plane, gauze can be introduced into the preperitoneal space toward Retzius' space (Fig. 46.3). The next step is then again to reduce the femoral hernia present and to parietalize the cord structures as far as possible [9]. By doing this there is no need to create a new internal orifice by incising the mesh laterally.

A last critical point in using this technique is to obtain a sufficient pocket at the lateral side of the internal orifice. To facilitate this part of the dissection, it sometimes can be helpful to introduce gauze laterally. One should only be satisfied with the created pocket once the index finger can reach the superior anterior iliac spine easily. After creation of the appropriate pocket, a malleable flat retractor is introduced medially to recline peritoneum, preperitoneal fat, and the lateral aspect of the bladder. Introduction of the mesh can now be performed, sliding the mesh over the malleable retractor.

The use of a mesh with a memory facilitates the introduction and fast placement. Different meshes are available (the PolySoft™ patch (Bard/Davol), which consists of a polypropylene mesh with a resorbable memory ring; the Rebound HRD Shield™ (Minnesota Medical Development, Inc. (MMDI)), which consists of a large polypropylene mesh with a non-resorbable nitinol frame) [10].

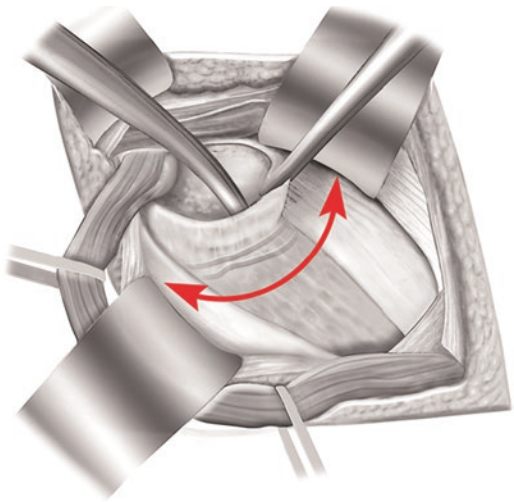

Fig. 46.3 Entrance of the posterior preperitoneal plane through the internal inguinal ring during TIPP

46.1.3.3 The Transrectus Sheath Preperitoneal Mesh Technique (TREPP)

As the previous TIPP technique still uses the inguinal canal as the entrance site to the preperitoneal space, the TREPP technique was described in detail by *Akkersdijk* et al. [11]. The access is cranially to the internal ring, in order to ascertain easy and secure inspection of the spermatic cord. The aponeurosis of the external oblique muscle is opened parallel with the groin. The anterior layer of the sheath of the abdominal rectus muscle is identified and opened, and the rectus muscle is identified. The inferolateral border of the muscle is separated from its surrounding fibrous structures. The rectus abdominis is retracted medially with a small Langenbeck retractor. In most cases the entrance of the preperitoneal space will be laterally from the epigastric vessels. The finger should push gently behind the muscle layers of the abdominal wall, toward the anterior superior iliac spine. When it reaches the iliac spine, the finger will be reflected over the anterior border of the iliopsoas muscle. During this movement, the iliac artery is used as a landmark, and the femoral canal can be very easily evaluated. Further dissection and parietalization are then performed as in the other techniques.

For its introduction, the memory-ring-containing type of mesh is grasped at its tail with forceps and pushed into the lateral compartment, directed toward the anterior superior iliac spine. Keeping the mesh fixed with a finger against the abdominal wall laterally, the inferomedial part of the mesh is grasped by the forceps and rotated behind Cooper's ligament and the pubic bone. The mesh should overlap Cooper's ligament and the symphysis by at least 1 cm (Fig. 46.4). The anterior rectus sheath can then be closed.

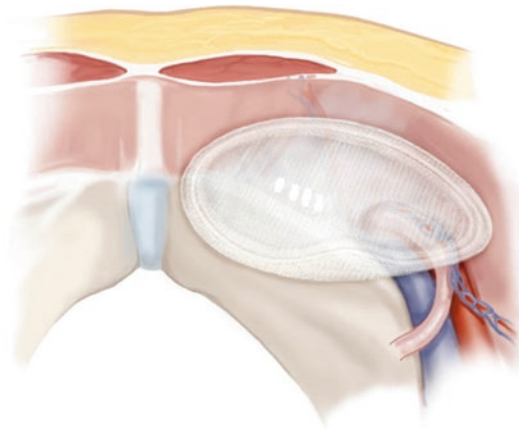

Fig. 46.4 Inside view on the mesh position after femoral hernia repair

46.1.3.4 Postoperative Recommendations

These are not specified for all available techniques but can be summarized as follows:

Patients are advised to take analgesics for 2 days and mobilize from day 1 without limitations. The time patients need to return to their normal daily activity is mostly between 2 and 4 days, and the time to return to full activity, including their job and sports, is around 10–14 days.

46.1.4 Literature and General Considerations

Although repair of groin hernias is one of the most frequently performed surgical procedures for the general surgeon, femoral hernia repairs are not as common. They account for about 2–4% of all groin hernia repairs [12, 13]. Although their incidence might be low, they are of clinical importance, as they often present with strangulation, which demands emergency repair and sometimes bowel resection, resulting in an increased morbidity and even low mortality [14].

The low incidence of femoral and also obturator hernias makes them difficult to study in randomized clinical trials, so that the current literature is still sparce and mainly based on patient series, systematic reviews, and some reports from national registries [15, 16].

In their report on emergency repair for femoral hernias, Dahlstrand et al. concluded that preperitoneal mesh techniques, both laparoscopic and open, were more effective than suture repairs in the elective setting, in terms of risk for reoperation due to recurrence. However, for emergency femoral hernia repair, no significant difference between mesh and suture repair was identified [16].

The low incidence of femoral hernias renders it difficult to acquitre sufficient experience, even for a surgeon specialized in abdominal wall surgery. As many femoral hernias are operated in emergency setting, a higher proportion is managed under suboptimal circumstances by surgeons not specialized in hernia surgery. Furthermore, there is still no standard femoral hernia repair technique that an unexperiencesd surgeon can rely on, when faced with a difficult situation.

Another issue is the clinical situation of recurrence after inguinal hernia repair, being an unmissed femoral hernia or secondary to the previous repair. In case of an open anterior repair, these femoral components might be missed if the inguinal floor or superficial thigh fascia is not routinely incised and the femoral space is not examined. There are series reported in which more than 50% of the femoral hernias had a concomitant inguinal hernia [17]. A surgeon might be satisfied with one diagnosis to repair the inguinal hernia, neglecting the femoral space; therefore, a posterior approach has a major advantage when treating inguinal hernias as it is impossible to perform an adequate preperitoneal mesh repair without recognizing and reducing a femoral hernia present. Vice versa, it is less favorable to approach femoral hernias by the infrainguinal approach, as the inguinal space cannot be assessed for any inguinal hernia.

Another outcome of hernia repair that receives lots of attention nowadays is chronic pain. Regarding acute and chronic postoperative pain issues, the treatment of inguinal and femoral hernias using mesh in the preperitoneal space might

have several advantages: minimal dissection around the inguinal nerves; location of the mesh in the avascular preperitoneal space, being more toward the human physiology, and not in contact with the nerves; minimal or no fixation of the mesh necessary; and no extensive amount of material to prevent severe local inflammation and fibrosis around the nerves and the cord structures during tissue ingrowth. Entering the inguinal canal to reach the preperitoneal space still includes the risk of harming one or more inguinal nerves. This might be an argument not to choose for the TIPP technique. However, although the transinguinal approach still includes dissection around the inguinal nerves, minimal dissection around the hernia sac only is recommended as well as not to take down all cremasteric muscles nor to free all boundaries of the inguinal canal itself as in a Lichtenstein repair. Staying outside the inguinal canal might be beneficial regarding nerve damage, favoring the TREPP or Kugel repair, but usually these approaches limit good visualization of the working space, specifically when dealing with strangulated or incarcerated femoral or obturator hernias.

Fixation still is one of the main etiologies for postoperative pain in all mesh augmentations for abdominal wall surgery. Therefore, we consider it favorable, as in laparoscopic inguinal hernia repair, that the mesh needs no or minimal fixation, using a memory-containing mesh device. The intra-abdominal pressure as well as the forces of the abdominal muscles will keep the mesh in place considering Pascal's law. Compared to the Lichtenstein method or the plug and patch techniques, this might most probably decrease the amount of postoperative pain.

In the literature there are no data comparing the open preperitoneal techniques with each other, so no recommendation can be made about the preferred open preperitoneal technique for femoral hernias nor for inguinal hernia. This is again stated in the recently updated guidelines of the European Hernia Society [18]. Most of the data involves the comparison between open preperitoneal techniques and the Lichtenstein technique for inguinal hernias, some series including also femoral hernias [10, 19, 20].

It can be concluded that open posterior repairs TIPP, Kugel, and TREPP seem efficient to approach femoral and obturator hernias and should be preferred, certainly in elective settings over open anterior repairs. They are effective in terms of recurrence and safe in case of strangulated femoral hernias. Using these approaches, femoral hernias will never be missed also leading to a lower recurrence rate after initial inguinal repair. Compared to the open anterior techniques, these open posterior/preperitoneal techniques may possibly result in less postoperative pain and faster recovery.

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47 Laparoscopic Femoral Hernia Repair

Erica D. Kane and Brian P. Jacob

47.1 Introduction to the Clinical Problem

Femoral hernias account for 8–11% of all inguinal hernias [1] and 3–5% of all abdominal wall hernias [2]. While groin hernias are more common in males, at a lifetime incidence of 2–5% compared to 0.3% for females [3], femoral hernias are more frequently found in women, accounting for 22–34% of all groin hernias versus 1.1% in men [4]. Therefore, in all groin hernias in female patients, femoral hernia should be considered in the differential diagnosis until proven otherwise.

The most prominent concern of a femoral hernia is the increased risk of bowel strangulation, presenting emergently in 32–39% of cases in large part because femoral hernias are often missed or misdiagnosed on initial exam [4–7]. From the time of diagnosis, the risk of incarceration has been identified as up to 22% at 1 month and 45% at 21 months [8, 9]. Acutely incarcerated femoral hernias are associated with a 30% increase in morbidity, including bowel resection, wound infection, and cardiovascular and respiratory complication, compared to those repaired electively [5, 10, 11]. Mortality is increased 10- to 20-fold in patients repaired emergently, whereas femoral hernias repaired electively are not associated with increased mortality compared to the general population, even in patients over 80 years of age [5, 12, 13]. For this reason, all patients with a femoral hernia diagnosed in the elective setting and all females and older patients identified to have a groin hernia should be offered timely surgical repair.

The objective of laparoscopic hernia repair is to broadly cover half of the lower preperitoneal abdominal wall with mesh, thereby effacing any potential weak area within the myopectineal orifice, including the area of the internal ring, Hesselbach's triangle, and the femoral ring. This can be accomplished via an open anterior approach, a total extraperitoneal (TEP), laparoscopic transabdominal preperitoneal (TAPP), intraperitoneal onlay mesh (IPOM), or robotic TAPP approach. The choice of technique utilized is based on the surgeon's experience and comfort level, the patient's physical exam, and their previous surgical history. Laparoscopic approaches are well suited for recurrent hernias in patients who have had a previous open repair or are presenting with bilateral hernias. Femoral hernias, in particular, are more likely to be missed or misdiagnosed during hernia repair when performed via an open approach [3, 14]. Laparoscopy holds the benefit of being able to visualize and diagnose abdominal wall hernias which were not identified preopera-

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tively, which occur in 11–25% of patients [15–17], thereby allowing for a "one-step" repair of concomitant hernias. Furthermore, a large study reporting long-term follow-up of femoral hernia repairs demonstrated decreased operative time and length of hospital stay for patients who underwent a laparoscopic repair compared to an open approach [4]. Robotic inguinal/femoral hernia repair further offers improved visualization of anatomic structures and enhanced dexterity given seven degrees of articulation granted by the robotic wrists compared to laparoscopic instruments [18]. Nonetheless, the surgeon must be trained on components of robotic surgery, including port placement, positioning the patient care, comprehending the relative distances of the patient's anatomy as seen in the console, and being able to troubleshoot technical issues with the robot itself. The surgeon must also feel comfortable with laparoscopic TAPP technique prior to performing this procedure robotically.

47.2 Differential Diagnosis and Diagnostic Work-Up

It is very difficult to distinguish femoral hernias from direct or indirect hernias, as the sac tends to slide superiorly after its egress from the femoral canal. Furthermore, they tend to be smaller in nature than other groin hernias, making them difficult to palpate during physical exam, particularly in obese individuals. Other diagnoses to consider in patients who present with a palpable femoral mass are femoral adenopathy and saphenous varix. Ultrasound may be used as an inexpensive, noninvasive adjunct for diagnosis of suspected occult hernia, with a sensitivity and specificity of nearly 100% for groin hernias; however, this test has variable accuracy based on the operator and poorly distinguishes between the types of groin hernias. Computed tomography better characterizes the hernia type but is expensive and exposes the patient to unnecessary radiation. The surgeon should have a high suspicion for femoral hernia in a patient with groin pain of otherwise unknown etiology, especially in female patients.

47.3 Contraindications to Laparoscopic Femoral Hernia Repair

Patients with significant cardiac or pulmonary comorbidities, who would not tolerate either general anesthesia or insufflation during laparoscopy, should proceed with an open hernia repair. Prior pelvic radiation and/or preperitoneal dissection, usually for surgery of the prostate, are relative contraindications as they may obliterate the preperitoneal plane. Many surgeons will opt to perform an open, rather than laparoscopic, repair in the case of an acutely incarcerated hernia due to the need for possible bowel resection. In the event of gross contamination of the surgical site, placement of mesh should be avoided, precluding the utilization of a laparoscopic technique.

47.4 Anatomic Landmarks and Areas of Concern

Femoral hernias occur when a peritoneal sac, usually containing preperitoneal fat and lymph nodes, protrudes through the femoral canal via the femoral ring. The bordering structures of the femoral canal include the inguinal ligament anteriorly and superiorly, the lacunar ligament medially, Cooper's pectineal ligament posteriorly, and the femoral vein laterally. The canal is contained within the femoral sheath, which is formed anteriorly by extensions of the transversalis fascia and posteriorly by the iliopsoas fascia.

Externally, the femoral hernia presents posteriorly and inferiorly to the ilioinguinal ligament, as opposed to inguinal hernias, which present superiorly. From the intraperitoneal perspective, the hernia protrudes below the iliopubic tract, which courses parallel and posteriorly to the more superficial ilioinguinal ligament. The iliopubic tract is a derivative of the transversalis fascia, evident as a thickened band forming at the deep surface of the anterior superior iliac spine, transversing the myopectineal orifice, and inserting on the pubic tubercle before reflecting to join

the pectineal ligament. It joins the iliopectineal arch to form the proximal portion of the femoral sheath, reinforcing the posterior aspect of the femoral ring. The iliopubic tract is an important landmark during transabdominal laparoscopic repair as it demarcates the safe regions for dissection and tack placement from vulnerable structures located inferiorly, including the branches of the lumbar plexus.

Areas where careful attention must be paid during laparoscopic preperitoneal dissection have traditionally been described as the "triangle of doom," between the peritoneal reflection and vas deferens medially and the internal gonadal vessels laterally where the iliac vessels, corona mortis, and genital branch of the genitofemoral nerve reside, as well as the "triangle of pain," located lateral to the gonadal vessels, containing the femoral branch of the genitofemoral nerve and the lateral femoral cutaneous nerve. The genitofemoral nerve originates at the L1–2 plexus and courses along the anterior psoas muscle, passing inferiorly to the iliac fascia and then dividing into genital and femoral branches. While the genital branch enters the inguinal canal, the femoral branch passes through the femoral canal alongside the iliac vessels. The femoral cutaneous nerve runs anterolaterally along the iliacus muscle before coursing posterior to the iliopubic tract and the inguinal ligament. The use of staples and tacks should be avoided in these locations to prevent injury causing hemorrhage for future inguinodynia.

When operating via extraperitoneal approach, the location of these nerves and vascular structures, particularly the iliac artery, can be highly variable as they course through the preperitoneal space. When looking inferiorly, the preperitoneal space is continuous with the space of Retzius and is oriented by the pubic bone medially, Cooper's pectineal ligament posteroinferiorly with the external iliac vessels running in parallel and laterally. The vas deferens from this approach courses over Cooper's ligament and enters the inguinal canal just medial to the inferior epigastric vessels; these vessels then course anteriorly along the abdominal wall.

47.5 Operative Technique

For the following laparoscopic techniques, patient placement and preparation are similar. The patient should be positioned supine, with arms tucked at the patient's sides to allow for complete mobility of the surgeon and assistant about the table during the case. The patient may be placed in Trendelenburg position at 15–20° for improved exposure of the pelvis during intraperitoneal procedures. If the patient was not instructed to void prior to surgery, a urinary catheter should be inserted for decompression of the bladder. Bladder decompression allows for adequate space to work within the pelvis and to allow the mesh to lie smoothly during placement and fixation, particularly during a TEP repair. The operating surgeon should stand on the opposite side of the table as the hernia defect and the monitor should be located over the patient's feet.

47.5.1 Total Extraperitoneal Repair (TEP)

An incision is made at the infraumbilical fold, and blunt dissection to the rectus fascia is performed using S-shaped retractors. A longitudinal incision may then be made medially along the anterior rectus fascia, sparing the rectus abdominis muscle, and the medial aspect of the muscle bed is then retracted laterally to expose the posterior sheath. This allows for entry into the space of Retzius, with dissection down to the arcuate line. Creation of the preperitoneal space may be performed manually or with a balloon dissector; either technique is acceptable, but many advocate for the use of the balloon dissector as it minimizes blood in the field by promoting hemostasis during disruption of the layers. The balloon dissector is inserted at a shallow angle along the posterior sheath, passing through the arcuate line, until it touches the pubis. The laparoscope can then be introduced into the balloon for insufflation under direct vision. The surgeon should be able to see the posterior aspect of the rectus abdominis anteriorly, along with the inferior epigastric vessels laterally, separating from the peritoneum

posteriorly. The balloon should be repositioned if the inferior epigastric vessels are noted to be posterior, along the peritoneal layer. If the abdomen is inadvertently entered via peritoneal injury, the procedure may be converted to a TAPP approach.

After the potential space has been developed and the balloon dissector has been desufflated and removed, a balloon-tipped trocar is inserted into the retrorectus space. Insufflation with carbon dioxide is achieved until pressure of the space reaches between 12- and 15-mmHg. A 45-degree 5- or 10-mm laparoscope is then introduced through the trocar to aid with the insertion of two more vertically positioned 5-mm trocars: one suprapubic and one halfway between the suprapubic trocar and the umbilicus.

The patient is placed in Trendelenburg position for improved visualization. Tissue within the preperitoneal space is cleared to expose the pubic bone and Cooper's ligament to the level of the femoral canal. The entire myopectineal orifice should be exposed in preparation for mesh implantation [19], as well as to identify other important vascular structures entering this area, like the corona mortis and the external iliac vein. A wide lateral and posterior dissection is essential to make adequate room for the placement of a large mesh, as is dissection of the peritoneum off of the spermatic cord or round ligament, anterior abdominal wall, retroperitoneum, posterior aspect of the pubis, and psoas muscle so that the mesh will lie flat. The peritoneal reflection must be completely swept back to prevent recurrence of peritoneal hernia under the lower edge of the mesh. Any attachments to the anterior abdominal wall should be taken down. However, it is recommended to leave a layer of preperitoneal fat over the abdominal wall to prevent injury to nerves coursing through that area and to limit the disruption of small vessels, which are prone to bleeding.

The lacunar ligament should then be exposed. Reduction of the contents into the peritoneum may be accomplished at this time with blunt graspers. Medial retraction of the hernia contents is key. Blunt dissection is used to sweep the areolar tissue back toward the iliac vein using countertraction aimed medially and superiorly, away from the vein. Thermal injury due to the use of electrosurgery must be avoided while working by the iliac vessels. Optimally, the contents will reduce easily. However, if there is a large mass and/or the contents remain incarcerated, a relaxing incision of the femoral ring is advised. To release the constriction at the femoral ring, the lacunar ligament can be incised medially with hook cautery after ligation of the corona mortis vein, by cutting superomedially (as shown in Fig. 47.1 by the dotted black line). Once the contents are reduced (Fig. 47.2), the surgeon should inspect the femoral canal to ensure hemostasis.

After dissection of the space is completed with clear visualization of the cord structures and hernia defect (Fig. 47.3), the peritoneum should be inspected for any defects which may have been

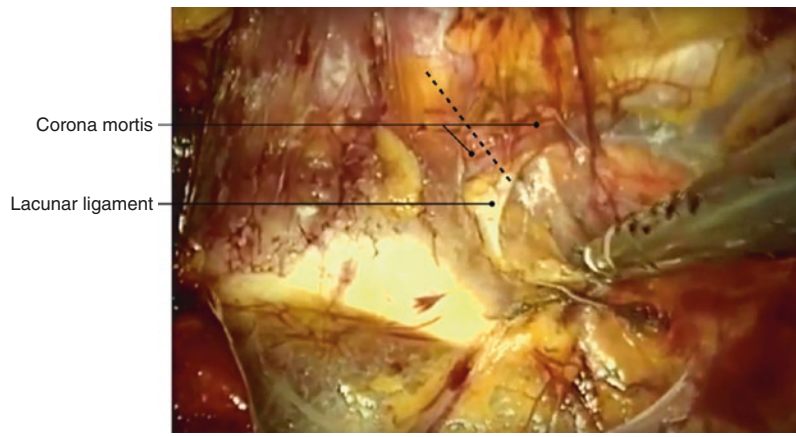

Fig. 47.1 Dissection of the femoral canal

sustained during the dissection. Defects may be clipped with clip appliers, but small holes often do not need to be repaired, as they heal quickly once the edges reapproximate with desufflation. If intraperitoneal insufflation occurs via a defect, insufflation pressures should be decreased to 10 mmHg or lower, and if necessary, a Veress needle may be placed intra-abdominally for desufflation (Fig. 47.2).

At this point, with the myopectineal orifice exposed, the hernia mesh may be introduced into the dissected pocket via the infraumbilical trocar and directed downward toward the ipsilateral side of the symphysis pubis as the hernia. The mesh is then unrolled over the myopectineal orifice using graspers, so that the lateral edge touches the anterior iliac spine, the midline is overlapped by at least 2 cm, the inferior edge overlies the cord structures, and the superior edge extends beyond the hernia defect by at least 4 cm. Once in place, the mesh should then be fixated by placing a permanent tack into Cooper's ligament or the bone just below the defect to ensure the mesh remains in place without clam shelling. Other surgeons may prefer to use suture or fibrin glue for fixation, and many will advocate for non-fixation in TEP repairs. However, we feel that permanent fixation to one of these durable anatomic structures is essential. The preperitoneal space may then be desufflated under visualization, making sure that the mesh remains unchanged in the appropriate position. The ports may then be removed and sites closed in standard fashion (Fig. 47.3).

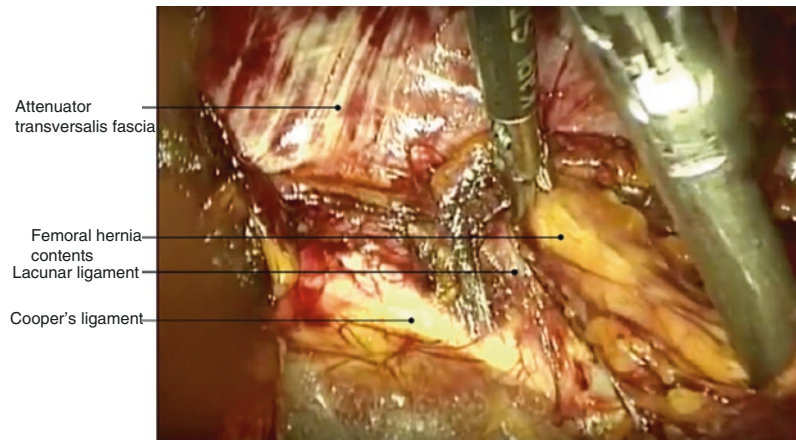

Fig. 47.2 Reduction of the hernia sac

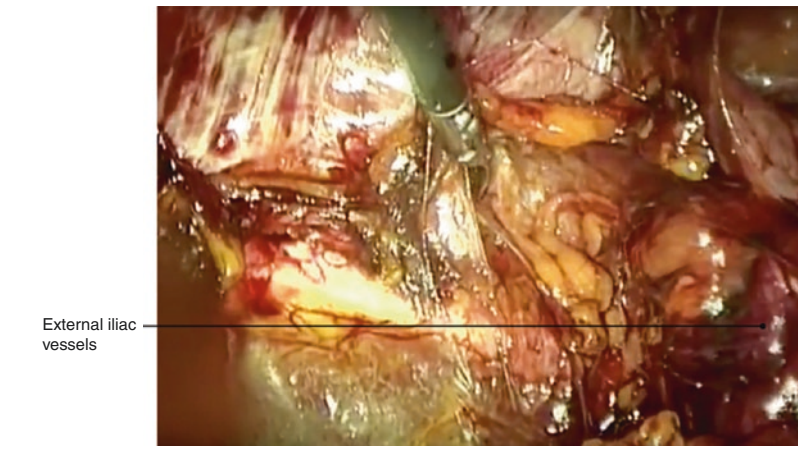

Fig. 47.3 Inspection of the canal post-reduction

47.5.2 Transabdominal Preperitoneal (TAPP) Repair

Access to the peritoneum is again initiated at the infraumbilical fold, carrying the incision down through the subcutaneous tissues until the median umbilical raphe is reached. The raphe is then incised vertically in the midline. Blunt spreading permits safe entry into the peritoneum and placement of a 12-mm trocar. Once the insufflation pressures reach 15 mmHg, the intra-abdominal contents may be surveyed with the laparoscope. The patient is placed in Trendelenburg position, and left- and right-sided 5-mm trocars are then placed in-line horizontally with the infraumbilical trocar under direct visualization or in a straight line which is perpendicular to a unilateral defect. Any small bowel may be swept away using blunt-tipped graspers to visualize the pelvis and any abdominal wall defects.

The peritoneal flap is created using electrosurgery or sharp dissection by making a curvilinear or "lazy-S" incision, beginning posterolaterally near the anterior superior iliac spine, curving anteromedially passing anterior to the hernia defect(s), and stopping medially at the median umbilical fold. The dissection is carried out bluntly exposing the medial space until Cooper's ligament is identified. The spermatic cord and testicular vessels are dissected off of the posterior peritoneal flap. The areolar tissues superficial to the urinary bladder and the fatty tissues between the bladder and the posterior pubis are dissected bluntly to expose the pubic tubercle and Cooper's ligament. Vigilance should be paid to the possible presence of and location of the corona mortis to avoid injury. The flap dissection is carried down to the level of the iliac vessels, creating a pocket laterally to the psoas body in order to develop a large preperitoneal space for mesh placement, exposing the myopectineal orifice completely [19].

The femoral canal should be apparent within the field, and hernia contents should be reduced back into the abdomen using blunt dissection along the superomedial and inferomedial aspects of the canal to avoid injury to the femoral and external iliac vessels. Reduction of the hernia contents is conceptually similar to the reduction described earlier in a TEP repair. A relaxing incision at the medial aspect of the femoral ring, where the iliopubic tract inserts into Cooper's ligament, may be necessary to release the constricted ring and allow for the evacuation of hernia contents into the abdomen.

A large hernia mesh may then be introduced into the peritoneal cavity and positioned into the pocket anterior to the peritoneal flap, covering the entire myopectineal orifice in a similar manner to a TEP repair. The mesh should be able to lay flat in this plane without kinking. It should be secured in place to the transversalis fascia, pubic tubercle, and Cooper's ligament using the fixation system of the surgeon's choice; though, again, we recommend securing the mesh with permanent tacks to these structures. Care should be taken not to deploy tacks or suture lateral to the inferior epigastric vessels.

After ascertaining that the mesh is in a good position and excellent hemostasis has been achieved at low insufflation pressures, the peritoneal flaps may be reapproximated. The edges of the flap may be apposed using permanent helical tacks, interrupted suture, or running suture, or laparoscopic staples or clips. Care should be taken to achieve a continuous closure without gaping of the flaps between tacks or interrupted suture to prevent internal herniation of bowel or exposure of the mesh to the abdomen, particularly when the mesh is not coated. If the operating surgeon should choose not to secure the flap in place, we recommend repositioning the peritoneum over the mesh and monitoring its position during desufflation. The laparoscopic ports may then be removed and umbilical fascia closed.

47.5.3 Intraperitoneal Onlay Mesh Repair

Laparoscopic access to the abdomen is achieved in the same manner as in the TAPP, with identical port placement. The patient is placed in Trendelenburg position, and the myopectineal areas are inspected bilaterally. The hernia sac may then be reduced into the abdomen. A large polytetrafluoroethylene (PTFE) or coated mesh is

employed with at least 3-cm overlap beyond the hernia defect(s); generally a 12 × 15-cm sized mesh is used. A choice of tacks, suture, or staples are used to secure the mesh medially to Cooper's ligament and laterally to the anterior superior iliac spine, and transfascial sutures should be placed at the superior edge of the mesh to rectus abdominis for better fixation. Placement of tacks or suture into the inferior edge of the mesh should be avoided due to the risk of injury to the iliac vessels. Again, the lie of the mesh should be monitored under direct visualization during desufflation of the abdomen to ascertain that it has not moved in position.

Of note, this technique is not recommended due to high recurrence rates, but it is historically described. Moreover, by not dissecting the peritoneum out of the defect, an occult femoral hernia may be missed or misdiagnosed. Some surgeons may defer to it as a last resort if the preperitoneal space cannot be accessed for hernia repair due to fibrosis from previous radiation or other procedures. If chosen, the surgeon may opt to perform a hybrid IPOM/TAPP repair to tuck the inferior edge of the mesh within a preperitoneal pocket.

47.5.4 Robotic Femoral Hernia Repair

Patient positioning may depend on the robot platform being used due to the variation in the array and maneuverability of the robot arms. Generally, the patient is placed supine, in Trendelenburg position, with the robot docked at the patient's hip, though the Xi platform provides greater flexibility for positioning about the patient. Abdominal access is obtained based on surgeon preference, and three ports are placed transversely at the level of the umbilicus: one 10-mm umbilical port, an 8-mm port to the right in the midclavicular line, and a 5-mm port (or 8-mm, if using the Xi) to the left in the midclavicular line.

The case should proceed in the same fashion as described in the TAPP section, with the following modifications for the robot system. Monopolar scissors should be used to make a curvilinear incision in the peritoneum above the myopectineal orifice between the anterior superior iliac spine and the medial umbilical ligament as the start of the flap. After development of the preperitoneal pocket, the assistant at the bedside should place the mesh into the abdomen via the 8-mm trocar and the operator at the console can unroll it and position it within the dissected preperitoneal space. After the mesh is fixated smoothly in place, the peritoneal flap should be closed, as it would be during a laparoscopic TAPP repair. An advantage of using the robot in this instance is the increased ease of intracorporeal suturing compared to the laparoscopic procedure.

47.6 Postoperative Complications and Considerations

Complications after laparoscopic hernia repair include hematoma due to injury to one of the vessels traversing the myopectineal orifice, inguinodynia from nerve injury or mesh irritation, mesh or surgical site infection, urinary retention or complications due to bladder injury, port site hernia, small bowel obstruction or internal herniation, and hernia recurrence.

Chronic pain is the most frequent adverse outcome after inguinal hernia repair [20], with rates reported as high as 25% [21]. Laparoscopic repair of inguinal hernia is associated with decreased chronic pain compared to open techniques [22, 23], and type of technique performed (TAPP versus TEP) carries an equivalent risk of postoperative pain after laparoscopic femoral hernia repair specifically [24].

Incidence of small bowel obstruction after laparoscopic herniorrhaphy is 0–0.1%, though may reach up to 2% of cases [25]. Intraperitoneal repair holds a higher risk than TEP repair due to the formation of peritoneal adhesions and the potential for tacks to cause a nidus for obstruction or volvulus. Furthermore, TAPP repair has the risk for viscera to herniate through defects from incomplete peritoneal flap closure, unlike a TEP repair, unless the peritoneum is violated [26, 27].

Femoral hernia recurrence is also a known potential event following repair, though true long-term recurrence rate is uncertain. Multiple randomized controlled trials and large retrospective studies have reported recurrence rates between 0% and 5% after laparoscopic groin hernia repair up to 10 years postoperatively [21, 28]. Compared to open femoral hernia repairs, rates of recurrence requiring reoperation in a large prospective nationwide analysis were much lower after laparoscopic repairs, with a 2.2% recurrence after elective laparoscopic repair versus 7.1% for open techniques [6]. Of note, this study also demonstrated nearly a twofold increased risk in need for reoperation for recurrence for female patients over males. Because femoral hernias are so challenging to identify preoperatively and many are missed during open repair due to lack of exposure of the femoral canal, a laparoscopic approach is optimal to minimize the risk of ipsilateral hernia recurrence, particularly in female patients.

Conclusion

Femoral hernias can be repaired safely using open or laparoscopic techniques. Laparoscopic approaches to the groin provide the advantage of finding both inguinal and femoral defects during the same dissection. Surgeon comfort with the anatomy and understanding of the surgical technique is critical to safe and appropriate repair. The use of the robot as an adjunct to laparoscopic repair remains in evolution although concerns with cost and training persist.

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Results and Complications of Femoral Hernia Repair

48

Sergio Alfieri, Caterina Cina, and Germana Savi

48.1 Risk Factors

The most important risk factors which adversely affect the outcomes of hernia repair for groin hernia are:

- Female gender
- Old age
- Severe pain at hernia site and signs of mechanic bowel obstruction
- Presence of coexisting cardiopulmonary diseases
- High ASA score
- Femoral-type hernia
- Late admission

Several authors analyzed a series of patients operated for groin hernia (series including femoral hernia) and defined risk factors correlated with unfavorable outcome in patients who underwent elective (majority) or emergency surgery. Incarceration and strangulation are usually more frequent in women and ASA 3 and 4 group. Tension-free hernioplasty is the most common procedure. Content of the hernia can be ileum only, omentum only, ileum with omentum, sigmoid colon, cecum, appendix, and preperitoneal fat in most of cases. Ovary and fallopian tubes were rarely found. Necrotic bowel resection or omentectomy are rarely required (0.3–1%) [1].

Major complications generally occur in patients with severe coexisting diseases. Emergency hernia repairs in elderly patients carry a high morbidity and mortality risk in the presence of coexisting cardiopulmonary problems.

48.2 Emergency Vs. Elective Surgery

Emergency episodes were related to higher incidences of visceral and small bowel involvement, increased small bowel resection rate, longer hospital stay, and higher mortality [2–4].

The femoral hernia has a rate of strangulation between 40 and 60%, tenfold the inguinal hernia, so it often requires emergency repair [5–7].

Incarceration and strangulation carry a sevenfold higher risk of postoperative overall mortality rate in high-risk patients and increase a 20-fold in case of concomitant emergency resection (9.3–5.3%), occurring in 9.3–46.44% of cases [8].

Data from the Swedish Hernia Register [9] showed a 30-day mortality rate of 4.4% following emergency surgery for femoral hernia, compared with 0.2% for elective repair.

Alhambra-Rodriguez de Guzman et al. [8] analyzed the effect of bowel resection on morbidity and mortality. They retrospectively analyzed a cohort of 86 patients undergoing emergency

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treatment for incarcerated femoral hernia between 1995 and 2009. In all cases the hernia repair was made with polypropylene mesh, and in 8 patients (9.3%), ischemia-related bowel resection was necessary. They found intake of oral anticoagulants and a maximum of 3 days' duration of the symptoms as the independent risk factors for bowel resection. 5 of the 8 patients resected (62.5%) developed wound infection in the 50% of cases with a complication rate of 10.5%.

Calik et al. [2] analyzed 80 patients who underwent surgical femoral hernia surgery between 2009 and 2013. 43 patients (53.8%) required emergency surgery to treat incarceration (omentum in 51% of the cases, small bowel 32.6%, small bowel + omentum 9.3%, sigmoid colon 4.7%, and right tuba 2.3%). 18 of them (41.9%) showed strangulation and underwent resection (of the omentum in 12 patients, of the small bowel in 5 patients, and of the omentum + small bowel in 4 patients). Plug mesh was used in the 73.8% of the procedures, McVay herniorrhaphy in 20%, primary repair in 2.5%, and Stoppa technique in 2.5% of the cases, and 1 patient was treated laparoscopically. The overall complication was developed in 11 patients (13.8%): wound infection (5 patients, 6.3%), pneumonia (4 patients, 5%), hematoma (1 patient, 1.3%), and cerebrovascular occlusion (1 patient, 1.3%). 2 patients died of pneumonia and cerebrovascular occlusion (2.5%). Recurrence occurred in 1 patient (1.3%) treated with McVay method. The authors concluded that risk factors predicting morbidity after surgical repair of femoral hernia are need of emergency surgery with bowel resection and interval between symptoms onset and surgery. Age, gender, comorbidity, ASA score, type of anesthesia, and surgical methods are considered controversial risk factors.

48.3 Surgical Technique Repair

Some series reported several types of complication related to mesh plug repair like foreign body feeling, chronic pain, migration of the mesh plug toward the scrotum or pelvis, intestinal obstruction, recurrence, or seroma [10–14]. Preperitoneal patch is located deep into the preperitoneal space, so it is fixed by the intra-abdominal pressure and it is not easy to displace it (Fig. 48.1). The sutures used to fix the plug to the tissue around the femoral ring produce tension, responsible of the foreign body feeling. Seroma formation is common when a synthetic material like polypropylene is used over fatty tissue. It increases effusion of fluid from tissues, while the patch placed deeply in preperitoneal space is not in contact with the subcutaneous fat [15, 16]. Preperitoneal repair also does not treat the femoral ring directly, so it avoids compression or injury to the femoral vein [17].

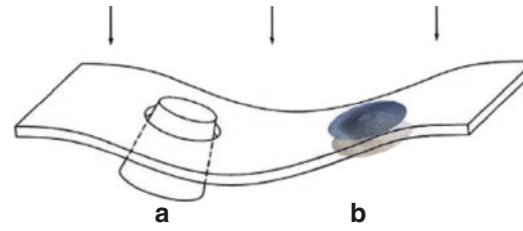

Fig. 48.1 Schematic representation of the abdominal wall with femoral hernial orifice. (**a**) The hernial defect has been filled with mesh plug. (**b**) Plug placed in the preperitoneal space and the intra-abdominal pressure is distributed in the femoral ring

Chen et al. [18] in 2010 published a prospective study in which 85 patients undergoing primary, unilateral femoral hernia repair surgery (enrolled between 2002 and 2008) were randomized in two arms: 45 patients were placed in a preperitoneal group (pre-PG—in 20 cases a medium-sized patch was used and in 25 cases an easy-prosthesis mesh) and 40 in mesh plug group (MPG). There were no perioperative deaths. No recurrence occurred in the pre-PG, while it occurred in 4 patients of MPG (10% with $p = 0.0451$); wound infection was recorded in 1 patient (2%) of pre-PG vs. 3 of MPG (7% with $p = 0.3383$); seroma occurred in 2 patients (4%) vs. 8 of MPG (20% with $p = 0.0490$); foreign body feeling was declared only in 6 patients of MPG (15% with $p = 0.0088$). Concerning complication and recurrence rate, the authors found preperitoneal herniorrhaphy superior to the mesh plug technique for repair for femoral hernia (Fig. 48.2).

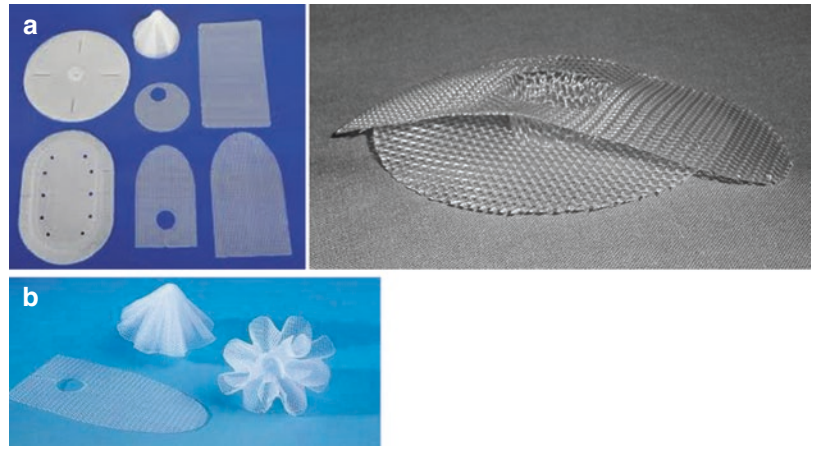

Fig. 48.2 (**a**) Hernia mesh; (**b**) hernia plug

Fig. 48.3 Structure of ULTRAPRO Plug

Fig. 48.4 Prolene 3-D patch

Song et al. [19] used an ULTRAPRO Plug (25% polypropylene, 75% monocryl, partially reabsorbable) (Fig. 48.3) as hernia repair device in a cohort of 121 patients that underwent electively surgical operation of femoral hernia repair between 2009 and 2013. Median follow-up was at 26 months. No mortality, recurrence, or major event is declared. The overall rate of morbidity was 8.3% (10 patients: 1 with wound dehiscence, 2 with superficial infection, 1 with subdermal hematoma, 2 with postoperative chronic pain, 1 with sensory loss, 3 with foreign body feeling).

Wenzhang et al. [20] performed 72 elective femoral hernia repairs with herniorrhaphy with Prolene 3-D patch device (Fig. 48.4) in a period of 5 years (2004–2009). After a median follow-up of 39 months, they did not record any postoperative complications like seroma, wound infection, edema, or recurrence. Postoperative pain assessed by VAS score was 6.3 after 7 days of surgical repair.

In 1999 the MRC Laparoscopic Groin Hernia Trial Group [21] conducted a randomized trial: 928 patients undergoing hernia repair for groin hernia (inguinal and femoral hernia) were randomized in two arms, laparoscopic repair (468 patients) and open hernia repair (460 patients of which 433 underwent tension-free mesh repair). In this large multicenter randomized trial, the overall surgical

complication rate was 5.6% for laparoscopic group and 1.4% for open group. Laparoscopic hernia repair was related to earlier return to usual activities and less persistent groin pain 1 year after the surgery, but it is also related to serious surgical complications (lateral cutaneousnerve of the tight damage, bladder injury and trocar injury to the left common iliac artery), hernia recurrence (1.95 vs. 0% in open repair group), and higher estimated cost for the healthcare system.

Nilsson et al. [22] used the Swedish Hernia Register and the Sweden National Patient Register to find surgical adverse events within 30 days of groin hernia surgery in a total of 143,042 patients registered between 2002 and 2011. The main complications investigated were severe cardiovascular complications, severe adverse surgical events, and intraoperative complications. In this study laparoscopy and suture repair were related to increased risk in per-operative complications compared to open anterior mesh technique.

Chia et al. [23] compare three different open surgical approaches (Lockwood's or LW, Lotheissen's or LT, and McEvedy's or ME) in 190 patients who have undergone emergency femoral repairs in a period of 13 years.

All three approaches appear safe and effective in femoral hernia repair in emergency surgery. McEvedy's procedure is related to a lower rate of laparotomy but also to a longer operation time and hospital stay.

48.4 Surgical Site Infection

Superficial and deep surgical site infections are most commonly related to mesh infection. Infected mesh as a postoperative complication of hernia surgery affects up to 13.6% of patients [24], with wound-related complications affecting 33% of patients postoperatively [25]. Mesh infections have been reported from 2 to 39 months postoperatively [26], and the most common organisms cultured by wound infection are *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus*, and vancomycin-resistant *Enterococcus* [27, 28].

Risk factors related to mesh infections included smoking, the American Society of Anesthesiologists (ASA) score of C3, age, duration of surgery, obesity, and emergency operations [24, 25].

Risk factors related to surgical site infection include age, comorbidities/underlying illness, obesity, smoking, wound classification and site, and complexity of procedure [29].

At the same time, the nonuse of mesh in hernia repair is related to an increased risk of hernia recurrence [30]. It has been shown that the use of mesh significantly reduces the rate of hernia recurrence by an average of 30% compared to suture repair [31, 32].

Mesh grafts may be biologic (absorbable) or synthetic (nonabsorbable). Biologic grafts are derived from either human or porcine dermis, and they act as a collagen and extracellular matrix scaffold, where the host fibroblasts can create angiogenesis and lay down new collagen. They have been advocated for their use in contaminated fields because of their greater resistance to infection compared to synthetic mesh, but they are also more expensive.

Polypropylene (monofilament, nonabsorbable, inert, sterile, and porous, approximately 0.44-mm thick) and polytetrafluoroethylene (1-mm thick, strong, soft inert, and conformable with a structure that ensures early fixation) are the most commonly used mesh materials.

Infected mesh wounds have traditionally been treated by surgical removal of the mesh, but it is potentially difficult and related to high recurrence. Stremitzer et al. [33] advocated the conservative management for the cases of infection in the presence of absorbable mesh grafts and recommended the surgical removal of infected nonabsorbable ones. Meagher et al. [34] treated successfully wound infection caused by nonabsorbable and absorbable meshes conservatively using e.v. antibiotic therapy and VAC medication.

Efficacy of antibiotic prophylaxis for prevention of surgical site infection (SSI) in the open tension-free hernia repair remains controversial. Mazaki et al., in a review and meta-analysis on 1920 patients who received antibiotic prophylaxis

and 1936 patients allocated to the control group, found an incidence of SSI of 3.0% and 6.0%, respectively. The authors did not find significant association between antibiotic prophylaxis and incidence of deep surgical site infections [35].

48.5 Persisting Chronic Pain

The prevalence of persisting pain after groin hernia repair is evaluated between 0 and 76% of the cases.

Chronic postoperative pain affecting everyday life is a complication as important for femoral hernia surgery as for inguinal hernia surgery; however, femoral hernias have previously shown to have a lower frequency of long-term postoperative pain then inguinal hernia.

Dahlstrand et al. [36] analyzed 1461 patients who underwent primary, unilateral, and femoral hernia repair in a period between 1997 and 2006 recorded in the Swedish Hernia Register (SHR). In this study preoperative pain was yet present in 81.6% of the patients in whom 50.2% reported pain interfered with daily activities. In 47.6% of the patients, the pain disappeared within 1 month and in the 13.0% within 2 months. In response to the questions regarding the ability to perform specific everyday activities, 151 (10.3%) patients reported that groin pain affected their ability to perform one or more of the activities.

Emergency surgery and long-lasting surgery were found to be independently factors related to a decreased risk for chronic pain. It is common in emergency surgery to find bowel incarceration that requires resection. In this perspective, the surgeon often limits the dissection to the tissue below the inguinal ligament. As this area is devoid of nerves and muscles, there is a lower risk for neuropathic pain and motion-related pain. Patients undergoing elective surgery are identified on the basis of symptoms before surgery, whereas patients undergoing emergency surgery are operated regardless of pain history. This may have led to selection of patients perceiving more pain in the electively treated group.

Preoperative pain was strongly related to a higher risk for postoperative chronic pain. In this study age or surgery technique had no impact on chronic pain (at the univariate analysis, preperitoneal mesh surgery is related to an increased risk of chronic pain).

Others studies, based mainly on inguinal hernia, state that open posterior or laparoscopic repairs are related to a lower risk of postoperative chronic pain. In fact, preperitoneal approach does not include dissection close to the three main nerves in the area [37, 38].

48.6 Recurrence and Reoperation

Recurrence rate after femoral hernia repair was reported in 1–10% of cases in literature [39, 40], and it represents one of the most important risk factors for reoperation.

The cause of recurrent femoral hernia after a tissue-based repair is most commonly due to excessive tension. This means that sutures tear through the inguinal ligament and transversalis fascia. Tension may alternatively transmit and cause damage in the internal oblique muscle at the superior-medial aspect of the inguinal canal and cause a direct hernia.

Another less common but difficult area to address is the "prevascular recurrence." Aggressive dissection and traction during reduction of the femoral hernia can open this potential space. It is technically difficult and dangerous to place sutures in order to close this space.

Recurrences after anterior mesh repair of femoral hernias are usually caused by poor fixation. The lateral edge of the mesh can curl back toward Cooper's ligament and results in a recurrence in the femoral space or in the prevascular location. It is necessary to fix the mesh to the inguinal ligament lateral to the epigastric vessels and to the internal oblique muscle beyond the deep ring. The fixation deep to the inguinal ligament in the preperitoneal space, also known as the triangle of pain, is dangerous.

Technical failure of an infrainguinal mesh plug repair is also the result of inadequate fixation. Dissection of these femoral recurrences usually finds the plug extruded from the femoral canal.

If the canal is not sufficiently dissected, the plug may not have been completely inserted.

Other areas of technical weakness are the lateral ones, where sutures cannot be placed because of the femoral vein and medial in the lacunar ligament, where sutures are not usually placed.

G. Chan et al. [41] conducted a prospective trail between 1999 and 2003 to examine 225 elective femoral hernia repairs for recurrence and complication with a follow-up once a year for 5 years. One-hundred twenty-three hernia defects were repaired with suture and 102 with mesh. None required a bowel resection or suffered any significant comorbidity. The overall rate of recurrence was 3.1% with a median time of 12 months (3–48 months): complete groin repair 3.3%, anterior sublay mesh 2.6%, and subinguinal plug 4.2%. There were no statistical differences in recurrence rates between the techniques of repair: primary vs recurrent, isolated femoral vs concurrent inguinal hernia, age, gender, BMI, chronic pain, size of femoral hernia, or preoperative symptoms.

There were 2 superficial surgical site infections treated successfully with oral antibiotics and 20 patients (8.9%) experienced postoperative chronic groin pain at 1 year: 18 of these had minor pain and 2 had moderate pain.

Dahlstrand et al. [42] have also published a study about the reoperation rate after femoral hernia repair due to recurrence of hernia. They analyzed 3980 patients who have undergone femoral hernia repair between 1992 and 2006 recorded on SHR. Five years after surgery, 6.3% of the patients that underwent emergency hernia repair and 7.4% of the patients who have undergone elective repair had a reoperation with an overall reoperation rate of 6.6%. Postoperative complication, male gender (in men femoral hernia is often related to inguinal hernia), and suture repair/non-mesh use repair are related to a higher risk of recurrence than open preperitoneal mesh repair.

Postoperative mortality rate within 30 days from surgery for elective repair was 0.16%, while emergency repair was 4.42%, and male gender, bowel resection, and postoperative complications are the found risk factors.

Sandblom et al. [43], in a study published in 1999 about 588 patients who have undergone femoral hernia repair recorded in the Swedish Hernia Register between 1992 and 1997, registered an incidence of reoperation of 4.6% (19 patients). They found that patient's age, emergency/elective surgery, primary/recurrent hernia, and side of the hernia don't represent risk factors for reoperation.

48.7 Risk of Malignancy

As femoral hernia sacs may include appendix, Meckel diverticulum, fallopian tube, bowel or ovaries, endometriosis, perivascular epithelioid cell tumor and pseudomyxoma peritonei can be examinated by pathologist [44].

Wang et al., in a series of examination of 1426 sacs of inguinal, femoral, and abdominal hernia, found 10 malignancies at histology examination [44].

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Part IV

Ventral (Midline and Lateral)

Anatomy of the Ventral Region

49

Jérôme Loriau

It is essential to consider the ventral region as a part of a system containing components that interact together to allow standing of course (since about a million years!) but many many other roles.

Without the simultaneous action of the spine, spinal muscles and psoas iliac muscle posteriorly, the diaphragm muscle, ceiling of the abdominal cavity, and perineal floor muscles that build the ground of the abdomen, the anterior components of the abdominal compartment system would be totally useless.

It could be described as a mobile scaffolding and like in any of it, and the solidity of it depends on every single small part of it.

It would be impossible to increase pressure in the abdominal cavity due to the action of the ventral muscles if the other solid muscular skeletal structures mentioned above were totally lacking.

49.1 Rectus, External Oblique, Internal Oblique, and Transverse Muscles: The Entwined Quartet

49.1.1 Rectus Muscle

Pronouncing the name of "abdominal wall" could be taken as a total misunderstanding of what really is this essential part of the body.

Considering it as a wall, a static and passive element is widely underestimating the actual role that the different muscles composing the abdominal wall are playing.

However, the muscles constitute an active support to the abdominal organs and are involved or responsible for many actions or movements. Without them it is impossible to imagine many movements of the trunk, impossible to do many "expulsive acts" like coughing, laughing, or even … straining, and impossible to simply breathe as the abdominal muscles are the main coactors for respiratory movements.

All these considerations should lead any surgeon to know and to RESPECT the ventral region anatomy. Doing that way, he'll be beloved by his patients when they'll look in the mirror. Forgetting those points he could face dramatic complications.

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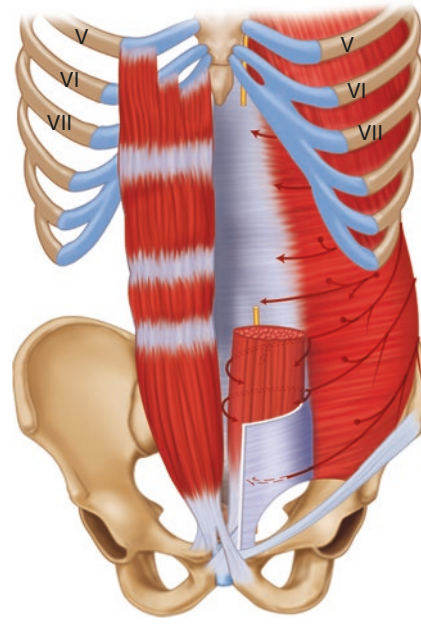
Fig. 49.1 The roman centurion



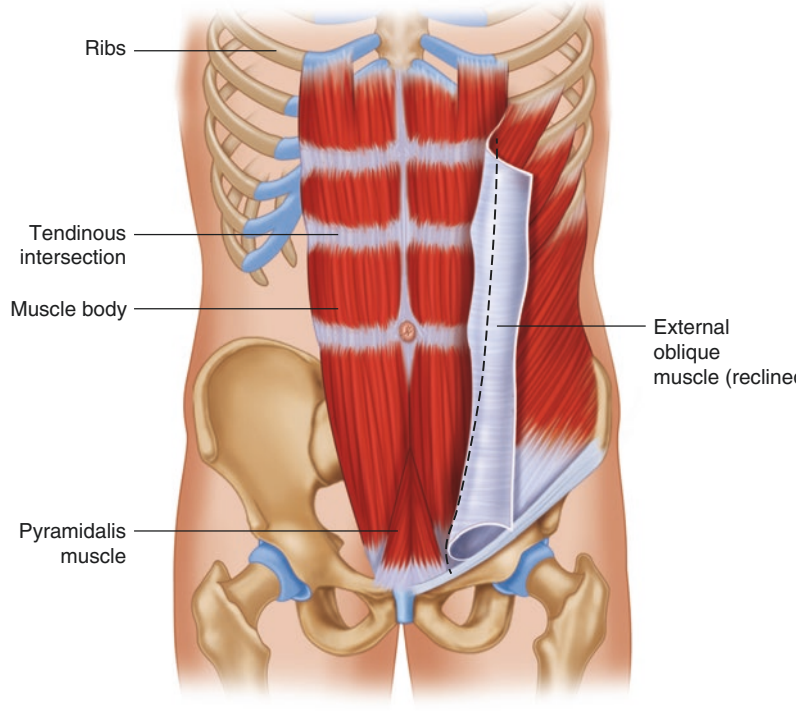


Fig. 49.2 Position of the muscles of the ventral region. *1* Ribs, *2* tendinous intersection, *3* muscle body, *4* pyramidalis muscle, *6* external oblique muscle (reclined)

What better than the school year memories about the roman centurion armor can represent the rectus muscle relief on the abdomen!

The rectus muscle, a paired muscle, runs vertically on each side, from the fifth, sixth, and seventh anterior costal cartilages and the xiphoidal appendix to the pubis and its spine. At that point, some fibers go laterally and horizontally to create the Henle ligament. The wideness of the muscle is not equal at its all length and as it is 10–12 cm wide at its top and it narrows progressively till 5–8 cm at the umbilicus and finally about 3 cm at the pubis. From the top to bottom, the body of the muscle is partially divided by 3–5 tendinous intersections made of connective tissue (remembrance of the metameric constitution of the body). Looking from the front, the two bodies of the muscle are separated medially by the linea alba and are limited laterally by the semilunar line; as the muscle bodies are divided by the horizontal intersections, six (four to ten depending on the number of intersections) muscle bellies can be seen in low fat persons (like on the roman centurion armor!).

Situated just under the skin, it represents an anterior strong pillar, symbol of power and manliness! This situation makes him the direct antagonist to the iliac psoas, the spine, and its posterior muscles constituting lateral and posterior pillars. But to be able to take this function, it has to stand vertical in his frontal position. In case it is translated laterraly, in the setting of a large medial incisional hernia for example, the balance beetween anterior, lateral and frontal forces is scrambled. Important musculoskeletal troubles can then occur.

Pyramidalis Muscle: Linea Alba Tensioner?

When present (from 30 [1] to 90% [2]), the pyramidalis is a triangle-shaped muscle standing in front of the lower part of the linea alba. It can be paired or not, and as its pointed superior extremity ends midway between the pubis and the umbilicus, inferiorly it attaches to the pubic crest and symphysis.

Whether unclear, its direction makes it considered as tensioning the linea alba.

For the surgeon, when present, this muscle can be used as a landmark of the linea alba in a C-section procedure.

The innervation of the pyramidalis is known to be depending on the ventral portion of T12 (subcostal nerve) but encounters high rate variations [3].

Blood supply to the pyramidalis comes from the inferior (and superior) epigastric vessels.

Laterally, we will see the three flat muscles arranged in crossed directions.

The external oblique is, as the rectus anteriorly, the first muscular subcutaneous plane. Its cranial insertions stand on the lateral surface of fifth to 12th ribs. Its fibers runs downward and forward to the caudal insertions contributing, on the midline, to built the linea alba (see below). The distal insertions are situated on two medial thirds of the iliac crest (including the anterior superior iliac spine) and to the pubic symphysis. Remember that during their course, the fibers split themselves in two pillars creating the superficial inguinal ring. Remember also that the caudal insertion of the external oblique muscle constitutes the inguinal ligament. External oblique is a myoaponeurotic muscle. Its muscular body is relatively short and from about the midclavicular line, it becomes aponeurotic. From the xiphoid process to the pubic symphyses on each side, those aponeurotic fibers, as a strong sheet of dense connective tissue, cross the midline and interdigitate with the one from the other side in a chevron pattern. It passes anteriorly to the rectus muscle and is one of the components of its anterior sheath.

Due to the direction of its fibers; contraction of the External oblique leads to pulling down the ribs to the pelvis. This contributes to expiration as an accessory respiratory muscle. It also plays a role in Valsalva maneuver, coughing, and straining.

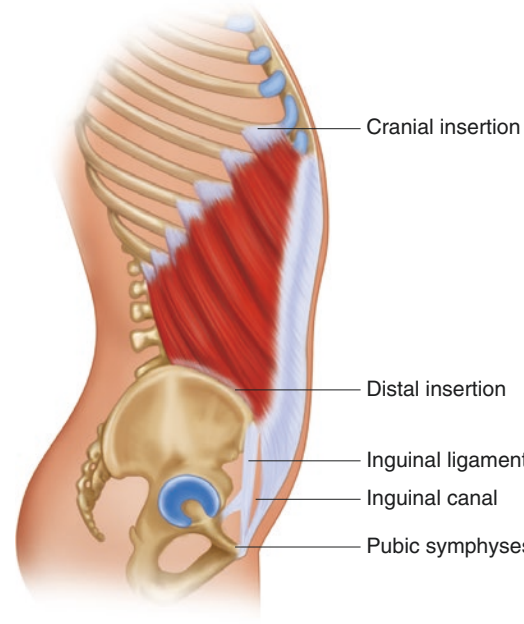


Fig. 49.3 External oblique muscle insertions. *1* cranial insertion, *2* distal insertion, *3* inguinal ligament, *4* inguinal canal, *5* pubic symphyses

The muscle receives many nervous branches coming from ventral branches of the lower six thoracoabdominal nerves and the subcostal nerve on each side.

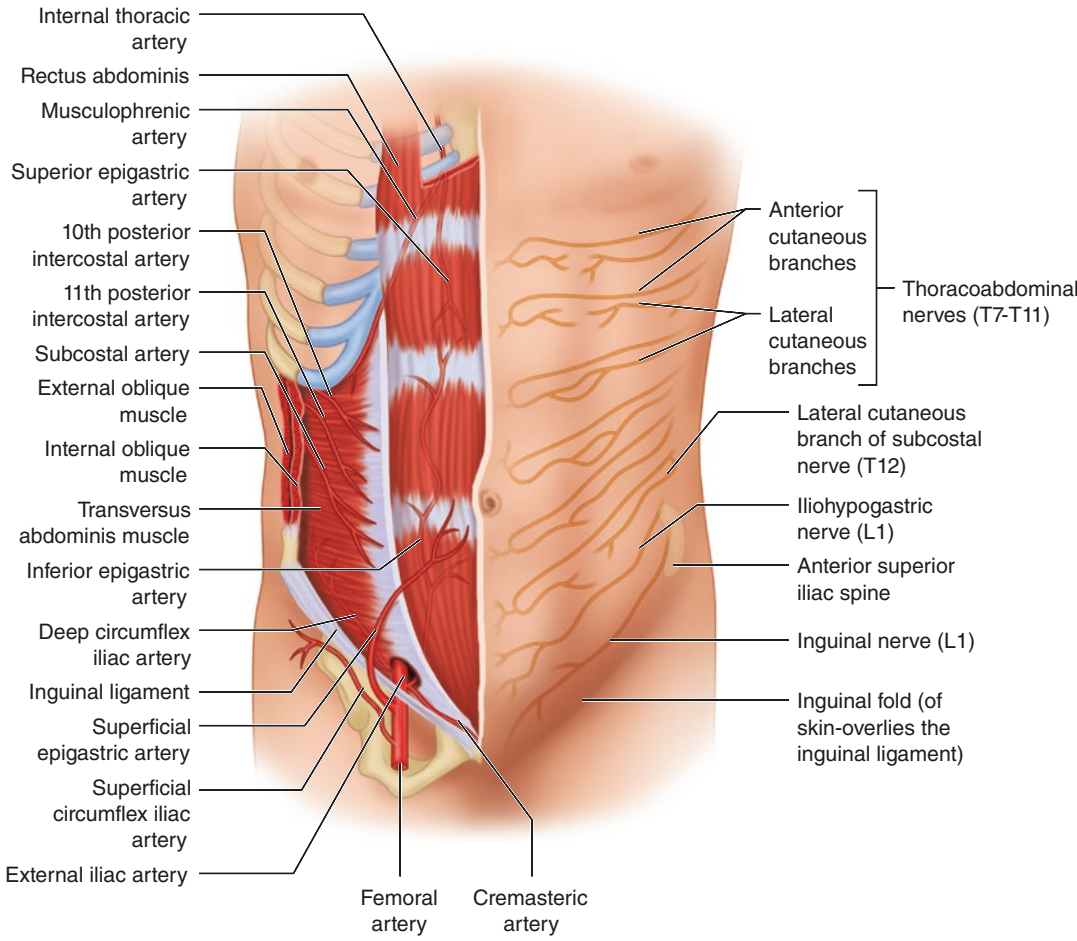


Fig. 49.4 Arteries and nerves network of the ventral region

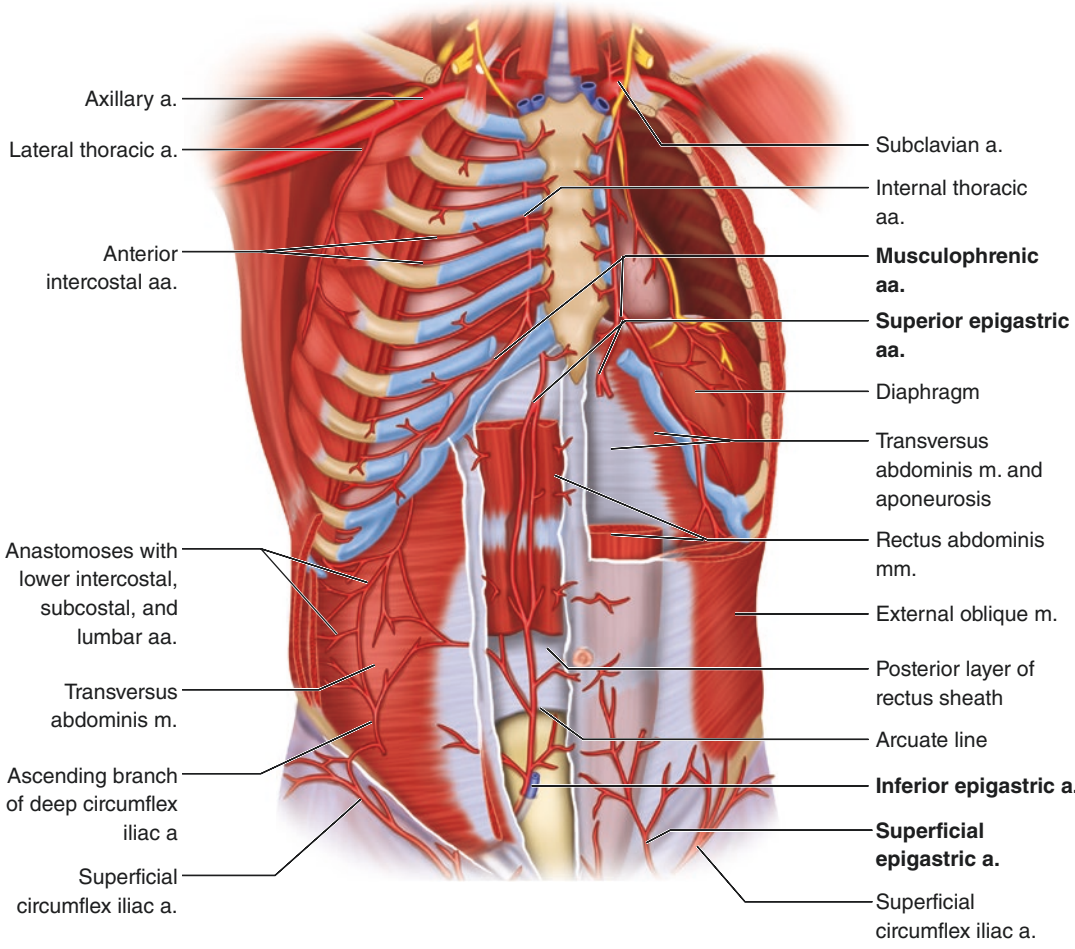


Fig. 49.5 Arteries and nerves network of the ventral region

As the upper part of the muscle receives blood from intercostal arteries, the lower part is supplied by arteries coming from deep circumflex iliac artery or the iliolumbar artery.

The internal oblique is the second layer. Its fibers run opposite to the one from the external oblique upward and forward. Its proximal insertions are on the medial two thirds of the iliac crest, the aponeurosis of the lumbosacral muscle, the anterosuperior iliac spine, the lateral third of inguinal ligament, and the iliopsoas fascia. Its cranial insertions stand on the lateral surface of 10th, 11th, and 12th ribs. It is of note that the fibers of the internal oblique coming for its medial pelvic insertions participate to the formation of the conjoint tendon and that the cremaster muscle is composed by the lower fibers of the internal oblique muscle (see anatomy of the inguinal region chapter). Internal oblique plays a major role in the constitution of the rectus sheath (see below).

Even if its fibers' direction is opposite to the ones of the external oblique, its contraction also results in pulling down the ribs. But in case of unilateral contraction of the muscle, the thorax is attracted to the side of contraction and rotates.

The muscle is innervated by branches from lower intercostal nerves (upper part) and iliohypogastric and ilioinguinal nerves (lower part).

Blood supply comes from subcostal arteries.

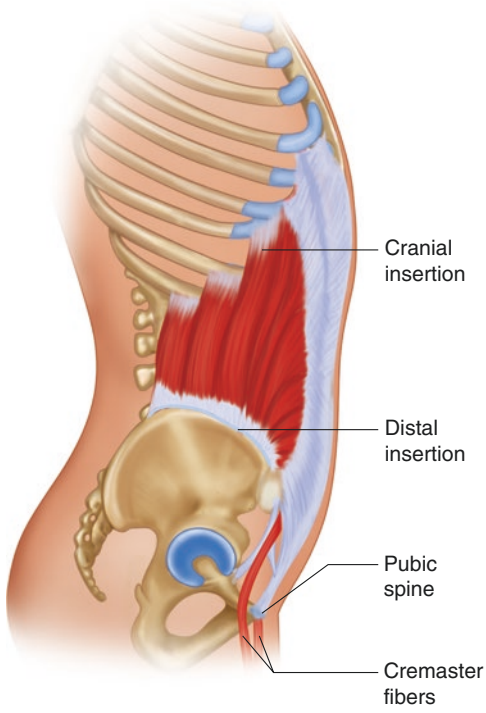


Fig. 49.6 Internal oblique muscle insertions. *1* cranial insertion, *2* distal insertion, *4* pubic spine, *5* and *6* cremaster fibers

The **transverse muscle** (transversus abdominis muscle) is the deepest flat muscle of the abdominal wall. As its direction is horizontal, it can be described as caudally inserted on five transverse apophyses and ending medially as an aponeurosis contributing to the rectus sheath (see below). Cranially, the transverse is inserted on the internal face of the 7th to 12th ribs cartilage. Those six palms are entwined with the other ones coming from the diaphragm insertion. Caudally, it is inserted on the two anterior thirds of the iliac crest and the external third of the inguinal ligament and iliac fascia. At that part, fibers contribute with one from the internal oblique to the conjoint tendon formation. It also contributes to the cremaster muscle (see above).

Transverse muscle is innervated by both lower intercostal nerves (thoracic nerve roots T7–T11) and iliohypogastric and ilioinguinal nerves.

Blood supply comes from subcostal arteries.

The transverse muscle is known as the "corset muscle." Acting like a horizontal muscular belt, the transverse compresses the visceras inside the abdomen and stabilizes together the pelvis, spine, and thoracic chest. This action is particularly significant during lifting efforts but also in expiration or during birth giving. The transverse is therefore the most antagonist of the diaphragm. Even if its role in back pain occurrence is debated, its action in releasing pressure on the vertebral discs by its contraction in lifting efforts is well recognized [4].

For the surgeon, performing a midline incision "opens" the transverse muscle belt and impaired highly respiration movements. In the mechanism of incisional hernia occurrence, transverse retraction attracts laterally the rectus muscle impairing both its function and enlarging the incisional hernia gap.

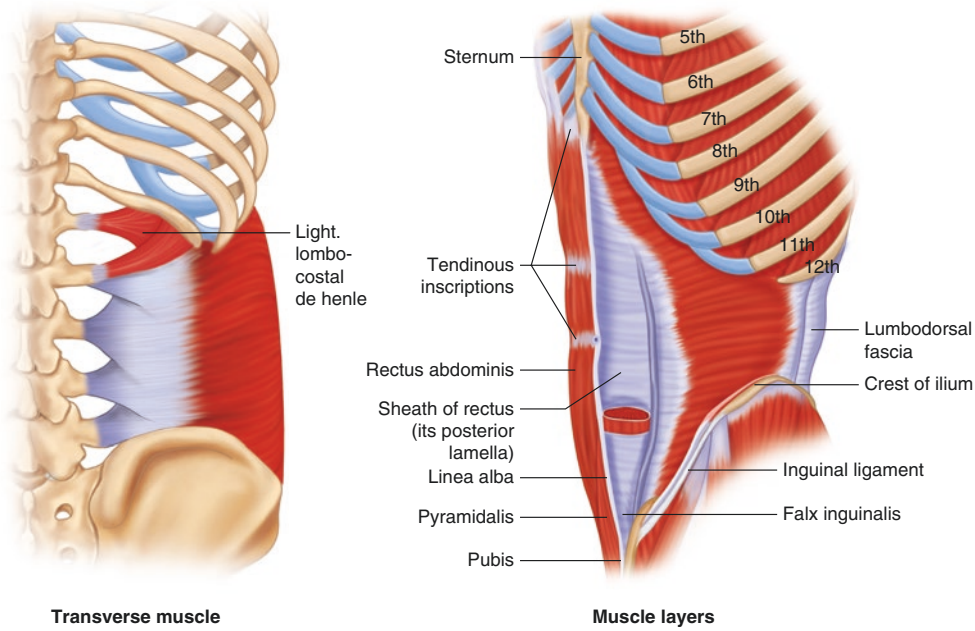


Fig. 49.7 Transverse muscle insertions and position of the muscles

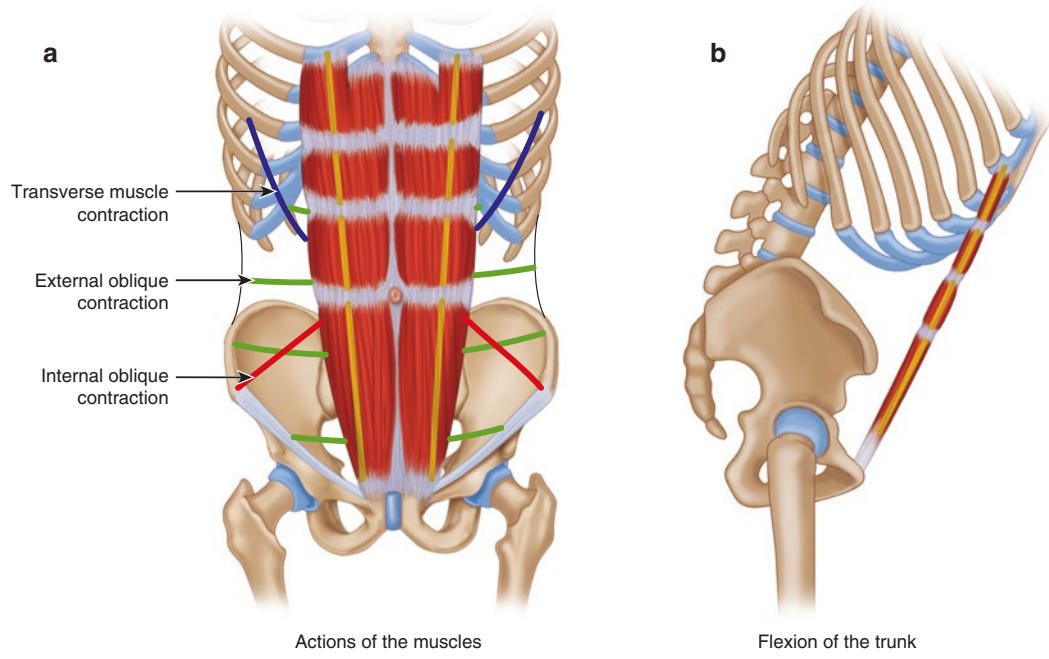
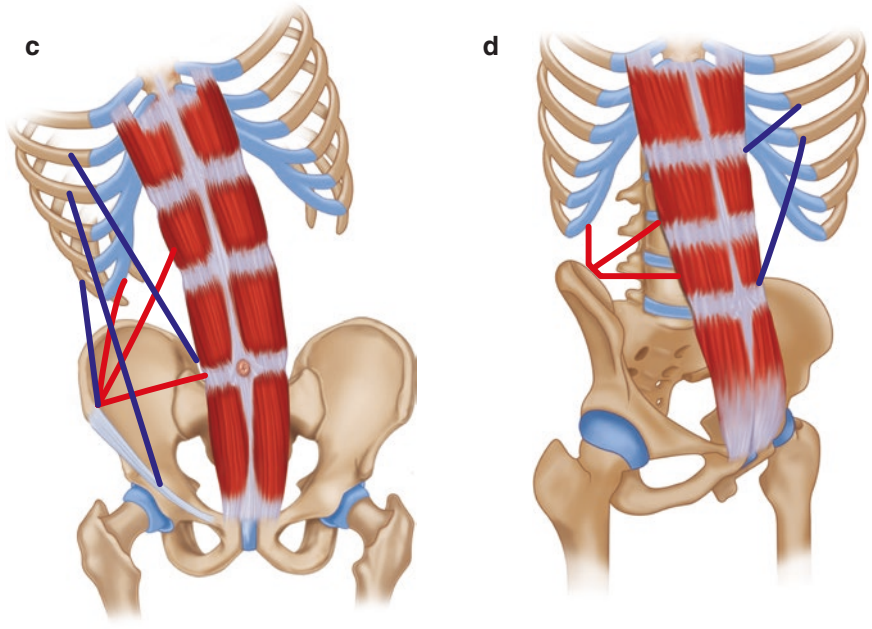


Fig. 49.8 *Green line* transverse muscle contraction, *blue line* external oblique contraction, *red line* internal oblique contraction



Inclination of the trunk

Rotation of the trunk

Fig. 49.8 (continued)

As all the flat muscles of the abdominal wall are "connected" together at the midline as they contribute to the rectus sheath formation, they act synchronously to allow thoracoabdominal movements.

Rectus Sheath and Linea Alba: The central point of the ventral region

Stretched from the xiphoid appendix to the pubis, the rectus runs vertically wrapped in a close aponeurotic sheath.

This structure is a complex network of collagen tissues formed by the aponeurosis of the flat muscles (external oblique, internal oblique, transverse).

The external oblique aponeurosis constantly passes in front of the rectus muscles, composing the anterior lamina of the sheath. Fibers from both sides are arranged in a chevron pattern responsible for the solidity of the lamina.

The internal oblique and transverse aponeurosis don't behave that constantly and lead to distinguish different area cranial to caudal.

The internal oblique aponeurosis (from about hallway between xiphoid and umbilicus) splits its fibers in an anterior and a posterior layer. The anterior layer joins the fibers of the external oblique in front of rectus muscle to constitute the anterior lamina. But some centimeters below the umbilicus, there is no split in the fibers, and all the aponeurosis of the internal oblique join the external oblique and transverse aponeurosis in constituting the anterior sheath. Below this level, one should understand that there is no more posterior layer of the sheath (can we still call it a sheath!) and that all the flat muscle aponeuroses have joined themselves to constitute the anterior lamina.

The transverse muscle aponeurosis also behaves differently from cranial to caudal. Cranially the fibers constantly remains posterior to the rectus and constitutes the deep layer of the sheath, but at a variable level some centimeters below the umbilicus, they go anteriorly will all other flat muscle aponeurosis.

This level where "everything changes" is known as the **arcuate line** (see below).

Another point of interest is the lateral margin of the rectus sheath, where lateral muscles aponeurosis joins themselves. Indeed from costal edge to pubis, the muscle aponeurosis doesn't join on a vertical line due to different myoaponeurotic boundaries. But the shape of that junction can be described as a medially concave line running at the lateral edge of the rectus muscle and called **Semilunar or Spigelius line**.

The surgeon has to know that this area is crossed by various nerves and pedicles and that entering or dividing it can be hazardous and provide unexpected damage.

On the opposite side of the rectus muscle, medially, the muscles are joined together by a solid fibrous structure called the **Linea Alba**. It is made of collagen connective tissue coming from the aponeurosis of all the flat muscles. Its length and breadth is highly variable between people, but the breadth is constantly higher below the umbilicus than under where rectus muscles can be joined together or joined by the pyramidal muscle. The breadth of the linea alba enlarges with age, and, for example, after 45 years old, it can reach 12–14 mm above the umbilicus, 19–23 mm at the level of the umbilicus, and 9–11 mm below the umbilicus. If the distance exceeds this ranges, diagnosis of rectus diastasis should be considered [5].

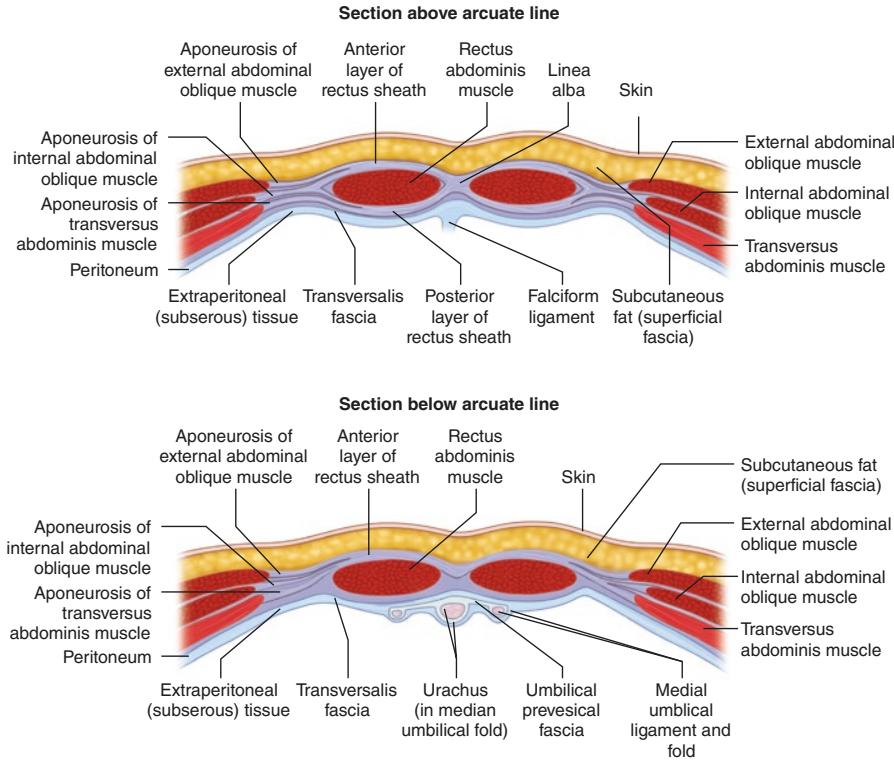


Fig. 49.9 Sectional view of the ventral region above and below the arcuate line

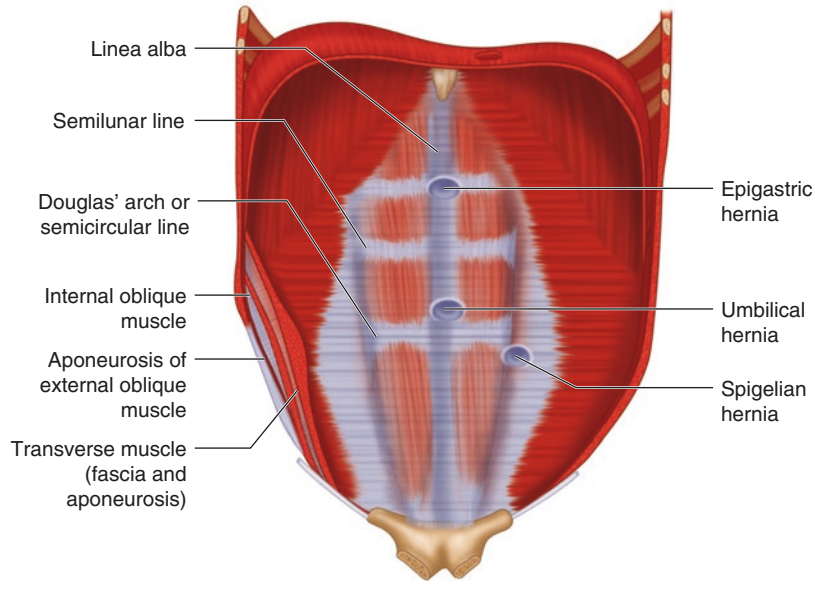


Fig. 49.10 Points of weakness of the ventral region

The Arcuate Line (Semi Circular Line of Douglas)

The lower third of the rectus muscle is not contained in a circumferential sheath but only cover by an anterior layer composed by internal oblique muscle aponeurosis (see above).

This means that the posterior lamina of the sheath ends upper than the anterior one leaving the deeper face of the rectus muscle only covered by the transversalis fascia.

This end or limit of the posterior lamina located about halfway (or upper third) between the pubis and the umbilicus forms a semicircular line called the Douglas line. Its exact level is highly variable, and moreover the arcuate line is inconstant [6].

The existence of the arcuate line can limit the lateral access to the Space of Bogros and Retzius in case of retrorectus dissection; thus, it might be necessary to release its lateral attachment to enlarge the dissected space. In that dissection, be aware of discriminating the arcuate line from the peritoneal edge.

49.2 Points of Weakness of the Ventral Region

As the solidity of the ventral region is a result of muscle and aponeurotic crossing, areas of weakness take place where this crossing process is less effective or absent.

For that reason at the umbilicus, the Spigelian line below the arcuate line and the linea alba of the ventral wall offers possible exit doors.

– Umbilical Frailty

Once you look at the linea alba, you can divide it by 100, and then starting at the top, count to the 56 to reach the umbilicus (Testut 1896)! In case of three transversal tendinous intersections on the rectus, it is usually the level of the lower one.

The umbilicus is a cicatricial whole in the linea alba. The size and shape of that orifice are highly variable, and even it has been described as measuring 2–8 mm, it can be totally occluded as age advances.

At the umbilicus, the peritoneum is only separated from the subcutaneous tissues by the umbilical fascia. Inconstant and only present in about two thirds of cases, the fascia consists in a reinforcement of the transverse aponeurosis (constituting the linea alba). But even when present, its location and connections with the umbilical fibrous ring might not or only partially cover the surface of weakness of the ring. This might predispose to umbilical hernia occurrence.

Some fibrous structures also contribute to "close" the umbilical ring. The round ligament of the liver divided its self at the top in two cords that are inserted on the umbilical ring. At its umbilical insertion, the round ligament of the liver is rather figurative and provides poor solidity. On the opposite side, the urachus is supposed to end at the bottom of the umbilical ring. Indeed, when present (one out of three patients), the urachus ends before reaching the umbilical ring and splits in fibrous stripes. These fibers join the one coming from the umbilical artery that run downward laterally in a fibrous network of poor solidity. The presence of the arteries also strengthens a little the area, but nevertheless, this solidity remains actually poor allowing hernia formation. Due to the adherence of the peritoneum to the umbilical ring, it might be difficult to divide them in order to place a pre-peritoneal mesh in order to cure an umbilical hernia.

– Linea Alba

Also called "epigastric hernia," there might be a defect inside the aponeurotic fibers constituting the linea alba. Inside the medial solid insertion of the flat muscles, some fibers can be spread allowing fatty tissues to protrude through that whole. This occurrence is only possible between the umbilicus and the xiphoid process. Under the umbilicus, the rectus muscles are close from each other enough to avoid this opportunity.

One must warmly be aware that this is totally different from diastasis recti. Diastasis

recti consists of an enlargement of the linea alba that is stretched but remains totally continuous. Surgical options are debated elsewhere but as there's no whole in the linea alba, there cannot be strangulation! In other terms, diastasis recti is never a life-threatening disease, and surgery (plastic surgeon? Hernia surgeon?) must be wisely selected.

– Spigelian Hernia

- Lateral to the rectus muscle, the semilunar line (Spigelian line), the lateral muscles have joined fibers in an aponeurotic fascia in which fibers are going to constitute the rectus sheath. This vertical band as it is not covered by muscular structures is a site of possible weakness. This is particularly true below the arcuate line where the boundaries of the rectus and lateral muscles are more distant delimitating a weak area just above the inguinal region (about 90% of Spigelian hernia). As they cross the area from the midline, the inferior epigastric vessels don't give any additional solidity to that region. As in this kind of hernia, the sac can stay for a long time "intraparietally" and if there, doesn't approach the subcutaneous tissue, it might stay for a long time asymptomatic, which is difficult to diagnose. Indeed, A. Van der Spiegel described the semilunar line in 1645, but Josef Klinkosch described this kind of hernia in 1764. It is of note that this can of defect has been described as possibly associated with ipsilateral cryptorchidism and testis malposition in Spigelian-cryptorchidism syndrome and Raveenthiran syndrome [7, 8].

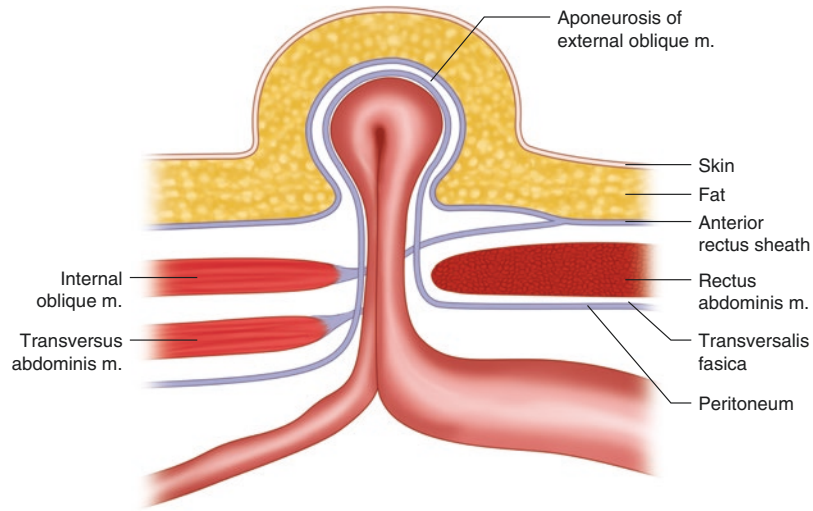


Fig. 49.11 Spigelian Hernia

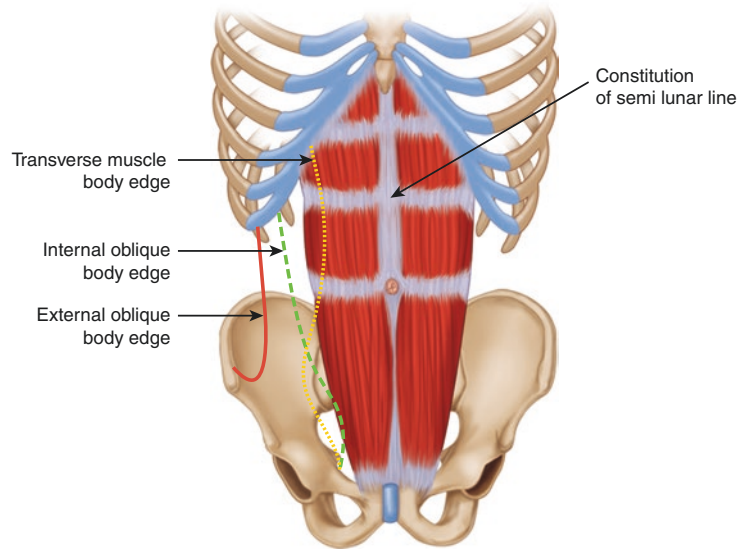


Fig. 49.12 Spigelian line. *Green line* internal oblique body edge, *yellow line* transverse muscle body edge, *red curve* external oblique body edge

Surgical take-home message about the anatomy of ventral region

- The anterior muscles aren't only components of a barrier but play an irreplaceable role in many vital actions like breathing, standing, and laughing!
- Opening the "transverse belt" by making midline incision is an important issue due to the consequences that can ensue from it.
- Knowing the precise "architecture" of the linea alba and muscle fascia is mandatory for a surgeon who planes complex abdominal wall reconstruction.
- Diastasis recti is not a hernia!
- Whether the way you approach the abdominal wall laparoscopically for TEP hernia repair or open for retromuscular repair, the arcuate line is a frontier between two spaces you'll have to consider and deal with.

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Umbilical Hernia Repair

50

Karl A. LeBlanc

50.1 Introduction

The repair of hernias at the umbilicus has undergone a multitude of changes over the years. Most surgeons have heard of the "pants over vest" repair that was described in the early 1900s. Numerous other techniques have been described since then. More recently, the use of a prosthetic material has nearly become the standard of treatment in most areas of the world. While the choice of mesh is relegated to the surgeon, this chapter will detail the various techniques for this operation.

In general, the results obtained in repairing these hernias have demonstrated that the use of a mesh of some type has improved results [1–4]. Because of the universal fact that the population of the world has grown much larger and heavier, this should not be unexpected. However, there are papers that contradict this statement [5]. A recent consensus conference has even opined that the ventral hernias in patients with a body mass index of greater than 50 should have surgery delayed until weight loss has lowered the BMI [6]. This, of course, is not always practical in symptomatic patients, but this reinforces the concept that morbid obesity is a significant risk factor.

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In general, I prefer to limit the tissue repair to normal weight, thin individuals with smaller defects. In the heavier patients (BMI > 30), I usually prefer to use the laparoscopic/robotic approach. However, if the BMI is under 35 in patients with defects less than 3 cm, I will consider an open approach. If the hernia is greater than 3–4 cm, the minimally invasive approach is preferred in my hands regardless of weight. These are general guidelines and each patient and hernia will need to be individualized.

All patients are placed under general endotracheal anesthesia. Nasogastric and bladder catheterization are not required in most cases. In most cases, it is important to have the patient cleanse the umbilical area prior to surgery. This will apply to the non-open repairs should the need arise to convert to open, and most often a central positioning suture is used in the robotic repair.

50.2 Open Repair

The patients are prepped and draped to provide an adequate amount of exposure of the abdominal wall. A curvilinear incision can be made either supraumbilically or subumbilically. I prefer the former. Dissection will continue to expose the entire fascial defect and an appropriate amount of adjacent fascia. Management of the hernia sac varies according to the size and thickness of the tissue. An attempt to keep the sac

G. Campanelli (ed.), *The Art of Hernia Surgery*, https://doi.org/10.1007/978-3-319-72626-7_50

intact is made, and I try to limit the dissection such that entry into the peritoneal cavity is avoided. With incarcerated contents, this is not usually feasible, however.

50.2.1 Tissue Repair

This option is usually applied to defects less than 2 cm in thin patients. The tissue dissection is usually carried out with electrocautery. The hernia is exposed easily (Fig. 50.1). The dissection continues until the sac is reduced, and adequate preperitoneal dissection is performed to assure that the neck of the sac is no longer attached underneath (Fig. 50.2). This aids in reduction of hernia recurrence. The use of a permanent suture is preferred (Fig. 50.3). As shown, I use a CV-0 expanded polytetrafluoroethylene suture. This suture is preferred as it is not stiff and is not multifilamented. A running suture rather than interrupted sutures is used. This minimizes the amount of suture knots used in an effort to reduce the potential of infection.

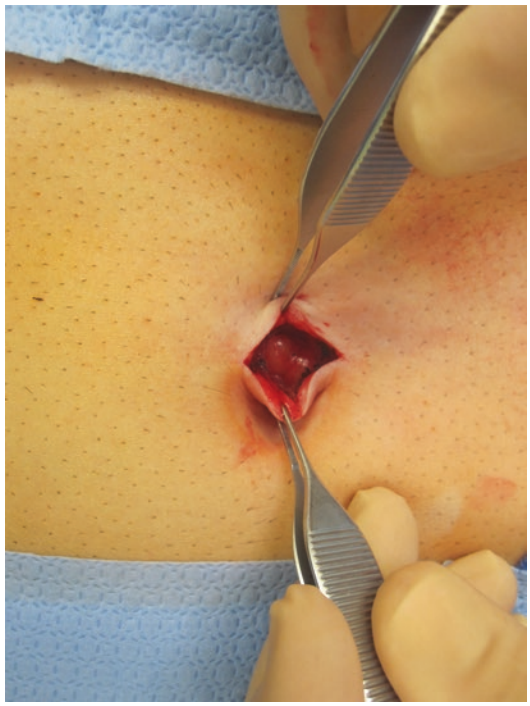

Fig. 50.1 Supraumbilical incision exposing the hernia

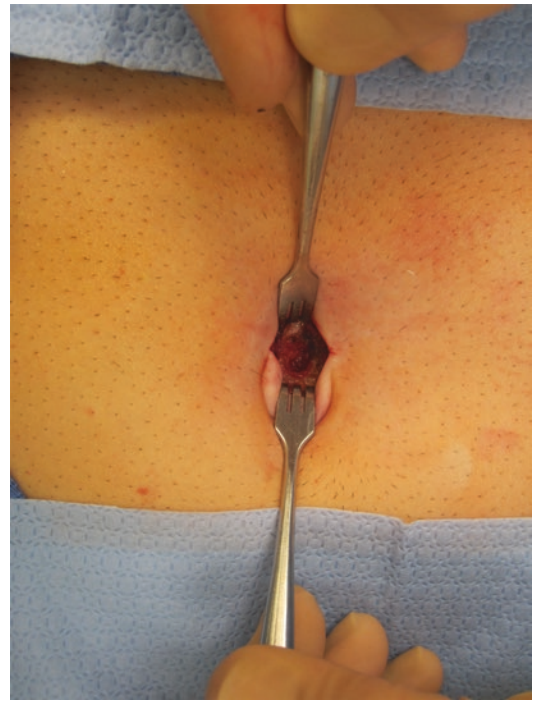

Fig. 50.2 The hernia sac is reduced fascia exposed

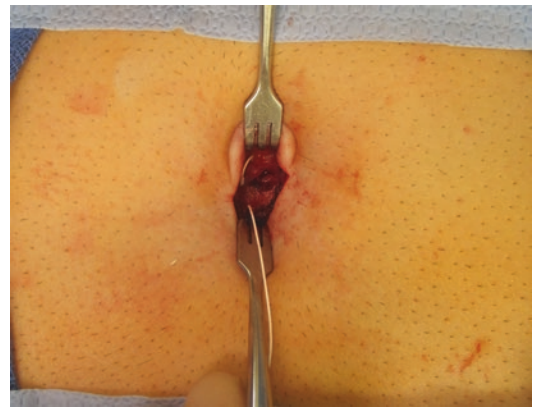

Fig. 50.3 First throw of the stitch

50.2.2 Mesh Repair

As noted above, this is the repair that is most commonly favored in the appropriate group of patients. The initial approach to the procedure is identical as that of the non-mesh repair. The dissection at the fascial level must be more extensive to allow for the placement of the four cardinal sutures described below. This exposure will

depend upon the size of the mesh that is chosen, which in turn will depend on the size of the fascial defect. The preperitoneal space must be dissected to the extent of that is required for the placement of the chosen mesh product. This frequently results in the exposure of the intra-abdominal contents. In some instances, this is not recognized. It is for this possibility that a barrier-coated product is chosen in this procedure.

The usual material chosen is that of a rounded coated mesh. This must be placed so that it is completely flat against the anterior abdominal wall (Fig. 50.4). The tether in the figure allows the surgeon to manipulate the mesh. Additionally, this will be sewn into and below the fascial closure to fixate the mesh in addition to the four cardinal sutures.

The most critical fixation of the product occurs with the four cardinal sutures [7]. Permanent sutures are used in a "U" fashion with the knots tied on the anterior surface of the fascia (Figs. 50.5 and 50.6). The tether will be incorporated into the transverse closure of the fascial defect in a

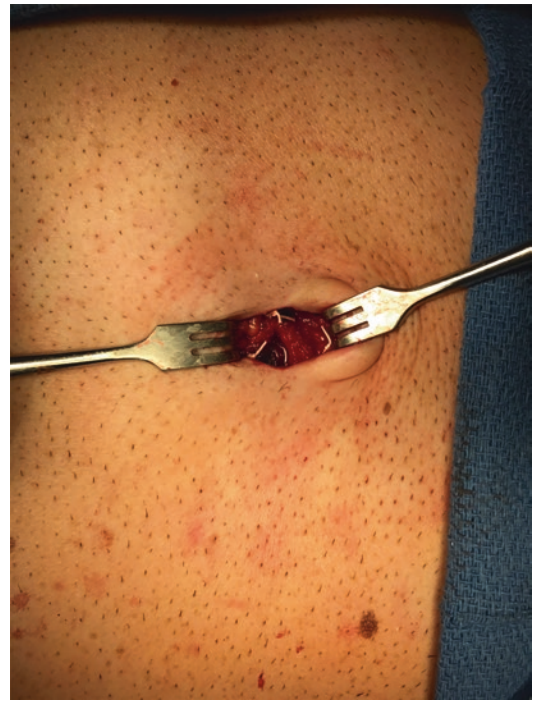

Fig. 50.5 Four cardinal ePTFE sutures in place prior to closure of the fascial defect

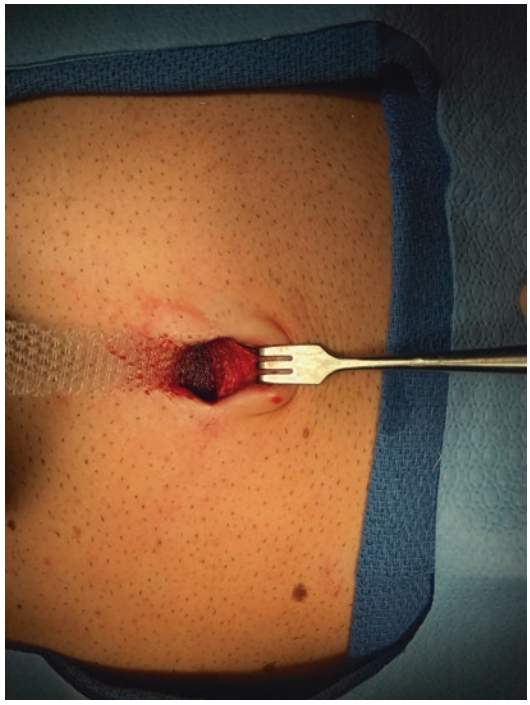

Fig. 50.4 Ventralex ST mesh with tether outside of the fascial defect

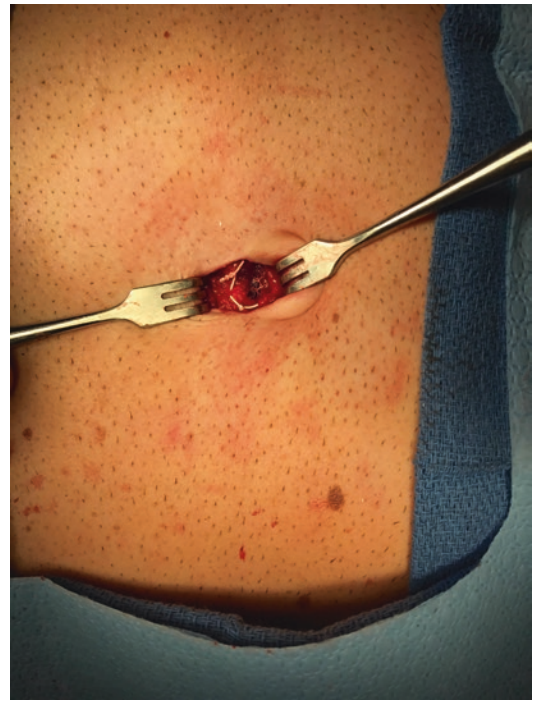

Fig. 50.6 Exposure of the tether prior to closure of the defect

manner similar to the open repair above. The umbilical skin will be grasped with the underlying suture to create an imbricated umbilicus at the completion of the operation.

50.3 Minimally Invasive Repair

50.3.1 Laparoscopic Repair

As with the open repairs, the minimally invasive repairs are very similar in many respects. They require an entry into the abdominal cavity by whatever method is selected by the surgeon. An initial inspection of the structures will occur. Notation of the presence of adhesions and incarcerated contents of the hernia will be the next step. This will aid in the placement of the additional trocars. A total of three or four trocars will be required. Depending on the choice of the surgeon, three can be placed on one side, and the entire procedure can be done with these, or an additional one can be placed on the opposite side to aid in fixation of the mesh (Fig. 50.7). Alternatively, two trocars can be placed on both sides (Fig. 50.8). This will alleviate the problem of "mirror-imaging."

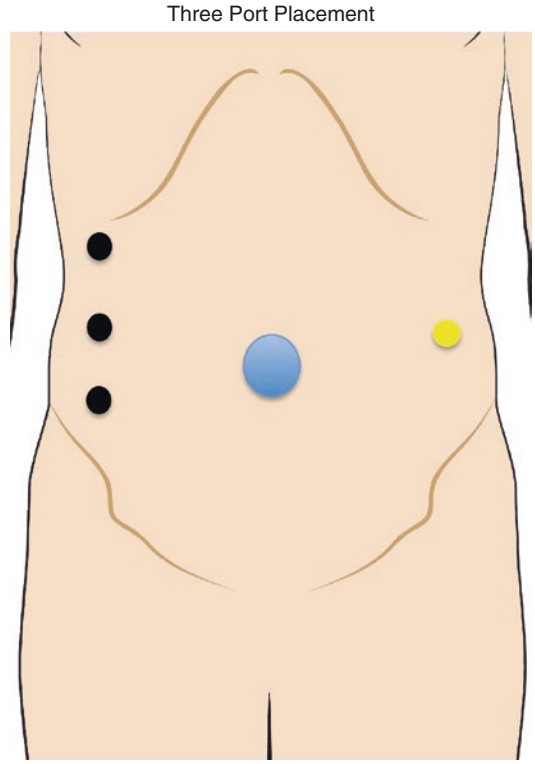

Fig. 50.7 The yellow port can be used instead of one of the ports on the opposite side

As with any laparoscopic procedure, any adhesions must be lysed prior to inspection of the operative area. For hernia repair, this is even more critical because any fat on the abdominal wall must be dissected free such that the applied mesh will contact tissue other than adipose tissue. This will ensure that ingrowth will occur into the mesh without the inhibition afforded by any fatty tissue between the mesh and the fascia. In many cases, intestinal adhesions or incarceration will be associated with these hernias. These will require release or reduction prior to mesh fixation (Fig. 50.9).

After this has been completed, one may elect to close the fascial defect. This has been reported to improve results in incisional hernia repair [8]. This can be closed either transcutaneously or intraperitoneally. The mesh is then inserted and fixed to the anterior abdominal wall with transfascial sutures and/or tacks that are either absorbable or permanent (Fig. 50.10). We prefer permanent sutures to fixate the mesh in addition to absorbable tacks; the sutures are not seen in figure. Generally, the tacks are placed first followed by placement of the sutures. It is important that the mesh is pulled taut so that there are no wrinkles, which will predispose to the development of adhesions at these sites.

50.3.2 Robotic Repair

Usage of the robot to repair these hernias is a matter of personal choice of the surgeon. This

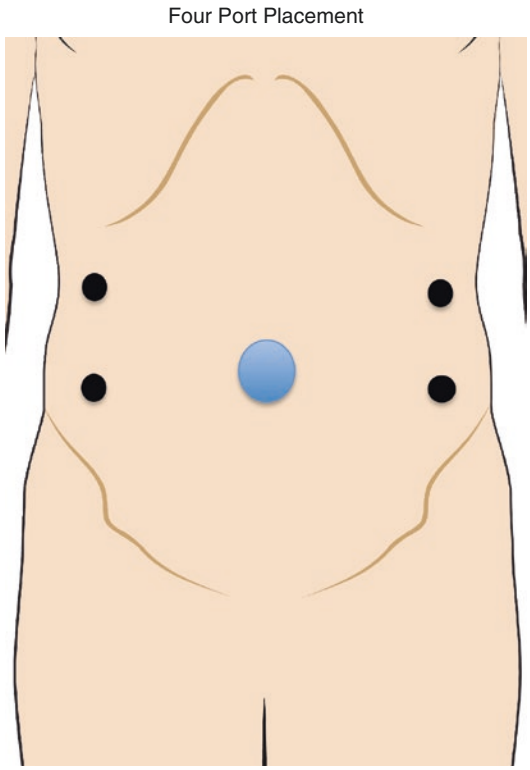

Fig. 50.8 Two ports on either side of the abdomen

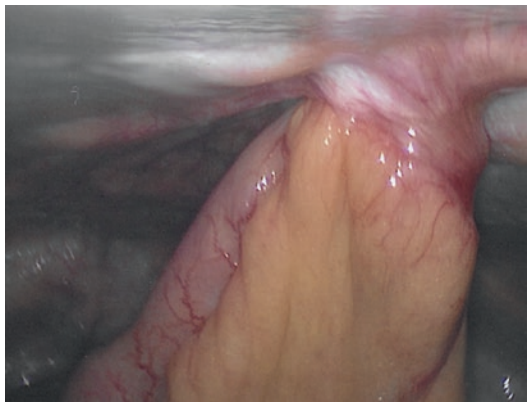

Fig. 50.9 Intestinal incarceration into an umbilical hernia

approach is especially desirable for the larger hernias in larger patients. One of the advantages is that the defect can be close reliably without

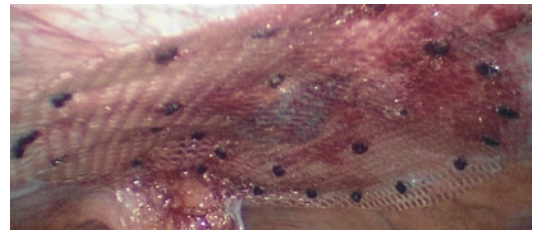

Fig. 50.10 Permanent mesh fixed with absorbable tacks and transfascial sutures

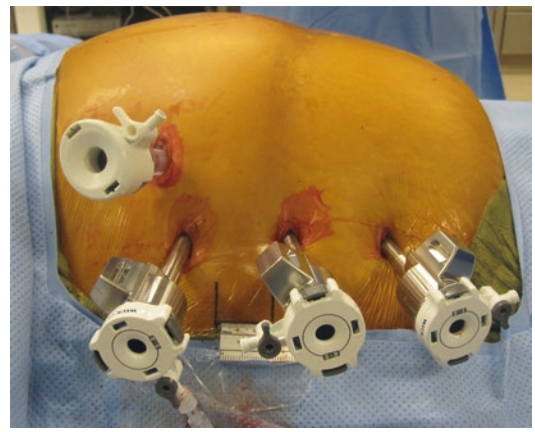

Fig. 50.11 Trocar positions for robotic repair

the use of percutaneous sutures, which (at least theoretically) will reduce the risk of infection. The approach to the abdomen does not differ from the laparoscopic approach above. The need for a safe entry into the abdominal cavity and the initial inspection do not differ. In these cases, however, four trocars are used (Fig. 50.11).

For primary umbilical hernias, there are minimal adhesions usually (Fig. 50.12). The usual instrumentation, as noted in the figure, is the fenestrated bipolar in the left hand and scissors in the right. After reduction of any incarcerated contents, an inspection of the tissues around the fascial defect will determine if there is a need to dissect the adipose tissue from the fascia (Fig. 50.13). In most cases, this will be required to allow for accurate measurement of the defect and to allow mesh contact to fascia rather than

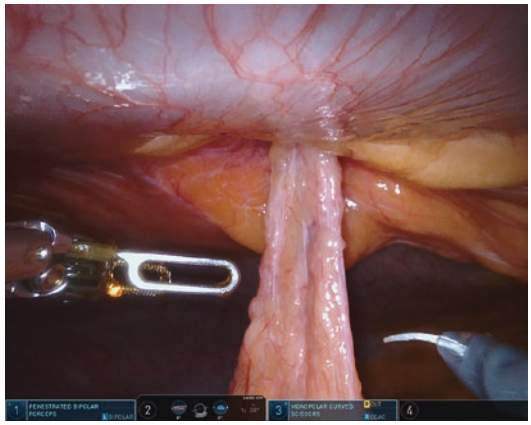

Fig. 50.12 Incarcerated omentum in the umbilical hernia

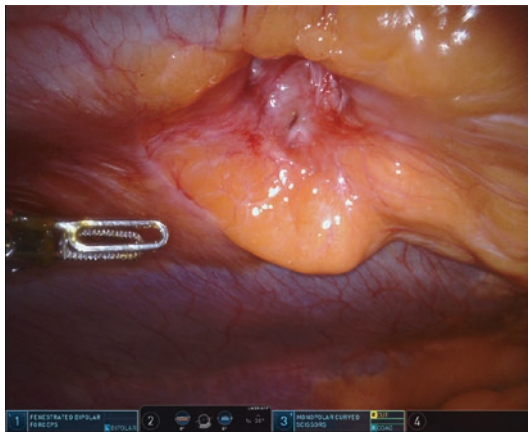

Fig. 50.13 Preperitoneal fat surrounding the fascial defect

fat. This is critical to ensure tissue ingrowth into the mesh (Fig. 50.14). The scissors will be exchanged to the needle holder after all dissection has been performed (Fig. 50.14).

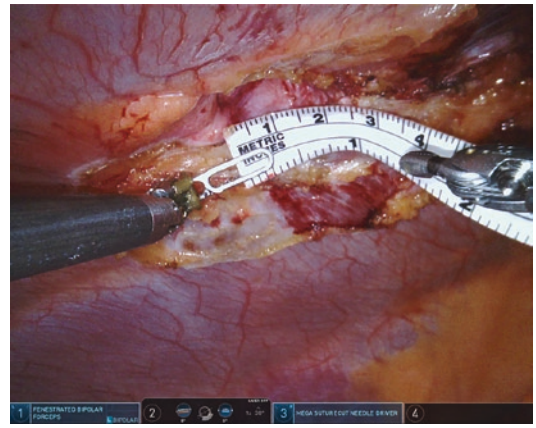

Fig. 50.14 Exposed fascia after dissection allowing an accurate measurement of the fascial defect

A ruler will be inserted into the abdominal cavity to measure the defect. To this measurement, 10 cm will be added to select the appropriate size of the mesh. As with the laparoscopic repair, a 5 cm overlap of mesh is critical to decrease recurrence rates [9]. The mesh will be inserted through the 12 mm trocar under direct vision. A preplaced central absorbable suture will be pulled through the middle of the hernia defect (Fig. 50.15). This is important to assure that the mesh is placed central to the defect and not malpositioned, which would compromise the 5 cm overlap.

After this, the defect will then be closed with a permanent suture that is noted in Fig. 50.15. The mesh lies below the defect and will be pulled up by that suture (Fig. 50.16). The mesh will be sewn in place with another permanent suture (Fig. 50.17). It is preferred if the mesh is taut in all directions.

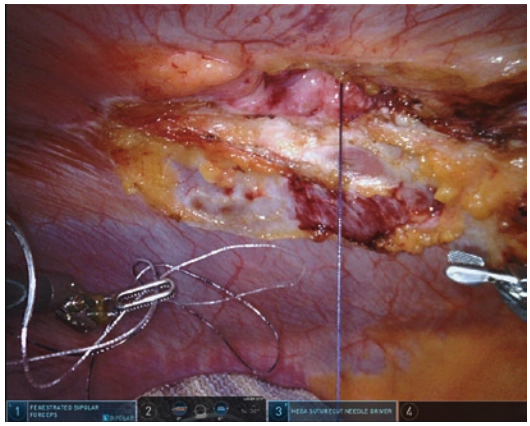

Fig. 50.15 The central suture has been pulled through the abdominal wall to assure central positioning of the mesh. The permanent suture to close the defect is also seen

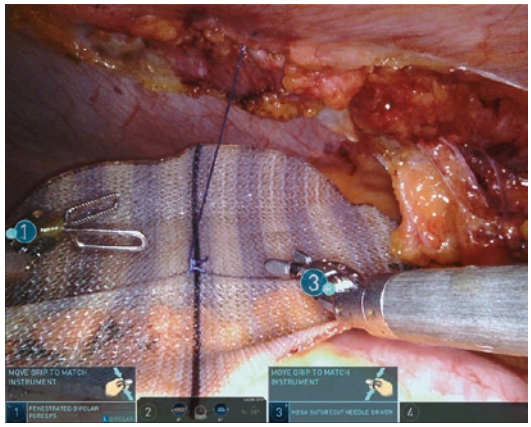

Fig. 50.16 Closed fascial defect

Conclusion

There are many options to repair umbilical hernias. The method will be selected based upon surgeon preference as it relates to the comorbidities of the patient and the characteristics of the hernia. Surgeons should possess the knowledge and skill to use more than one type of repair to provide optimal care to the patient.

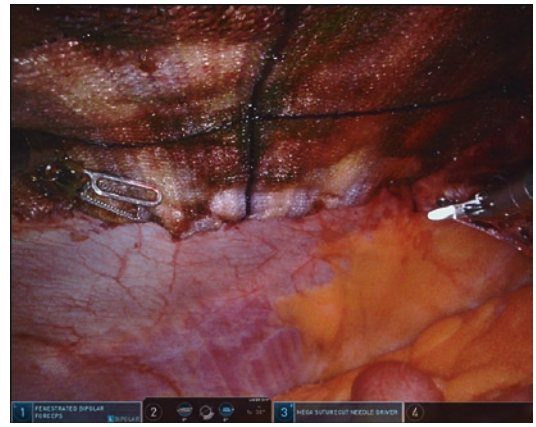

Fig. 50.17 Completed repair with a barrier coated mesh

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51 Endoscopically Assisted Mini or Less Open Sublay (MILOS) Mesh Repair of Abdominal Wall Hernias

W. Reinpold

51.1 Introduction

Primary abdominal wall and incisional hernia repair figure among the most frequent operations in surgery. The risk of incarceration is 1–2% per year. The main cause seems to be genetically determined insufficient cross-links between the collagen molecules. Since the advent of synthetic mesh [1], recurrence rates could be reduced from 25 to 60% to below 15%.

The open sublay mesh implantation based on techniques of Jean Rives and René Stoppa and the laparoscopic intraperitoneal onlay mesh plasty (Lap IPOM) are the internationally leading procedures for the treatment of incisional hernias [2–8] (Fig. 51.1a, b).

In open sublay repair, the alloplastic mesh is inserted via a large skin incision between the peritoneum/posterior rectus sheath and the abdominal wall. Today, the sublay mesh position is considered most advantageous because direct contact of foreign material with bowel and other viscera is omitted. Because the intra-abdominal pressure pushes the alloplastic prosthesis against the abdominal wall, in many cases, only no or minimal atraumatic fixation is necessary. The disadvantages of the procedure are the more invasive access trauma and, according to the literature, the higher infection rates.

Despite the advantages of the small skin incisions in Lap IPOM surgery, the pain level is not low. A further concern is the implantation of a foreign body in the abdominal cavity, which is a risk factor for adhesion formation to the bowel and injuries to the viscera. In addition, the mesh has to be fixated with many staples, clips, tacks, or extensive sutures to the pain-sensitive peritoneum [6, 9–11] (Fig. 51.1a). Expensive implants with adhesion barriers on the area facing the bowel have to be used. Reoperations have shown that all IPOM prostheses can lead to massive adhesions and do not provide secure protection of the viscera. Another disadvantage of Lap IPOM repair is the fact that the hernia defect is often not fully closed but only bridged by the synthetic prosthesis. This often leads to a persisting protrusion that frequently regresses slowly or not at all. Current data from the German hernia register "Herniamed" show significantly more 1-year recurrences after Lap IPOM hernia repair than after open sublay operations.

51.2 The MILOS Technique

For the further reduction of complications and pain in abdominal wall hernia repair, we developed a new minimally invasive technique—the mini or less open sublay (MILOS) repair. The MILOS repair permits insertion of a large mesh

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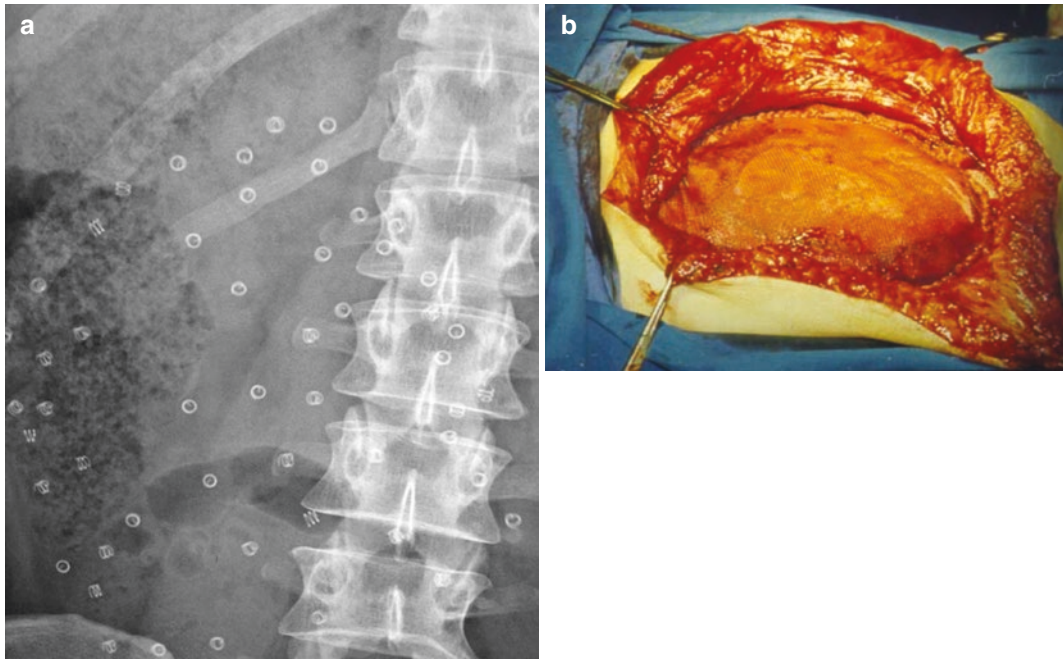

Fig. 51.1 (**a**) Extensive tack fixation of Lap IPOM mesh (**b**) Large incision in open sublay surgery

in the retromuscular/preperitoneal space and anatomical reconstruction of the abdominal wall via a small transhernial incision. Using the MILOS technique, major trauma to the abdominal wall and entering the abdominal cavity is avoided. The MILOS operation can be performed mini open with light-armed laparoscopic instruments either under direct vision or endoscopically assisted. Today, in our institution, all primary and incisional abdominal wall hernias are operated on with the MILOS technique. Exceptions are small hernias with a hernia defect diameter smaller than 2 cm and extremely large hernias.

The MILOS operation starts with an incision of 2–6 cm directly above the center of the hernia defect. The abdominal wall is lifted with retractors. The preparation is carried out in "mini-open" technique under direct vision or endoscopically assisted. After transhernial mini-open preparation of an extraperitoneal space of at least 8 cm diameter and closing of the abdominal cavity, the procedure can be continued as total extraperitoneal gas endoscopy (TEP of the abdominal wall) using either standard trocars (Fig. 51.2) or a transhernial single port (Fig. 51.3) [12].

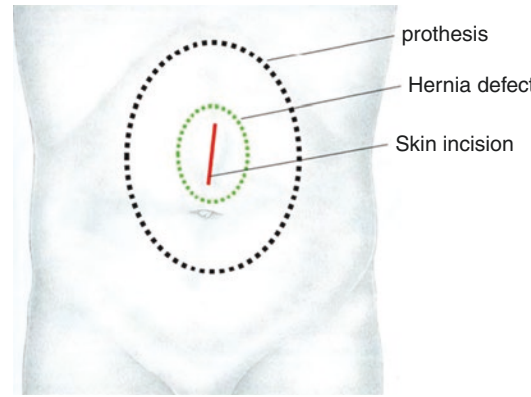

Fig. 51.2 eMILOS-TEP ventral hernia repair with standard trocars

The MILOS technique enables the extraperitoneal preparation of the whole rectus compartment and both lateral compartments. Very large synthetic meshes can be implanted (Fig. 51.4) minimal invasively if the size of the hernia requires it. Posterior component separation can be performed using the MILOS technique. Thus, a total sublay repair of the abdominal wall is possible.

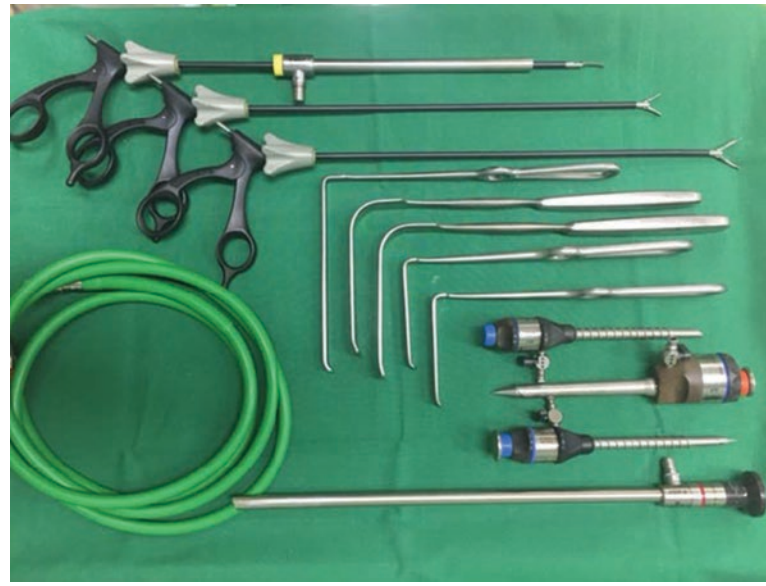

Fig. 51.3 eMILOS-TEP ventral hernia repair with single port

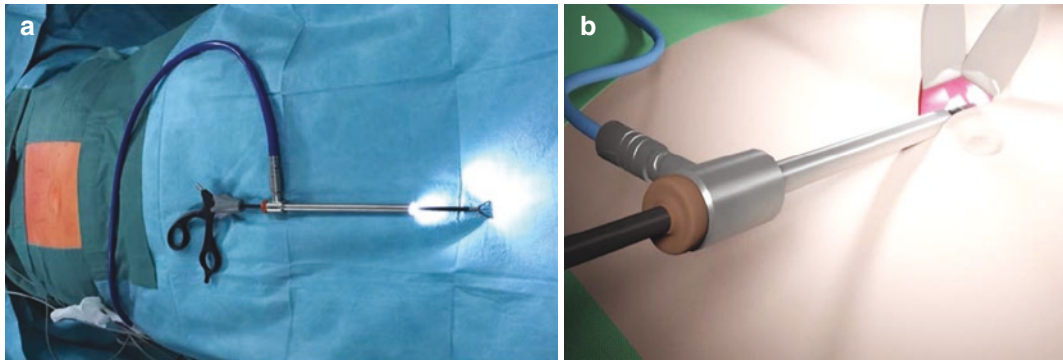

Fig. 51.4 MILOS operation of the fourth recurrence of an incisional hernia after open prostatectomy

The surgical steps of MILOS repair:

1. Small incision directly above the center of the hernia defect (Fig. 51.5).
2. Hernia sac preparation.
3. Small incision of the peritoneum for diagnostic laparoscopy.
4. Resection of abundant peritoneum of the hernia sac.
5. Complete and precise exposure of the fascial edge of the hernia orifice.
6. While the abdominal wall is lifted with rectangular retractors (Figs. 51.6b, 51.7, 51.8), transhernial extraperitoneal dissection around the hernia gap is performed using laparoscopic instruments armed with a light tube specifically designed by us and WOLF Company (Endotorch TM, Figs. 51.6a, b and 51.9). Via a 4 cm incision, the Endotorch TM allows circumferential dissection of the extraperitoneal plane with a radius of up to 20 cm from the fascial border of the hernia gap.

Transhernial longitudinal incision of the posterior rectus sheath is performed in all quadrants to correspond with mesh size (Figs. 51.7 and 51.8). Figure 51.10 depicts the endoscopic incision of the cranial section of the left posterior rectus sheath.

Fig. 51.5 Incision of 2–6 cm directly above the hernia defect showing synthetic mesh (black interrupted line), hernia defect (green), incision (red)

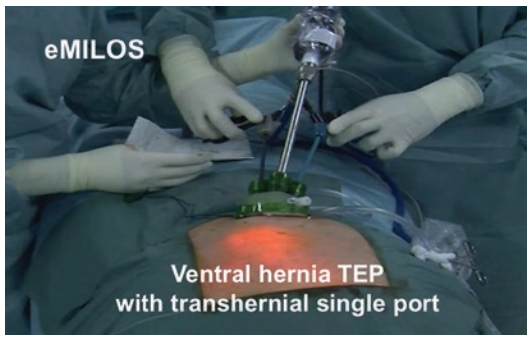

Fig. 51.6 (**a**) Endotorch TM: light-armed 5 mm laparoscopic forceps (**b**) Transhernial dissection with Endotorch TM and laparoscopic 5 mm instruments

7. Closure of the abdominal cavity with absorbable suture.
8. Transhernial extraperitoneal implantation of synthetic mesh. The posterior rectus sheath is closed if possible with low tension. If the posterior rectus sheath is not adapted, the mesh is the placed in the preperitoneal space in the midline and on both sides laterally in the retromuscular position (Fig. 51.11).
9. Mesh fixation is only necessary in cases were the hernia defect cannot be closed with low tension (bridging of large hernia defects). The intra-abdominal pressure fixates the mesh between the peritoneum and supporting abdominal wall. We use large pore standard polypropylene or polyvinylidenfluoride meshes, which cover the hernia defect with a radius of 5 cm–25 cm (Figs. 51.4 and 51.12) according to the hernia defect size.
10. The hernia defect is closed anatomically with a running nonabsorbable or long-term absorbable suture.

The MILOS technique is also appropriate for lateral abdominal wall hernias. In the case of large incisional hernias, the surgery is carried out in "less open" technique (skin incision >6–12 cm).

51.3 MILOS Operation of Diastasis Recti

Surgical repair of symptomatic diastasis recti may be indicated, especially in cases where concomitant primary ventral or incisional hernias are present. An epigastric or infraumbilical diastasis recti can be closed with the MILOS technique without extending the incision. While the skin is elevated with a pair of adequate retractors (s.a.), MILOS dissection with light-armed endoscopic instruments is performed under direct vision or endoscopically assisted. In order to prevent an ugly cutaneous rim, the subcutaneous tissue is detached from the linea alba and medial aspect of the anterior rectus sheath (2–4 cm on every side). Diastasis recti is anatomically closed by an anterior inverting nonabsorbable running suture (0). Alternatively, a mini-open or endoscopically assisted posterior inverting suture is possible. If mesh augmentation is indicated, we prefer the insertion in the sublay position. However, onlay mesh repair is also possible (20).

51.4 Results

From January 2010 to February 2017, we carried out 894 MILOS operations for incisional hernias and an approximately equal number of primary abdominal wall hernias. Data on all patients were documented in the "Herniamed" register.

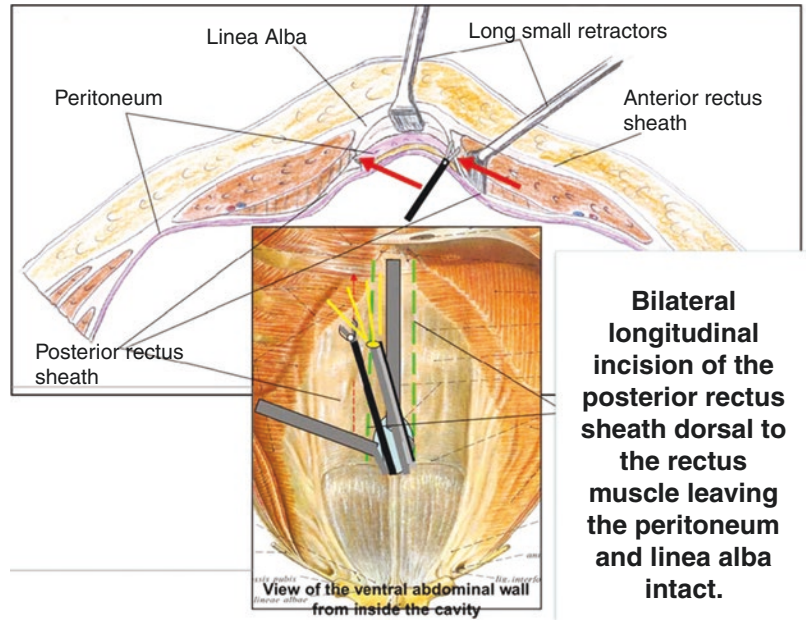

Fig. 51.7 Transhernial bilateral incision of the posterior rectus sheath

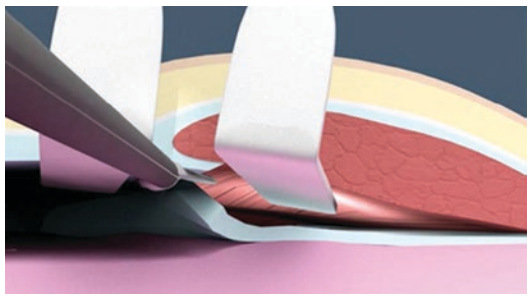

Fig. 51.8 Incision of the posterior rectus sheath 1 cm lateral to the medial border of muscle

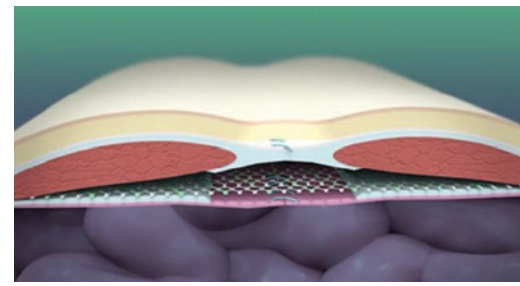

Fig. 51.10 Single port TEP: Incision of the upper left posterior rectus sheath

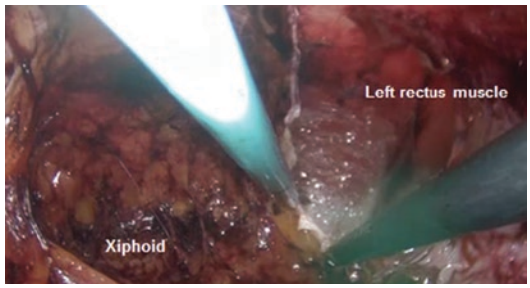

Fig. 51.9 Set of MILOS instruments

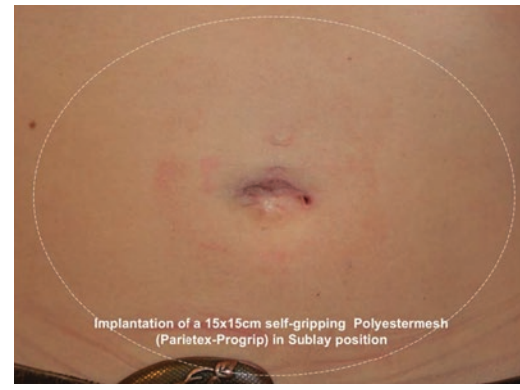

Fig. 51.11 Retromuscular/preperitoneal mesh position; hernia defect is anatomically closed

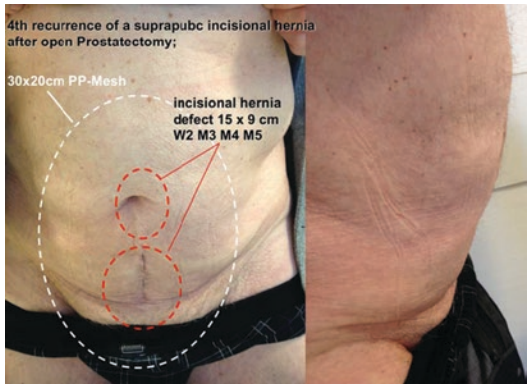

Fig. 51.12 Young woman with 3 cm incisional hernia after umbilical hernia suture repair. MILOS operation with 3 mm instruments, 5 mm endoscope, and 2 cm incision. Implantation of a 15 × 15 cm mesh

The hernia orifices and the size of the mesh are given in Tables 51.1 and 51.2. Postoperative consumption of analgesics was comparably low. The standard postoperative pain medication was Metamizol 4 × 1 g p.o. Additional opioids are necessary in only 10% of the cases. Even in the case of large incisional hernias, a peridural analgesic catheter is dispensable.

In 42 cases of large ventral and incisional hernias, the MILOS technique was combined with posterior or anterior endoscopic component separation (hybrid procedure) in order to achieve a low-tension anatomical closure of the large hernia defect after the insertion of a large extraperitoneal synthetic mesh.

The average operating time of MILOS incisional hernia repair was 102 min, 7 and 20 min longer than open sublay (95 min) and Lap IPOM repair (82 min), respectively. Complication rates after MILOS incisional hernia repair are very low (Tables 51.3 and 51.4). There were two enterotomies of the small bowel without spillage. The bowel lesions were closed with absorbable sutures. MILOS mesh repair was performed without complications. Three superficial wound infections healed without mesh infection. A recent propensity score matching of MILOS, Lap IPOM, and open sublay operations of the German Herniamed Register revealed significantly fewer perioperative complications, reoperations, recurrences, and chronic pain after 1 year in the MILOS cohort [13].

Table 51.1 Size of hernia gap in incisional hernias (MILOS-OP; $n = 865$)

Area (in cm²)	0–5	5–10	10–20	20–50	50–100	100–200	>200
Number	95	64	115	173	133	173	112

Area (in cm²)

Table 51.2 Size of mesh in incisional hernia operations (MILOS-OP; $n = 865$)

Area (in cm²)	0 bis 50	50 bis100	100 bis 200	>200
Number	0	10	91	764

(Area (in cm²)

51.5 Discussion

To further improve abdominal wall hernia surgery and overcome the obvious disadvantages of the currently most widely used open sublay and Lap IPOM repair, we have successfully developed the MILOS technique which is the first technique that allows the minimally invasive sublay repair of all primary and recurrent abdominal wall hernias, with the exception of giant eventrations. But even in extremely large primary and incisional ventral hernias, the principles of MILOS repair help to reduce the surgical trauma to the abdominal wall. Our experience with 865 MILOS incisional hernia operations and about the same number of primary ventral hernia MILOS repairs showed the following advantages of this novel technique:

1. Minimally invasive extraperitoneal implantation of (large) standard synthetic meshes without traumatic mesh fixation.
2. Closure of hernia gaps and anatomical reconstruction of the abdominal wall. Protection of viable abdominal wall structures including nerves.
3. After MILOS operations, there were significantly less perioperative complications, reoperations, general complications, recurrences, and chronic pain after 1 year compared to open sublay and Lap IPOM repair.

Table 51.3 MILOS incisional hernia repair at Gross-Sand Hospital ($n = 865$) vs. all incisional hernias in the Herniamed Register (40.066)

	MILOS incisional hernia operations % ($n = 865$)	All incisional hernia operations in Herniamed register (40.066)
No complications	96.0	80.5
Total number of complications	4.8	19.5
Surgical complications	3.2	9.6
Hemorrhage/postoperative hemorrhage	1.0	1.9
Enterotomy	0.2	0.5
Impaired wound healing	0.3	0.7
Seroma	0.9	4.1
Infection	0.3	1.2
Ileus	0.4	1.2
Revision surgeries	1.9	4.1
General complications	1.6	4.1
Mortality	0.1	0.25

Table 51.4 MILOS incisional hernia operations at Gross-Sand Hospital ($n = 782$) vs. all incisional hernias operations documented in Herniamed Register ($n = 33.335$) with complete 1-year follow-up

	MILOS incisional hernia surgeries ($n = 782$) %	Incisional hernias in Herniamed Register ($n = 33.335$) %
Recurrence after 1 year	1.8	5.8 (6.8 Lap IPOM; 3.9 open sublay)
Pain at rest	3.8	9.4 (9.3 Lap IPOM; 9.5 open sublay)
Chronic stress-induced pain	6.6	18.5 (18.6 Lap IPOM; 17.1 open sublay)
Chronic pain requiring therapy	2.6	7.6 (7.9 Lap IPOM; 6.9 open sublay)

4. The MILOS technique allows minimally invasive repair of rectus diastases.
5. The MILOS repair can be combined with endoscopic anterior and posterior component separation.
6. Very good cosmetic results.
7. In comparison with Lap IPOM operations, there is a saving of around 1.200 € in material costs per operation.

Prospective analysis of MILOS repair in primary ventral hernias with 1 year follow-up revealed also very low complication rates.

Conclusion

The novel MILOS technique allows the minimally invasive endoscopically assisted extraperitoneal repair of primary and incisional eventrations with very low perioperative morbidity, recurrences, and chronic pain after 1 year. The technique has the potential to revolutionize abdominal wall hernia repair if future studies of other working groups can reproduce our very promising results.

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The Spigelian Hernia

52

Alexander H. Petter-Puchner, Simone Gruber-Blum, and Karl S. Glaser

52.1 Introduction

The spigelian hernia is probably the most famous of all "rare" hernias. It was named after Adriaan van den Spiegel, an anatomist from Brussels who first described the semilunar line, but it was Klinkosch more than a century later (1764) who actually referred to this type of hernia for the first time. Josef Thaddäus Klinkosch was an anatomist from Prague, and his opus magnum "Programma Quo Divisionem Herniarum" is fully available at Google Books and a true treasure of medical history.

The spigelian hernia is a defect on the intersection of linea semilunaris and arcuata where the fasciae of the internal oblique and the transverse abdominal muscles form the spigelian aponeurosis. This zone is also termed "spigelian hernia belt" by some authors. It has been suggested that the transgression of vessels creates a "locus minoris resistentiae" leading to the formation of this small but often symptomatic hernia.

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52.2 Epidemiology

The prevalence is approximately 1–2% of all hernias. Spigelian hernias mostly occur on the right side of the abdominal wall. Patients are generally affected between the fourth and seventh decade of life with a proposed slight predilection of the female sex [1].

52.2.1 Symptoms

The leading symptom of a spigelian hernia is the local pain by intercurrent incarceration, increasing with contraction of the abdominal wall muscles. This is noteworthy as, unlike in many other hernias, a swelling or protrusion is not easily detectable. The anatomical reasons are twofold: the hernia sac is small (usually only about 0.5–2 cm in diameter) and does often not protrude through all layers of flat abdominal muscles as depicted in Figs. 52.1, 52.2 and 52.3. In consequence, palpation of the small hernia defect can be difficult even for experienced explorers. In most cases, the hernia sac contains a lipoma, but incarceration of small bowel and even the appendix (the latter more frequent in patients suffering from Crohn's disease) can occur. Other symptoms include nausea and vomiting and all signs of a manifest ileus [2]. A rare finding is an (inflammated) appendix in a spigelian hernia, an ovary and fallopian tube, and, most exotic, a gallbladder volvulus in the spigelian hernia sac [3–5].

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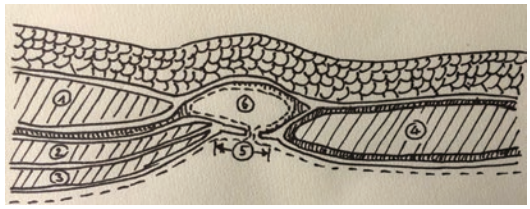


Fig. 52.1 Spigelian hernia sac entering space between rectus and external oblique muscle 1, M. obliquus externus; 2, M. obliquus internus; 3, M. transversus abdominis; 4, M. rectus abdominis; 5, Spigelian hernia belt with locus minoris resistentiae (hernia defect); Hernia sac with its content

Fig. 52.2 Spigelian hernia penetrating the rectus sheath, as well as space between M. rectus and external oblique muscle

Fig. 52.3 "Most user-friendly" variation of spigelian hernia, with hernia fully transgressing spigelian fascia as well as fascia of external oblique muscle

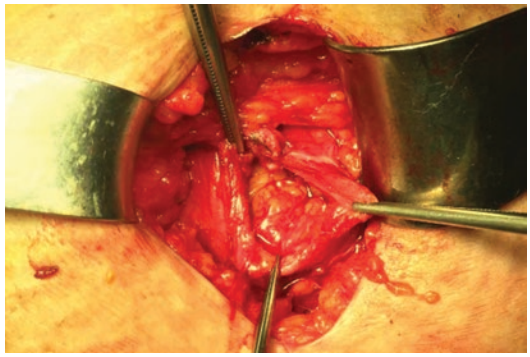
52.3 Imaging

In a chronic setting, usually an ultrasound will be sufficient to confirm the diagnosis. When difficult, the diagnostic should be performed in the standing patient, Valsalva maneuver included. However, because the hernia defect is small and investigators might not be aware of the differential diagnosis of a spigelian hernia when exploring the patient for an appendicitis, or adnexitis, it can be overlooked with this modality. Other differential diagnoses sometimes confounded with the hernia include hematoma of the rectus muscle and diverticulitis. In case of an acute onset of symptoms, e.g., incarceration, or remaining uncertainties, a CT scan should provide the correct diagnosis [6]. In difficult or unclear cases, an MR imaging can be performed additionally.

52.4 Treatment

52.4.1 Conventional, Open Approach

The classical, open approach consists of inverting the hernia sac and primary closure of the hernia defect with nonresorbable, running sutures. The major drawback of this technique is the unavoidable aspect of adding traction to an area which is at an intersection of traction forces per se. This makes the open approach using sutures alone prone to recurrence formation. Furthermore, detection of a spigelian hernia can be tricky even in open technique; often it is required to incise the aponeurotic fascia of the external oblique muscle and trace the hernia sac which usually is embedded between the muscles (see Figs. 52.1, 52.2 and 52.3). In consequence on the subcutaneous level, no trace of a hernia can be present on the exposed abdominal wall. After detection and following the hernia sac to its base, the hernia orifice can be identified. The placement of mesh in open technique improves outcome and patient satisfaction. There are no conclusive data from robust studies whether onlay or sublay techniques should be favored. It can be necessary to widen the fascial defect in order to liberate the hernia sac/lipoma. The placement of a mesh in a sublay position often requires to open the rectus sheath in order to have a sufficient overlap of the mesh over the defect medially (5 cm are required in all directions; see Picture 52.1). The ventral rectus sheath then can be closed in line with the external oblique fascia. In the opinion of the authors, sublay mesh placement should be preferred over onlay techniques.



Picture 52.1 In an obese, 60-year-old lady, a painful swelling in the right lower abdomen was palpable, and a spigelian hernia was suspected clinically. The diagnosis was confirmed in a CT scan. Surgery was performed in open technique (because of a preexistent large laparotomy due to bowel surgery). Although a 6 × 7 × 7 cm large mass of omental fat was incarcerated, it was not before incision of the fascia of external oblique muscle that the hernia sac and its content could be detected during the operation. The preparation included the enlargement of the hernia defect in the spigelian fascia in order to liberate the content of the hernia sac, which was consequently resected, the defect (about 2 cm in diameter) closed with running prolene suture and a mesh (round-shaped 8 cm in diameter) placed in sublay position and fixed with vicryl—a redon drainage (CH 12 was placed in the mesh compartment for 48 h). The aponeurotic fascia of the external oblique muscle was closed with a running Monomax® suture. The patient received a single-shot antibiotic prophylaxis 1.5 h before start of the operation. Operation time was 45 min. Figures 52.1, 52.2 and 52.3 (© with the authors, courtesy of Dr. Gruber-Blum). Figures 52.1, 52.2 and 52.3 illustrate the most common varieties of spigelian hernias, with Figs. 52.1 and 52.2 emphasizing to always explore the area underneath the fascia of the external oblique muscle

52.4.2 Laparoscopic Approaches

Laparoscopy nowadays is considered the standard of care, and this makes especially sense in the spigelian hernia which can be so reluctant to detection [6]. Spigelian hernias can be approached both in TAPP and TEP technique. Similar to inguinal hernia repair, the transabdominal access allows exploration of the abdominal cavity, which might be a real advantage when it comes to identifying other possible causes of pain in the area (adhesions, appendicitis, adnexitis). It is noteworthy that the mesh placement should always be performed preperitoneally and that opening of the peritoneum and dissection will often be mandatory to precisely locate the small hernia defect. At our department we use a trangular trocar position in the left middle abdomen and over the symphysis for right sided and a trocar in the right middle abdomen for left sided spigelian hernias. In the rare case an inguinal and a spigelian hernia is suspected, we use standard TAPP trocar position. There is no satisfying literature on the issue, but it seems logical that mesh fixation then can be achieved with tacks or sealants when a sufficient overlap is provided. The peritoneum should be closed with running suture or cyanoacrylate glue. As demonstrated in inguinal TAPP, fibrin sealant alone is not appropriate for the closure of the peritoneum.

52.4.3 Robotic Repair

If available, robotic spigelian hernia repair is feasible as it offers convincing degrees of freedom in terms of preperitoneal, retromuscular operations.

Acknowledgment *Conflict of Interest*: The authors, Drs. Petter-Puchner, Gruber-Blum, and Glaser report no conflict of interest.

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Flank Hernia

53

Giampiero Campanelli, Piero Giovanni Bruni, Andrea Morlacchi, Francesca Lombardo, and Marta Cavalli

53.1 Introduction

Flank hernia repair is a challenging technique in abdominal wall reconstructive surgery. Due to the low rate of incidence in population, and the consequent lack of data, there is no agreement about the best way to repair this rare hernia problem.

Many surgical techniques are described, open or laparoscopic, with mesh or without mesh; the best plane to put the mesh is even argument of discussion [1, 2]. In any case, the recurrence rate reported is very high.

Flank hernia is more often acquired, due to an increase of the abdominal pressure, or secondary to previous surgery, trauma, or abscess, and is typically described as a "flank bulge" [3].

According to EHS guidelines, the limits of a lateral defect are cranially the costal arch, caudally the iliac bone, medially the lateral edge of ipsilateral rectus muscle, and laterally the lumbar region [4].

In our experience, we understood that all the defects included among L1 and L4 [4] are to be considered as a flank hernia and so treated in the same way (Figs. 53.1, 53.2 and 53.3).

The difficult aspect of repairing a flank hernia is due to the fact that this region is limited by bones that make challenging to create the adequate overlap of the mesh [5]; moreover, in the large majority of the surgical technique reported in literature, the anatomy of the lateral region of the abdominal wall becomes the limit of the

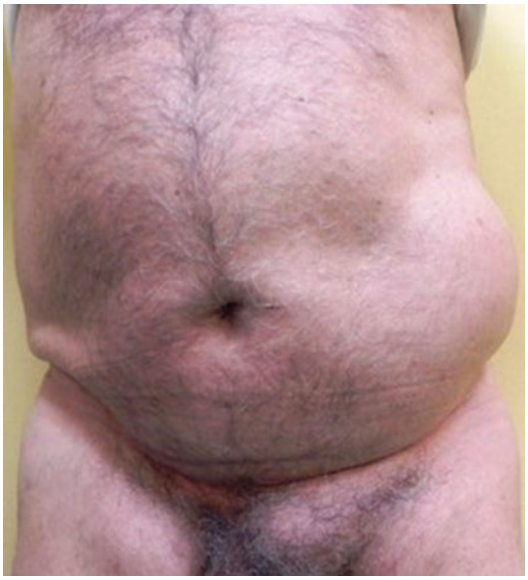

Fig. 53.1 Patient with L3-L4

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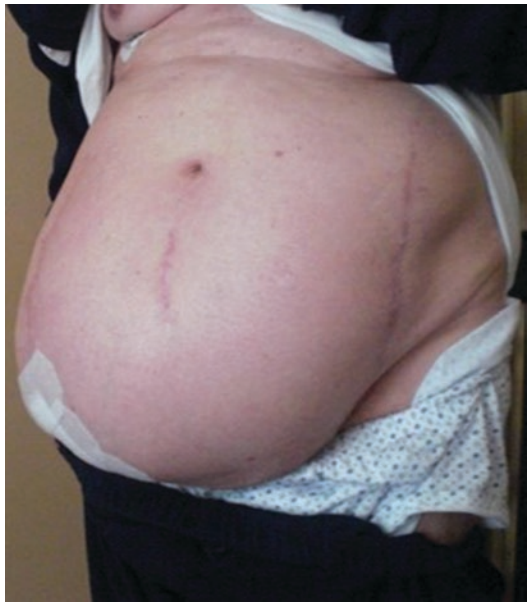

Fig. 53.2 Patient with M4, M5, L3, L4

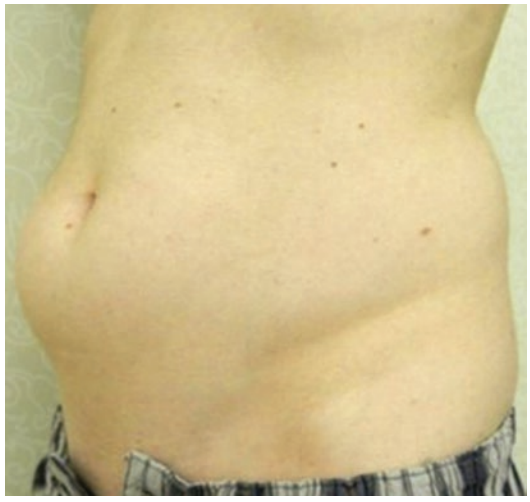

Fig. 53.3 Patient with L3

repair in the meaning that the mesh normally is anchored to these structures. This is one of the major points of failure for this kind of procedures, as the absence of a consistent muscular fascia and nerve structures should be considered also, determining the complete relaxation of the region that cannot be solved only by a limited placement of a small mesh fixed to the edges (costal arch, pubic bone).

53.2 Patient Selection and Evaluation

Because of the high risk of complications described in literature (25% of incarceration ad 8% of strangulation), every patient diagnosed with a flank hernia that is suitable for surgery should be surgically treated [3, 6].

The gold standard for diagnosis is CT scan [7] (Figs. 53.4 and 53.5); this can give many information helpful in planning the operation. It can distinguish real defect from "flank bulge," a situation where the denervation of lateral muscles of the abdomen following a trauma or surgical incision causes a relaxation and atrophy of them; it allows the evaluation of the real dimension of the defect; it gives information about muscular

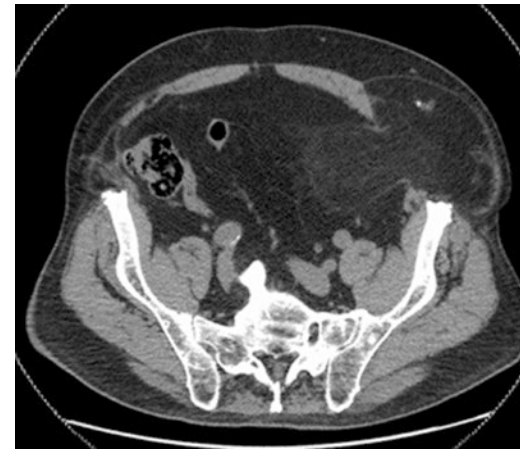

Fig. 53.4 CT scan of patient in Fig. 53.1

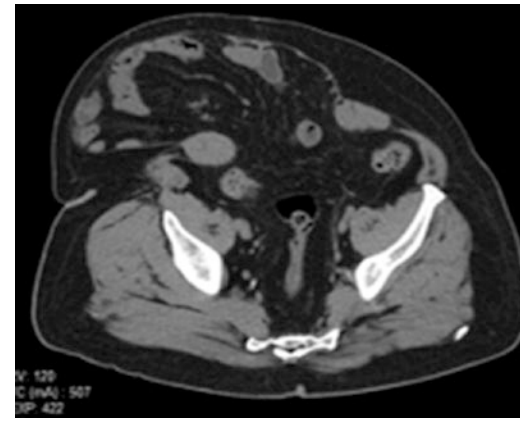

Fig. 53.5 CT scan of patient in Fig. 53.2

planes and about previous surgery when present. Regardless of size and location of the defect, the approach to repair should be the same. Frequently, these patients, at least in our experience, reported a previous repair, failed after short time after the procedure. Typically, this kind of patients has small piece of mesh placed just between the limit of the defect, in a very superficial layer: reason why they had an immediate recurrence.

Preoperative evaluation of the patient consists in blood tests, chest X-ray, ECG, and surgical and anesthesiologic evaluation.

53.3 Surgical Technique

It is always required general anesthesia. The patient lays in lateral decubitus, opposite to the defect. Nasogastric tube and urinary catheter are placed, and antibiotic prophylaxis is administered.

Skin incision usually is a pararectal incision. In case of an incisional hernia after lobotomy, previous transversal incision could be used.

The beginning of the procedure consists in the identification of the defect and the isolation of the hernia sac (Fig. 53.6), if any, that usually arises through the fibers of the internal oblique or transversus abdominis muscle in case of primary defect. The entire procedure could be performed in a totally retromuscular extraperitoneal plane, if the characteristics of the hernia sac allow to do it. If the peritoneum must be opened, lysis of all the adhesions has to be done carefully to avoid bowel injury.

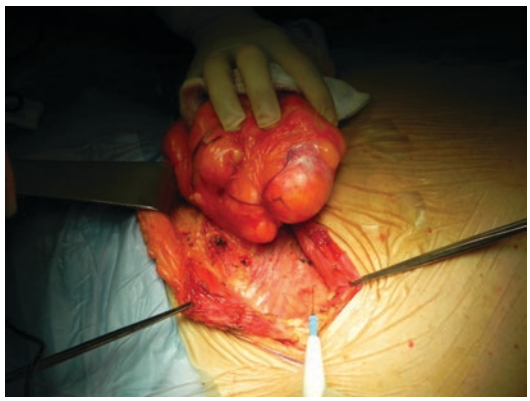

Fig. 53.6 Isolation of hernia sac

Then the external oblique aponeurosis is opened longitudinally at the lateral edge of the rectus muscle and gets the access to the transversus plane.

Following, the procedure could be divided into four steps (Fig. 53.7) to create the adequate pocket to place the mesh: the surgeon must remember to move from one side to the other while dissecting medial, lateral, superior, and inferior space.

First step: the dissection proceeds laterally, from the incision to the medial edge of psoas muscle and quadratus lumborum in the extraperitoneal plane, following a plane underneath the transversus muscle between it and peritoneum until the paravertebral region (Fig. 53.8).

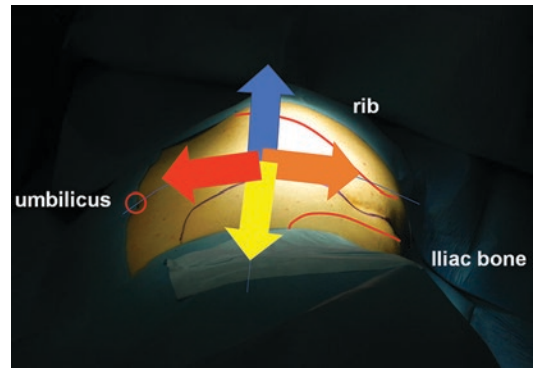

Fig. 53.7 Patient in lateral decubitus. *Arrows* show the four surgical steps. *Orange arrow* lumbar/paravertebral step, *yellow arrow* iliac wing/retropubic step, *red arrow* retrorectus-lina alba-controlateal retrorectus step and *blue arrow* retrocostal/fatty triangle step

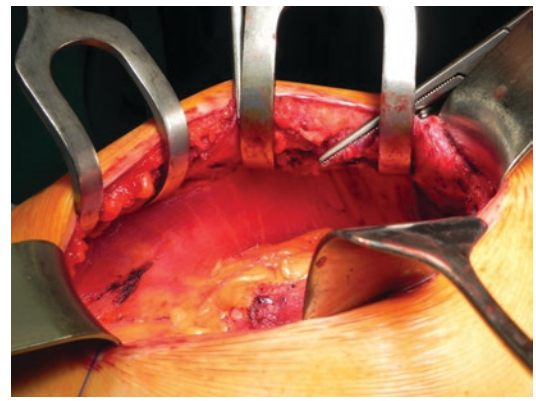

Fig. 53.8 Lateral dissection in a totally preperitoneal plane transversus muscle is well evident

Second step: the dissection proceeds, always in the extraperitoneal place, to the isolation of the entire iliac wing (not only the spine and the crest) and the iliac vessels in the Bogros space (Figs. 53.9 and 53.10). From here, the dissection has to be completed in the Retzius space, isolating the ipsilateral Cooper ligament (Fig. 53.11).

Spermatic cord should be isolated and parietalized during this step of the procedure (Fig. 53.12).

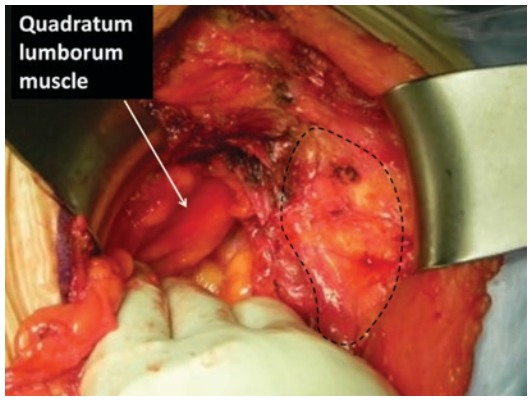

Fig. 53.9 The iliac wing totally exposed

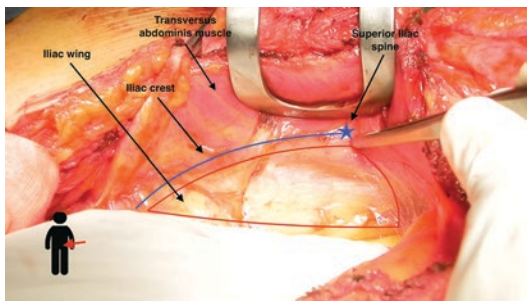

Fig. 53.10 The iliac wing totally exposed

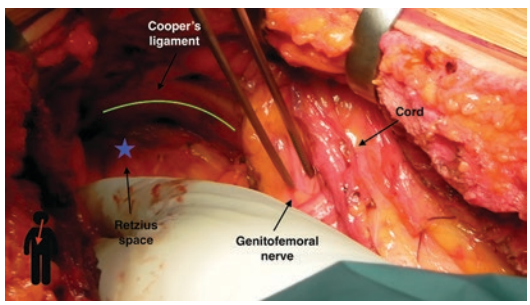

Fig. 53.11 The Retzius space

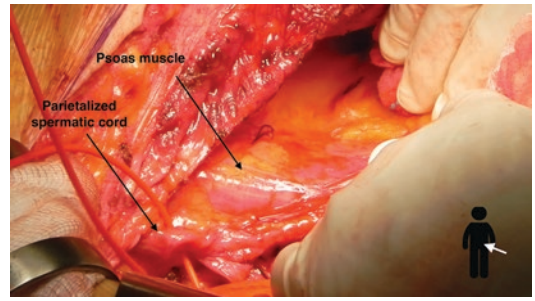

Fig. 53.12 Parietalization of the cord

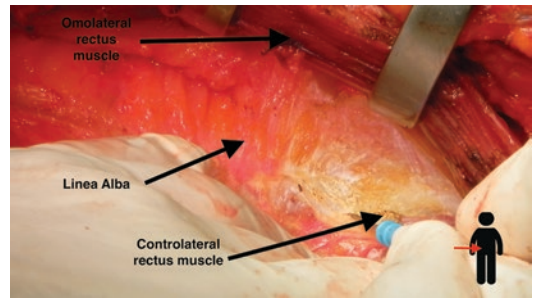

Fig. 53.13 Medial dissection is extended to the contralateral rectus muscle, crossing the linea alba

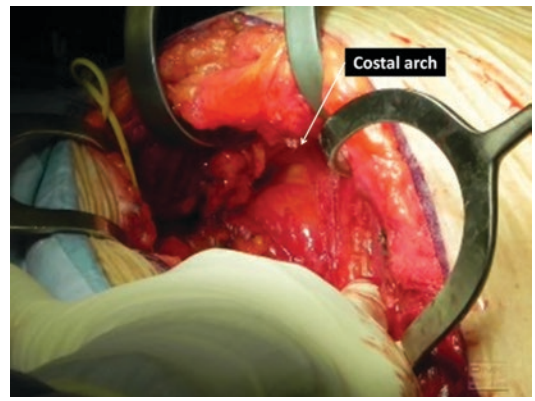

Fig. 53.14 The space beyond the costal arch

Third step: the dissection goes on medially in the retromuscular plane, above the arcuate line, crossing the linea alba in order to reach the contralateral retrorectus space for at least 2 cm (Fig. 53.13).

Forth step: the dissection continues cranially in the retromuscular plane until reaching first the retroxiphoid fatty triangle space and after beyond the retro costal arch space for at least 5 cm (Fig. 53.14).

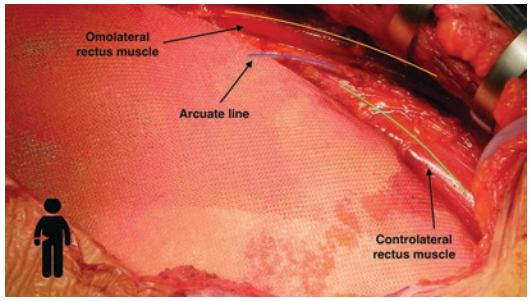

Fig. 53.15 The mesh in place

At the end of the dissection, a big pocket extended from behind the costal arch to retropubic space cranio-caudally and latero-laterally from paravertebral region to contralateral retrorectus space in a retromuscular-preperitoneal plane is created.

Then the closure of the peritoneum, if opened, and the posterior rectus sheath is obtained with an absorbable running suture. If the two edges do not approach, an absorbable or biological mesh should be used to fill the gap and reduce the tension.

A big middle-heavyweight polypropylene mesh, 30 × 30 cm at least, is placed to recreate all the lateral wall, not only to cover or bridge the defect (Fig. 53.15). Dimension of the mesh does not depend from the defect's size; it has to reinforce the entire mediolateral portion of the abdominal wall. It should be folded back like "sheets behind the mattress" in the bed, covering from psoas muscle to contralateral retrorectus plane, from the iliac wing to the inguinal-crural region and to the retro costal arch space.

If this wide dissection is properly realized and the entire mesh is easily placed although the big dimension, this could be even not sutured except with two absorbable stitches on Cooper's ligament and on xiphoid. Fibrin glue could be useful on the surface of the mesh. An adequate mesh in an adequate pocket is maintained in its position by the abdominal pressure itself.

A drain close to the mesh and the closure of the pararectal incision, juxtaposing the lateral edge of the rectus muscle to the transversus plane, completes the procedure.

Figures 53.16 and 53.17 show patient and CT scan in long-distance follow-up.

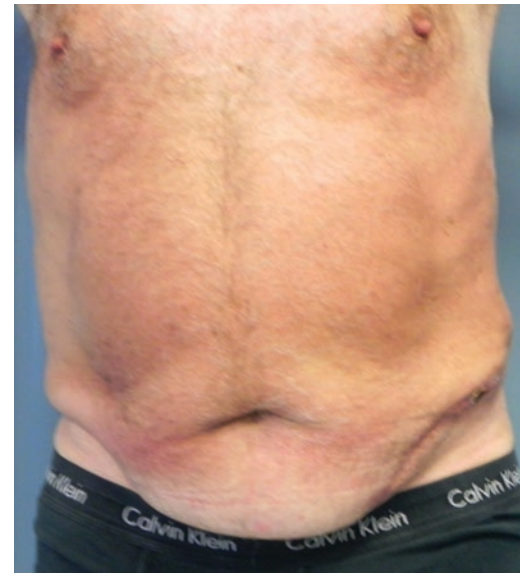

Fig. 53.16 Long-distance follow-up of patient of Fig. 53.1

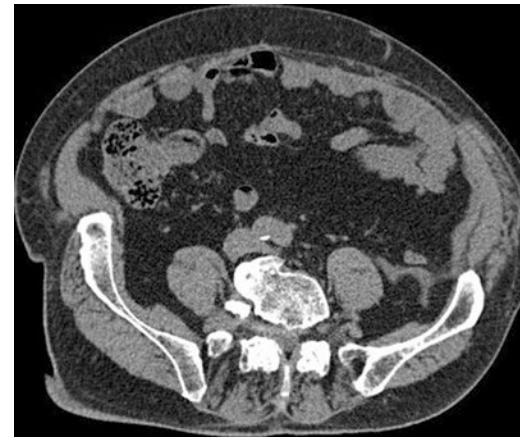

Fig. 53.17 CT scan of patient in Fig. 53.16

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Diastasis Recti and the Floppy Abdomen

54

Maurice Y. Nahabedian

54.1 Introduction

Diastasis recti is a benign condition affecting the anterior abdominal wall that is characterized as a widening or separation of the rectus abdominis muscles due to attenuation of the linea alba. In some cases the attenuation of the supportive layers of the anterior abdominal wall may extend to the linea semilunares and result in a central and lateral laxity of the anterior abdominal wall. True diastasis recti is differentiated form a true hernia in that there is no fascial defect with a diastasis, whereas with a hernia, a fascial defect is present. This chapter will outline and review the salient features of diastasis recti as well as a step-by-step approach to its correction.

54.2 Anatomy

The anterior abdominal wall is composed of various layers that include the skin subcutaneous fat, anterior rectus sheath, abdominal muscles, and the posterior rectus sheath (Fig. 54.1). The muscular component of the abdominal wall includes the rectus abdominis as well as the external oblique, internal oblique, and transverse oblique muscles (Fig. 54.2). Each of these muscle is invested by an aponeurotic layer that coalesces to form the anterior and posterior rectus sheath as well as the linea alba and the linea semilunares. The linea alba is the midline convergence of the anterior and posterior rectus sheath and is primarily involved with the formation of a diastasis.

The anterior rectus sheath and the linea alba are composed of collagen fibers arranged in an interwoven lattice. The width and thickness of these structures will vary along the surface and regions of the anterior abdominal wall [1]. The width of the linea alba ranges from 11 to 21 mm between the xyphoid process and the umbilicus and decreases from 11 to 2 mm from the umbilicus to the pubic symphysis. The thickness of the linea alba ranges from 900 to 1200 μm between the xyphoid and the umbilicus and increases from 1700 to 2400 μm from the umbilicus to the pubic symphysis. The thickness of the anterior rectus sheath ranges from 370 to 500 μm from the xyphoid to the umbilicus and increases from 500 to 700 μm from the umbilicus to the pubic symphysis. The posterior rectus sheath is slightly thicker than the anterior rectus sheath above the umbilicus from 450 to 600 μm but is thinner from the umbilicus to the arcuate line from 250 to 100 μm.

The vascularity of the anterior rectus sheath and linea alba is derived from the perforating branches of the deep and superior inferior epigastric vessels as well as the superficial epigastric vessels. The loose areolar fascia over the surface of the anterior sheath and linea alba is highly vascularized and important to preserve (Fig. 54.3).

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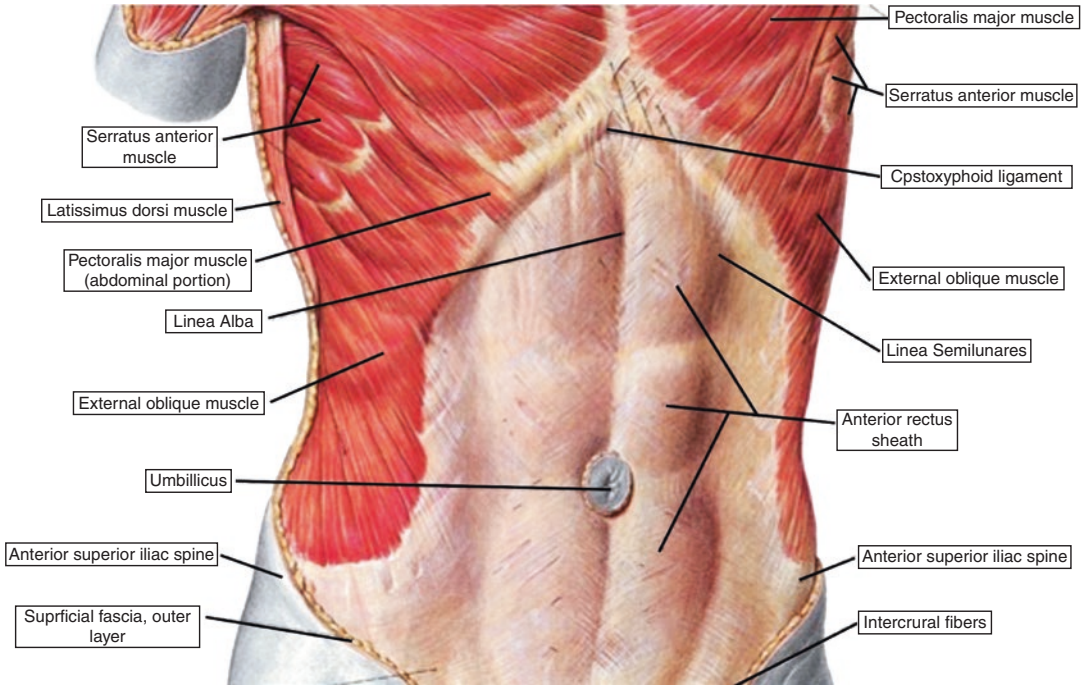

Fig. 54.1 The superficial anatomy of the anterior abdominal wall including the anterior rectus sheath and midline linea alba is depicted

54.3 Etiology

Diastasis recti is often the result of increased intraabdominal pressure and usually associated with pregnancy. Other factors such as obesity and prior abdominal operations can also cause diastasis recti [2]. In cases of severe diastasis recti, the myofascial laxity is both vertical and horizontal and can involve the entire anterior abdominal wall [3]. In a study of 92 patients following abdominoplasty with documented diastasis recti, the inter-rectus distance was measured and analyzed. Findings demonstrated that the distance of rectus abdominis separation was <1 in. in 7% of patients, between 1 and 2 in. 83%, and exceeded 2 in. in 10% [3]. Comparisons between nulliparous women and postpartum women have demonstrated a doubling of the inter-rectus distance from approximately 0.5–1.0 cm to 1.2–2.3 cm using ultrasound-assisted measurements [2]. Postpartum patients demonstrated a gradual decrease in the distance over time; however, baseline values were never achieved at 6-month assessments. Postpartum patients had a reduction in abdominal strength at 6 months that was rated as 4/5, whereas nulliparous women had 5/5 strength of the trunk flexors and rotators.

54.4 Diagnosis

Diastasis recti presents as a midline bulge without a fascial defect that can occur above or below the umbilicus. It is amplified by having the patient lie flat and perform a straight leg raise (Fig. 54.4). In cases of severe diastasis, there may be diffuse abdominal laxity due to attenuation of the linea alba as well as the linea semilunares. In all cases there is no true fascial defect but rather attenuation. Confirmation of rectus diastasis can be made using CT, MRI, or ultrasound, but these tests are usually not necessary.

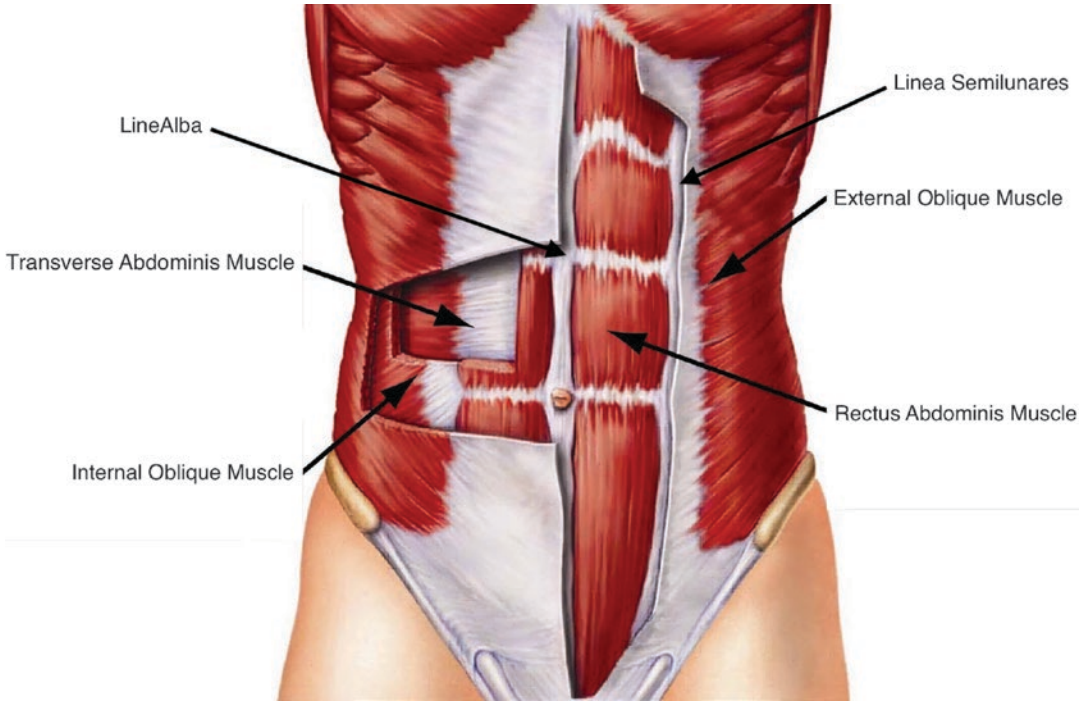

Fig. 54.2 The deeper anatomy of the anterior abdominal wall including the rectus abdominis and transverse abdominis muscles as well as the internal and external oblique muscles is depicted. The line alba and semilunares are also shown

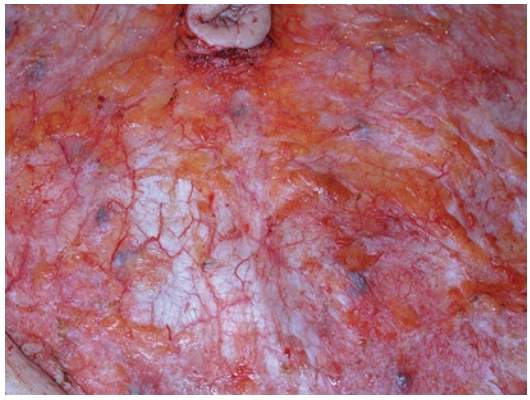

Fig. 54.3 The vascularized loose areolar layer over the anterior rectus sheath is depicted

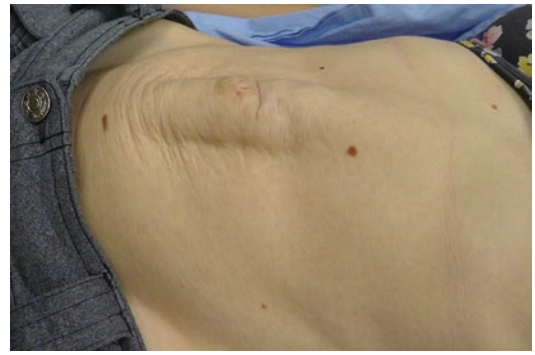

Fig. 54.4 The midline bulge characteristic of diastasis recti is depicted

54.5 Classification

There are three classification systems that have been described for diastasis recti. The Nahas classification is based on the myofascial deformity and the etiology [4] (Table 54.1). The Rath classification is based on the level of the attenuation relative to the umbilicus and the patient age [5] (Table 54.2). The Beer classification is based on the normal width of the linea alba as determined from 150 nulliparous women [6] (Table 54.3).

54.6 Indications for Surgery

The indications for diastasis repair are based on symptoms and physical findings. Most patients will not experience any discomfort from a diasta-

Table 54.1 The Nahas classification based on the myofascial deformity

Nahas classification		
Deformity	Etiology	Correction
Type A	Pregnancy	Anterior sheath plication
Type B	Myoaponeurotic laxity	External oblique plication
Type C	Congenital	Rectus abdominis advancement
Type D	Obesity	Anterior sheath plication and rectus abdominis advancement

Table 54.2 The Rath classification based on the level of the attenuation relative to the umbilicus and the patient age

Rath classification		
Level	Age < 45 (mm)	Age > 45 (mm)
Above umbilicus	10	15
At umbilicus	27	27
Below umbilicus	9	14

Table 54.3 The Beer classification based on the normal width of the linea alba

Beer classification	
Normal width of the linea alba (mm)	
Level	Width
at Xiphoid	15
3 cm above umbillicus	22
2 cm below umbillicus	16

sis unless the defect becomes large or it is associated with an umbilical hernia. The pathophysiology of diastasis recti sometimes results in an attenuation of the fascia near the umbilicus resulting in the appearance of an umbilical hernia. Correction of the umbilical hernia alone without correction of the diastasis is often associated with recurrence due to the poor quality of surrounding tissue and because it is not a true hernia. In most cases of diastasis recti, the midline bulge is exacerbated with muscle contraction and, when large, will often have the appearance of a true abdominal hernia, albeit without any associated fascial defect. It is at this degree that many patients will consider surgical correction.

54.7 Treatment

The majority of patients with diastasis recti will not require treatment other than conservative. For those patients that become symptomatic or desire elective correction, there are several options ranging from exercise to simple plication of the linea alba and anterior rectus sheath to more advanced excisional techniques with or without the use of a surgical mesh. Endoscopic and laparoscopic techniques can also be used in select situations where a small midline hernia is present as well. In many cases of diastasis, especially following pregnancy, an abdominoplasty is also considered to excise the redundant abdominal skin and fat.

54.8 Exercise and Support Garments

The benefit of exercise to prevent or correct diastasis recti is associated with mixed results [7, 8]. Corrective exercise protocols include core strengthening, aerobic activity, and neuromuscular reeducation. The presumed benefits of core strengthening are based on the premise that stimulation of the oblique and transversus abdominis muscles will facilitate the midline movement of the paired rectus abdominis muscles, improve the quality of the anterior rectus sheath and linea alba, and increase fascial tension [8]. Compression garments are presumed to provide support to the abdominal musculature and mimic tension that is provided by the anterior rectus sheath and linea alba [7]. This may serve as a biofeedback mechanism to assist with musculoaponeurotic activation. Although mild to moderate benefit has been reported based on a reduction of the inter-rectus distance, there is insufficient evidence to recommend exercise as a means of preventing or treating rectus diastasis.

54.9 Abdominoplasty

In many women with postpartum diastasis recti, the overlying adipocutaneous component of the anterior abdominal wall has also become stretched

and flaccid, hence the term "floppy abdomen." An abdominoplasty in conjunction with a diastasis repair is typically performed to further improve the abdominal contour [9–11]. The techniques for abdominoplasty are varied and can include a low transverse excision, vertical excision, or a fleur-de-lis pattern incorporating a vertical and horizontal skin excision pattern.

54.9.1 Step by Step

1. The patient is marked preoperatively in the standing position. The anterior superior iliac spine is delineated, and the proposed upper and lower abdominal incision sites are marked.
2. The low transverse incision is created and extends to the anterior rectus sheath. The adipocutaneous tissues are elevated off of the anterior rectus sheath to the level of the umbilicus.
3. The umbilicus is incised and preserved on its stalk.
4. The dissection plane is extended to the costal margin.
5. The diastasis is repaired (see below).
6. Following diastasis repair, the patient is flexed at the waist approximately 30°. The excess skin and fat to be excised is measured to ensure adequate closure and split along the midline. The excess tissue is excised.
7. The skin and fat are closed in a layered fashion. A drain may be considered.

54.10 Plication of the Linea Alba and Linea Semilunares

For mild to moderate diastasis recti, midline plication of the linea alba can be considered [12, 13]. With this technique, the attenuated linea alba is delineated and plicated using absorbable or nonabsorbable sutures. A two-layer repair technique is usually performed using an absorbable interrupted suture followed by a running continuous suture for further reinforcement. The length of this repair can extend from approximately 2 cm below the costal margin to approximately 2 cm above the pubic bone. Studies evaluating absorbable and nonabsorbable sutures have demonstrated no significant difference in the interrectus distance as measured by CT scan 6 months following correction [13].

54.10.1 Step by Step

1. The midline separation of the paired rectus abdominis muscles is measured and delineated.
2. The decision to retain or excise the attenuated linea alba is based on the quality of the tissue. When highly attenuated, thin, and fragile, it can be excised.
3. The plication is usually in two layers and includes a triangular suture technique that incorporates the lateral edges of the fascia and the midline of the posterior rectus sheath.
4. In patients with significant laxity of the anterior rectus sheath, lateral plication near the linea semilunares can also be performed on both sides to further improve and tighten the abdominal contour.
5. When the linea alba is severely attenuated, it can be excised with reapproximation of the thicker edges of the anterior rectus sheath.
6. A two-layer repair technique is usually performed using an absorbable interrupted suture followed by a running continuous suture for further reinforcement.
7. The length of this repair can extend from approximately 2 cm below the costal margin to approximately 2 cm above the pubic bone.

54.11 Fascial Plication and Onlay Mesh

The use of a surgical mesh can be considered in cases of extensive fascial laxity to further reinforce the anterior rectus sheath [9]. This is usually considered in patients with attenuation of the linea alba as well as the linea semilunares. A biologic, resorbable, or synthetic mesh can be used and is positioned over the anterior rectus sheath

following the plication. Considerations for a synthetic mesh include healthy patients' low risk for adverse outcomes and lower cost. Figures 54.5, 54.6, 54.7, 54.8, 54.9, 54.10, 54.11, 54.12, 54.13, 54.14, 54.15, and 54.16 illustrate a patient with severe diastasis recti having abdominoplasty, plication of the linea alba, and onlay mesh placement.

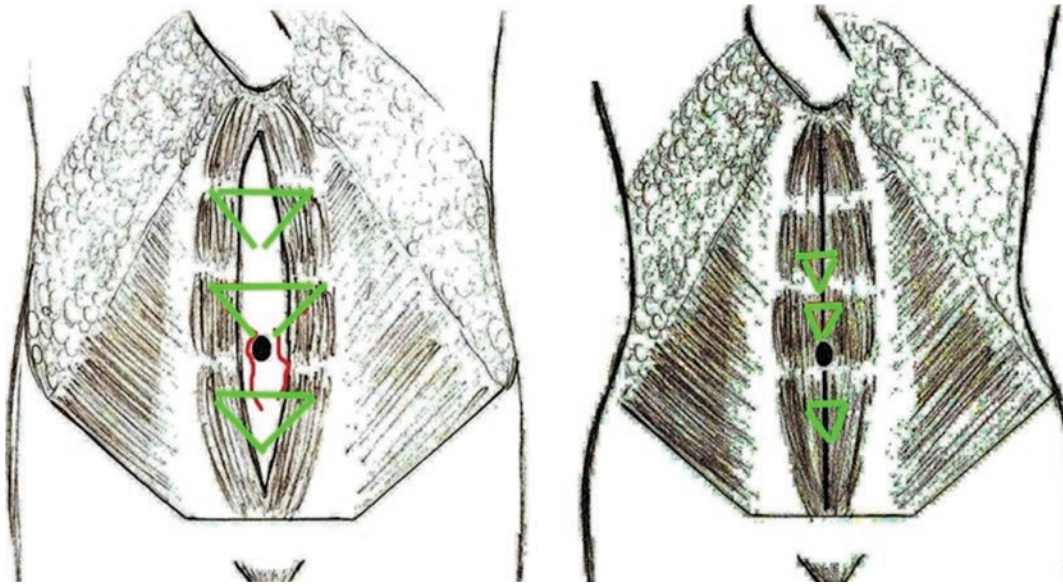

Fig. 54.5 The triangular suture technique for midline plication of the diastasis recti is depicted

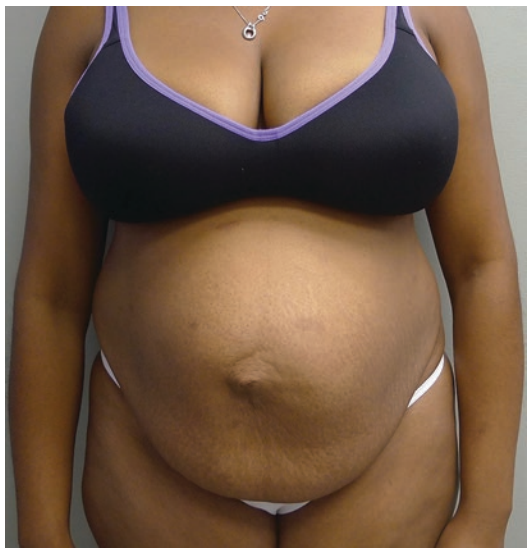

Fig. 54.6 Preoperative image of a postpartum patient with severe diastasis recti involving the linea alba and linea semilunares

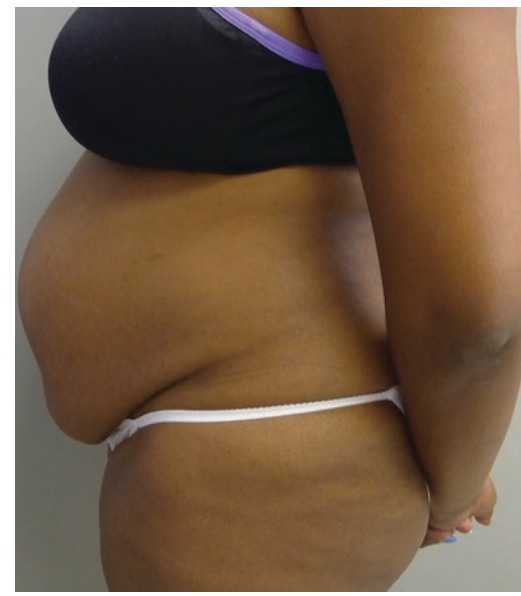

Fig. 54.7 Lateral view demonstrating the severity of the anterior bulge

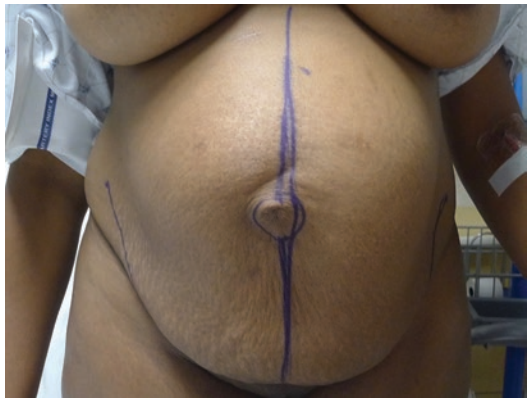

Fig. 54.8 Preoperative markings. The approach will be through a low transverse abdominoplasty incision

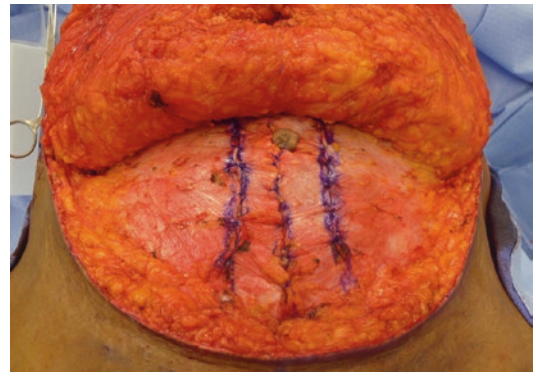

Fig. 54.11 Two-layer plication sutures of the linea alba and the region of the linea semilunares are completed

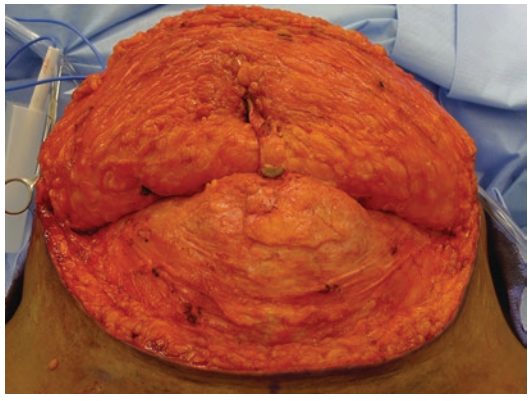

Fig. 54.9 The central bulge involving the linea alba, linea semilunares, and anterior rectus sheath is depicted

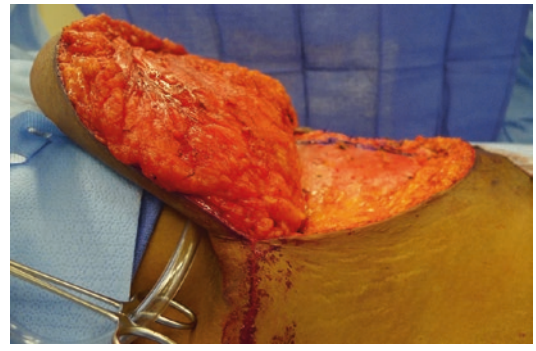

Fig. 54.12 Lateral view following plication demonstrating flattening of the midline bulge

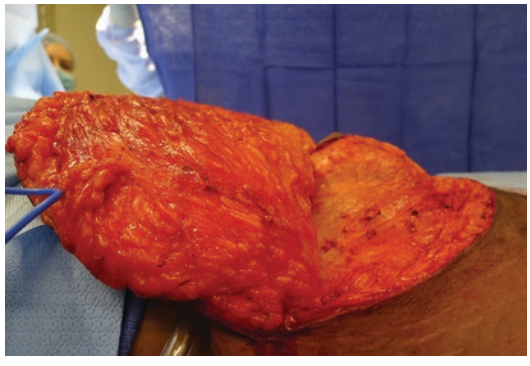

Fig. 54.10 Lateral view of the central bulge is depicted

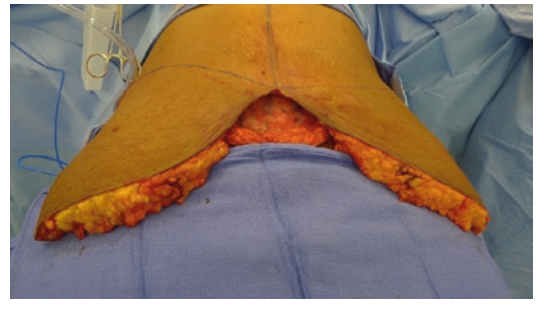

Fig. 54.13 The initial stage of the abdominoplasty demonstrating the degree of skin excess

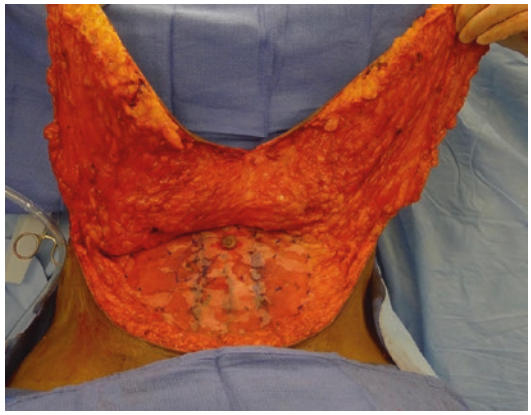

Fig. 54.14 The abdominoplasty flaps are elevated demonstrating the onlay mesh over the anterior rectus sheath

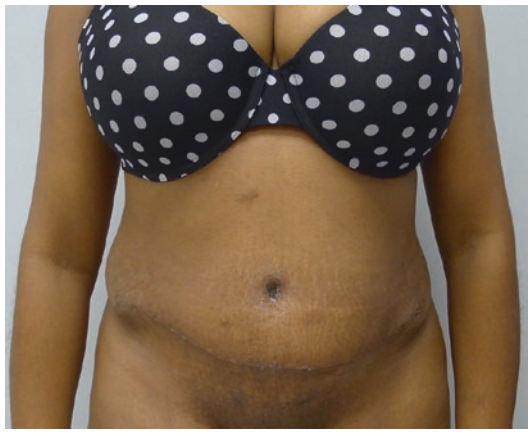

Fig. 54.15 Postoperative view demonstrating improved contour following abdominoplasty, fascial plication, and onlay mesh placement

54.11.1 Step by Step

1. The surgical mesh is obtained and trimmed to fit the dimensions of the anterior abdominal wall and extends from the costal margin superiorly to the pubic region inferiorly and to the anterior axillary line bilaterally.
2. The edge and the central portion of the mesh are sutured to the anterior rectus sheath with absorbable interrupted sutures. The quilting sutures prevent bowstringing of the mesh during flexion.
3. Abdominoplasty is performed as indicated.
4. A single closed suction drain is used.
5. The skin is closed.

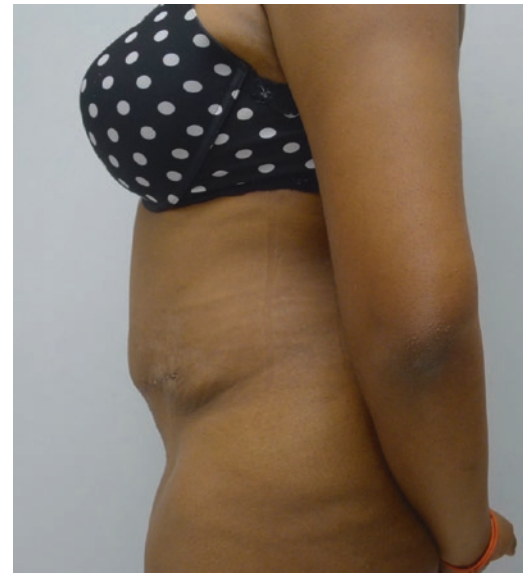

Fig. 54.16 Postoperative lateral view demonstrating marked improvement in contour

54.12 Retro-Rectus Repair with Sublay Mesh

In cases of moderate to severe diastasis recti, a retro-rectus repair can be considered [14, 15]. With this technique, an abdominoplasty is almost always recommended and can be performed via a low transverse excisional pattern a vertical paramedian incision extending from the xiphoid to the pubic bone. The benefit of this approach is that the mesh is placed between two well-vascularized layers and confers high protection against recurrence. The disadvantage is that it is a more extensive procedure that may be associated with a longer recovery.

54.12.1 Step by Step

1. Following elevation of the adipocutaneous layer, the medial aspect of the rectus abdominis muscle is identified, and the retro-rectus space is entered. The rectus abdominis muscle and posterior rectus sheath are separated. The retro-rectus dissection continues to the lateral edge of the rectus abdominis muscle.

2. The vascularity and laterally based innervation of the rectus abdominis muscle is preserved.
3. The degree of redundancy of the posterior rectus sheath is approximated and then plicated along its midline using a resorbable suture in an interrupted manner.
4. The posterior rectus sheath repair is reinforced using a resorbable or non-resorbable mesh that is placed on the surface of the posterior rectus sheath in the retro-rectus space.
5. Interrupted suture fixation of the mesh is completed with interrupted absorbable sutures.
6. The umbilical stalk is passed through an opening created in the mesh.
7. Following the posterior repair, the rectus abdominis muscles are reapproximated along the midline.
8. The anterior rectus sheath is repaired using interrupted absorbable sutures.

54.13 Endoscopic/Laparoscopic

Endoscopic repair of diastasis recti can be considered in patients with diastasis and a midline/umbilical hernia measuring <2 cm, no prior hernia repair or laparotomy, and no need for abdominoplasty [16]. The laparoscopic placement of an intraperitoneal mesh is an alternative to onlay mesh placement [17]. Laparoscopic reinforcement can be considered in patients that have had plication of the attenuated linea alba and anterior rectus sheath.

54.13.1 Step by Step

1. Place a trocar into the supra-aponeurotic space and create a dissection plane under direct vision exposing the linea alba and the anterior rectus sheath.
2. The endoscopic repair includes sheath plication and reinforcement with a synthetic mesh.
3. A nonabsorbable barbed suture can be used.
4. A drain is placed and a soft compression garment is applied.

54.14 Outcomes

Outcomes following sheath plication for diastasis recti have been mixed. In a review of 20 women following vertical sheath plication using an absorbable suture, a 100% recurrence was demonstrated after 1 year [18]. Reasons included a repair that was localized to the defect only, a repair that addressed only the horizontal component of the diastasis, and fraying of the anterior rectus sheath due to the cutting effect of suture placement. In a similar study utilizing a two-layer plication repair with nonabsorbable sutures, positive outcomes were achieved in the majority of patients [13]. Efficacy of the repair was evaluated by postoperative CT scans in 12 women at 3 weeks, 6 months, and again at a mean of 81 months postoperatively demonstrating no recurrence in any patient at all levels studied. In a comparative abdominoplasty study between parous women with a diastasis and nulliparous without a diastasis that had fascial plication with an interlocking continuous absorbable suture, the mean inter-rectus distance was essentially equal at all levels studied between the two cohorts [19]. Postoperative assessment was performed via physical examination and ultrasound in all women at 12–41 months following the repair. In a comparative study between absorbable sutures and nonabsorbable sutures, CT scans obtained at 3 weeks and 6 months demonstrated no significant difference. In a cadaveric study that compared horizontal and vertical suture placement, a significant increase in rupture strength was noted for vertically placed sutures based on dynamometric testing [20].

Outcomes following the retro-rectus repair have been demonstrated to be effective. In a review of 52 women following abdominoplasty and diastasis repair with the retro-rectus approach using vicryl mesh, 100% of patients reported high satisfaction with improvement of the abdominal contour [14]. It was postulated that posterior plication alone may not be sufficient in all cases. The use of a resorbable mesh was preferred because it effectively relieved fascial tension, was resorbed by 6 weeks, was placed in an

extraperitoneal position, and did not increase the incidence of complications. In a review of 32 patients with severe diastasis recti treated with vertical abdominoplasty and retro-rectus support using a midweight macroporous polypropylene mesh, no recurrent bulge or hernia was demonstrated at a mean follow-up of 1.5 years [15]. Differences in psychological outcomes in patients following diastasis repairs with anterior sheath plication or retro-rectus mesh placement have not demonstrated any significant difference with improvement in both cohorts [21]. Subjective improvement in muscle strength was improved more in the retro-rectus cohort compared to the suture cohort (6.9 vs. 4.5, Likert scale, 0–10, $p = 0.01$).

54.15 Complications

Complications following rectus diastasis repair are infrequent and include infection, mesh extrusion, recurrence, nerve injury, seroma, complex scar, skin necrosis, contour abnormality, and visceral injury. Patients using tobacco products are at increased risk of delayed healing and tissue necrosis [14].

In a randomized controlled trial comparing outcomes and complications in women with rectus diastasis managed with layered closure of the anterior rectus sheath or retro-rectus placement of synthetic mesh, superficial wound infection occurred in 24.5% of patients of which 8.8% were in the suture repair cohort and 15.8% were in the retro-rectus mesh cohort [21]. Postoperative pain was assessed using a visual analog scale demonstrating an improved reduction in pain in the retro-rectus cohort (6.9/10) compared to the sheath plication cohort (4.8/10).

In a single study evaluating the endoscopic technique, the most frequent adverse event was a seroma (23%) with no hernia or diastasis recurrences at 20-month follow-up [16]. The mean inter-rectus distance was significantly improved 1 month following the procedure with preoperative measurements ranging from 24 to 39 mm and postoperative measurements ranging from 2.1 to 2.8 mm. One- and 2-year follow-up did not change from the 1 month measurements (2.5–3.7 mm). Patient satisfaction was assessed on a visual analog scale and graded with a mean score of 8.7/10.

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55 Results and Complications of Laparoscopic Ventral and Incisional Hernia Repair

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For purposes of convenience, postoperative outcomes after laparoscopic ventral incisional hernia repair (LVIHR) have been classified as:

1. **Early postoperative outcomes:**
   - Iatrogenic enterotomy (IE)
   - Early postoperative pain
   - Seroma
2. **Late postoperative outcomes:**
   - Recurrence
   - Chronic pain
   - Mesh infection
   - Small bowel obstruction
   - Trocar site hernia
   - Quality of life (QOL)

55.1 Early Postoperative Outcomes

55.1.1 Iatrogenic Enterotomy (IE)

Iatrogenic enterotomy (IE) is the inadvertent transmural penetration of any part of the bowel during laparoscopic ventral hernia repair. It has an incidence of 0–14% [1]. In previously reported study, Leblanc et al. reported incidence of 1.7%, and Sharma et al. reported incidence of 1.4% [2].

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IE can occur at any stage of LVIHR. IE may occur during initial intraperitoneal access, trocar entry, bowel handling, and during adhesiolysis. IE may occur from mechanical injury during adhesiolysis or from the use of high-energy source for the same. A study reported incidence of 33/2346 iatrogenic enterotomies. The mechanism of injury was sharp dissection in 16 patients, bowel handling/blunt dissection in 11 patients, and monopolar cautery and trocar access injury in 4 patients. In another four patients, access injury due to Veress needle and harmonic scalpel contributed to the cause of iatrogenic enterotomies [2].

An IE from the use of high-energy source (electrocautery, harmonic scalpel) typically presents 48–72 h after surgery. IE commonly occurs in the setting of dense bowel adhesions, in patients with recurrent hernia and multiple previous laparotomies. A poor vision and improper surgical exposure are common predisposing factors for an IE. Sharma et al. [2] reported that IE was recognized intraoperatively in 28 out of 33 patients, and Leblanc reported an intraoperative recognition rate of 82%. Peritoneal spillage of intestinal contents after IE is uncommon, and identification of bowel mucosa appears to be the key determinant in identifying IE.

After IE, the setting of surgical procedure is converted from "clean to clean contaminated." There is a controversy over the placement of prosthetic/biological mesh to complete the hernia repair after IE for fear of mesh contamination and subsequent mesh infection. It has been suggested

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that removal of synthetic mesh is required in 50–90% of cases when it is placed in contaminated field [3, 4]. In a study, 56% of surgeons preferred delaying placement of mesh with median interval of 4 weeks (3 days–6 months). However, 3% of respondents preferred placement of mesh irrespective of spillage during enterotomy [5].

If an enterotomy is recognized, but there is no spillage or contamination, prosthetic mesh may be placed after closing the enterotomy. It is advisable to defer the placement of prosthetic mesh in case of significant contamination [1]. The recent trends of placement of mesh in contaminated field are supportive due to availability of newer-generation meshes which are monofilamentous, lightweight (<40 g/m^2), and macroporous in nature [6, 7]. The studies regarding failure of mesh in infected fields were performed using microporous and heavyweight meshes. Thus, newer meshes have improved surgical outcomes.

The mortality rate of LVIHR was reported to be 0.05% [1]. However, if an enterotomy occurred, it increased to 2.8%. A recognized enterotomy was associated with mortality rate of 1.7%, but an unrecognized enterotomy had a rate of 7.7% [1]. In a study conducted on 2346 patients by Sharma et al. [2], reported mortality rate of 40% in five patients with IE recognized postoperatively. The most common complication was wound infection (nine patients). The other surgical complications observed were prolonged postoperative ileus (eight patients), hernia recurrence (eight patients), mesh infection (six patients), and fistula formation (two patients).

IE is one of the most serious complications during LVIHR. It is associated with high mortality, when the enterotomy is not recognized intraoperatively. The surgeon should have a high degree of suspicion for an IE, especially during adhesiolysis. When it occurs, it may be associated with suboptimal surgical outcomes.

55.1.2 Early Postoperative Pain

LVIHR may lead to acute postoperative pain and discomfort that may appear disproportionate for a laparoscopic procedure. There are several reasons for acute postoperative pain. The use of mesh on the sensitive peritoneal layer, transabdominal sutures and tacks used for fixation, the creation of raw areas on sensitive peritoneum from extensive adhesiolysis, and the presence of blood within peritoneal cavity may cause acute pain after LVIHR. Also, transabdominal sutures penetrate through the full thickness of abdominal wall musculature and fascia contributing to acute postoperative pain due to local muscle ischemia [8].

55.1.3 Seroma

Seroma may be defined as a serous fluid retention within hernia sac between subcutaneous tissue and prosthetic mesh. There are wide variations in reporting the incidence of seroma after LVIHR. The real incidence of seroma is difficult to determine since these have not been properly documented and analyzed in literature. Different studies have reported a wide variation in the rate of seroma formation from 0.5 to 7.8% [9, 10].

Traditionally, seromas have been reported in literature as "significant seroma," "prolonged seroma," and "symptomatic seroma." These terms have been used to report seromas based on clinical evaluation. There have been reports that have documented seroma based on radiological evaluation. Morales-Conde [11] has reported 95.2% incidence of radiological seroma, and Susmallian et al. [12] reported 100% incidence, respectively.

The occurrence of postoperative seroma has been described as sequelae, a complication or an incident [13, 14]. A large majority of seromas are asymptomatic and resolve spontaneously within 6–8 weeks [15]. Most surgeons advocate a conservative approach to treat seromas. However, the rate of seroma aspiration varies from one author to another from 0 to 33.3% [16, 17].

The potential complications related to seroma formation include pain, infection, and recurrence of hernia. Large seromas may cause pain and discomfort due to increased tension of the fluid contained within. Infection of seroma is one of the more important complications since it may lead to mesh removal and recurrence of hernia [18,

19]. It has been postulated that the weight of serous fluid between mesh and the anterior abdominal wall could decrease the tensile strength at the fixation sites of mesh leading to mesh detachment from the abdominal wall and possible recurrence of hernia.

The presence of seroma may cause distress and anxiety in patients who have not been counseled preoperatively. This is due to the fact that seroma occurs as a bulge at the site of hernia and therefore mimic recurrent hernia. Several authors have reported different strategies to minimize seroma formation. These include cauterization of hernia sac [20, 21], excision of hernia sac, use of laser, and closure of hernia defect during LVIHR [22].

Seromas are common occurrences after LVIHR. Patients should be counseled preoperatively about their occurrence in postoperative period. Most seromas resolve without active intervention, and needle aspiration may be required only in persistent and symptomatic seroma.

55.2 Late Postoperative Outcomes

55.2.1 Recurrence

Traditionally, recurrence has been the primary end point in studies on hernia repairs. LVIHR was first reported in 1993 by Karl Leblanc and has gained steady popularity since then. Early results of LVIHR have generally been favorable with shorter hospital stay, decreased wound morbidity, and better cosmetic results. Recurrence rates appear to be equivocal with laparoscopic and open hernia repair surgical approaches, although a systemic review published in 2008 showed results in favor of LVIHR [23].

The risk factors for recurrence after LVIHR may be broadly divided for purpose of convenience into patient-related, hernia-related, and surgeon-related (surgical technique-related) risk factors. Morbid obesity is well known to be associated with increased recurrence after hernia repair [24]. Obese patients need to reduce their weight and BMI prior to elective surgical repair to reduce chances of recurrence. Smoking is strongly correlated with increased recurrence raters after hernia repair [25]. COPD and restrictive disease of lung, diabetes mellitus, and altered collagen synthesis are the other risk factors for hernia recurrence [26, 27].

Peripheral abdominal wall hernias like suprapubic, lumbar, subcostal, and subxiphisternal hernia are considered difficult hernia to repair because of problems of mesh location, fixation, and their proximity to viscera like urinary bladder, colon, and large vascular structures [28]. Surgical repair of recurrent hernia is known to be associated with higher recurrence rate [29–31]. Surgical site infections (SSI and mesh infection) are the other hernia-related risk factors that predispose to higher recurrence.

The surgeon-related risk factors are primarily faults in surgical technique that contributes to increased recurrence rate. The size of mesh used for hernia repair is an important prognostic factor for recurrence. Commonly smaller-sized meshes have been associated with greater recurrence rates in case of groin hernia [32]. It is important to ensure complete coverage of incision scar and hernia with mesh to prevent recurrence [33]. The incorrect positioning of mesh on the abdominal wall is another contributing factor. During laparoscopic repair, it is not uncommon for the mesh to slide too far on one side of hernia defect prior to fixation of mesh. Improper fixation of mesh and the presence of large seromas postoperatively have been reported to cause mesh detachment from abdominal wall, leading to recurrence. Patients undergoing LVIHR with absorbable tack fixation of mesh have been reported to be at higher risk of recurrence [34].

55.2.2 Chronic Pain

55.2.2.1 Chronic Postoperative Pain

The term chronic pain is used when pain continues for more than 3 months postoperatively [35]. There have been many methodological techniques used to evaluate the pain score. The intensity of pain is measured by two unidimensional scales visual analogue scale (VAS) and verbal rating

scale (VRS). VAS comprises a horizontal line with end points labeled "no pain" (0 mm) and "worst possible pain" (100 mm) and is sensitive to changes in pain intensity [36, 37].

In the literature VAS has been used for estimation of pain during rest and movement-evoked pain. The results have suggested more intense pain during movement in the first 3 postoperative days [38]. VRS is a four-point category scale (1, none; 2, light; 3, moderate, 4, severe) and is less sensitive to changes in pain intensity compared with VAS [39]. It is a convenient and user-friendly scale compared to VAS, and only minimal instruction is needed from the clinician. VRS can be used to assess the overall pain. There are a myriad of questionnaire formats for pain assessment like short-form McGill Pain Questionnaire (SF-MPQ), Neuropathic Pain Questionnaire (NPQ), and Activity Assessment Scale which acts as screening tools.

The etiology of postoperative pain after laparoscopic surgery includes patient-related factors [40], surgical-related factors [41, 42], and inadequate preoperative analgesic treatment [41, 43]. Furthermore, postoperative pain intensity is largely dependent on interindividual threshold and variation.

LVIHR has gained popularity due to several advantages over conventional open repair [44]. Fewer complications, early return to normal activity, reduced postoperative pain, and lower recurrence rate have set a new standard of care of ventral hernia repair [45, 46]. The incidence of chronic pain has been reported in 22% of patients after LVIHR [47].The postsurgical pain influences the general well-being and quality of life of patients.

The controversy in LVIHR exists in literature regarding optimal method of mesh fixation which influences the postoperative surgical pain. Transabdominal sutures and tacks are the two most common methods of mesh fixation. Sutures pass through all layers of fascia and muscle of the anterior abdominal wall, while tacks secure the mesh to the innermost millimeters of peritoneal cavity. There are studies which have demonstrated the association of chronic postoperative pain and type of fixation methods. Muysoms et al. [48] reported more patients with abdominal wall pain (VAS > 10 mm) after sutures and tacks (31.4%) compared to tacks in a double circle shape (8.3%). Cobb et al. [49] have also proposed that intercostal nerves become entrapped within the transabdominal sutures causing chronic, persistent neuropathic pain. There are many studies which have reported persistent discomfort and pain (1–6%) in repairs using transfascial sutures [50–52]. Pain from muscle ischemia has been proposed to be generalized at all suture sites. The study reported by Nguyen et al. [53], comparing postoperative pain after LVIHR using sutures versus tacks, showed no significant difference between the two methods of mesh fixation.

New methods for mesh fixation have been introduced. The application of fibrin sealant for mesh fixation has contributed to reduce the postsurgical pain as compared to tacks [54]. The adhesive effect being superficial, mesh is readily secured and stabilized without traumatizing the underlying tissues. Pain is one of the important components of postoperative outcomes which needs to be assessed and monitored to improve clinical practice. Existing data support the contention that the intensity of chronic pain is minimized using laparoscopic techniques.

55.2.3 Mesh Infection

Mesh hernia repair is accepted as the standard procedure worldwide for the treatment of most adult hernia. Mesh-related infections following surgery are relatively rare but pose a greater risk of morbidity once infection is established. The rate of mesh infections after elective open repair is 1.5%. Laparoscopic hernia repair has low rates of infection, varying from 0.03 to 0.095%. Mesh infections are multifactorial in relationship between bacteria, device, and host factors [55]. The incidence of mesh infection in a study reported by Heniford et al. [56] is 0.7% in 822 laparoscopic ventral hernia repairs. In contrast, Peterson et al. [57] showed 7% mesh infection in 121 open incisional repairs. The incidence of mesh infection in open incisional hernia repairs

has been reported up to 8% [58] as compared to 0.98% [59] in laparoscopic hernia repairs.

The microorganisms which are related to mesh infections involve the following bacteria: *Staphylococcus* species especially *Staphylococcus aureus*, group B streptococcus, and gram-negative and anaerobic bacteria. In addition to these organisms, atypical microorganisms like *Mycobacterium fortuitum*, *Mycobacterium chelonae*, and *Mycobacterium abscesses* are also known to cause mesh infection. *M. chelonae* bacteria are associated with nosocomial skin, soft-tissue infections following contaminated injections, surgical procedures, and laparoscopic surgery. The source of infection is contamination of wound directly or indirectly with colonized tap water. The mesh infections post laparoscopic surgery are attributed to fallacy in the sterilization technique [60]. There are also studies which have shown that risk of infection can be lowered by impregnating meshes with antiseptics [61]. The studies in experimental animals have shown the superiority of macroporous meshes to microporous meshes with decrease in incidence of infection in the macroporous meshes [62–64].

Clinicians should consider the occurrence of mesh infection in operated patients who have fever of unknown etiology or symptoms and/or signs of infection of the abdominal wall. Late infections are more indolent with varied presentations. Symptoms can be chronic, recurrent, or totally absent until the progression of sepsis. The reported interval between hernia repair and the manifestation of a mesh infection ranges from 2 weeks to 39 months [65].

Diagnostic imaging techniques like ultrasonography, computerized tomography, are used for confirming the mesh infection. In the presence of infection, an image has different psychogenic or density characteristics from that in other conditions like seroma. It reveals an area of inflammation in the subcutaneous fat around mesh. The imaging methods also aid in assessing the presence of a fistula or an abscess [66]. In situations of extensive infection and abscess formation, early surgical intervention is the method of cure.

55.2.4 Small Bowel Obstruction

The incidence of small bowel obstruction following laparoscopic hernioplasty is about 2.5% [67]. It is usually port or mesh related. The reasons include incarceration of the bowel into port site following release of pneumoperitoneum due to negative pressure and abdominal adhesions. Intra-abdominal adhesions also contribute to the cause and may have deleterious effects, like intestinal obstruction followed by chronic pain and reduced quality of life [67]. CT scan is a valuable imaging tool in such patients [68]. This complication can be prevented by removing all trocars under vision, by closing defects larger than 5 mm under direct vision, and by interposing a layer of omentum between the mesh and the bowel [69]. Early laparoscopic intervention is an accepted management option [70].

55.2.5 Trocar Site Hernia

Trocar site incisional hernia (TSIH) may occur following laparoscopic ventral hernia repair. The incidence following LVIHR is 1–2.6% [71, 72]. TSIH following LVIHR could develop at the open introduction of the port, the mesh insertion port, or any other working instrument ports. The majority of studies report an incidence of less than 3%, which is considered an acceptable rate, especially if compared with open repair and its morbidity [73]. Boldó et al. [74] reported an incidence of 22% (6 patients) in a series of 27 LVIHR. The risk factors for development of TSIH are trocar diameter, trocar design, preexisting fascial defects, and some operation- and patient-related factors, in addition to the direction of the port insertion, use of a drain, and the site of the port [72].

The occurrence of TSIH is less with trocars ≤12 mm, radially dilating trocars, or bladeless trocars [75]. In order to reduce the chances of port site hernia, all 10/12 mm size ports should be closed with figure-of-8 sutures after removal of the port. A Berci fascial closure needle is commonly used, and a full thickness closure of the port site is done, including all layers of the abdominal wall [60].

55.2.6 Quality of Life (QOL)

It is now believed that clinical postoperative outcomes following surgical procedures are best measured with QOL assessments. QOL assessments provide a holistic response of outcomes in an individual after surgery. These are considered to be more reliable indicators of surgical outcomes, since they measure several parameters like physical function, role limitations due to physical and emotional problems, vitality, social function, mental health, and emotional well-being.

Several QOL assessments have been proposed and studied by investigators. Numerous reports have been published on QOL assessments after inguinal hernia repair. SF-36 is considered an attractive method for assessing health-related quality of life because of its brevity, rigorous psychometric development, and patient acceptance [76]. The preliminary reports have been promising, detecting beside improvement in postoperative pain a possible quality of life improvement [77, 78]. De Jonge et al. [79] believed that TAPP is greatly superior in terms of quality of life. Gholghesaei and associates [80] presented laparoscopic technique as the preferred choice from patients' point of view because of its effects on quality of life.

A few investigators have reported on QOL assessments after LVIHR. LVIHR was reported to be associated with considerable postoperative pain and fatigue in the first month after surgery and had significant effects on patients' QOL for up to 6 months postoperatively [81].

Mesh fixation methods, pain and QOL after LVIHR, were reported by Wassanar et al. [82]. They found, compared with preoperative status, patients in all three mesh fixation groups. Absorbable sutures, double crown, and nonabsorbable sutures had improvements in QOL by 3 months after LVIHR. Minimal intergroup differences in postoperative QOL measures were observed.

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Part V

Incisional

The Prevention of Incisional Hernia

56

Y. Yurtkap, E. B. Deerenberg, J. J. Jeekel, and J. F. Lange

56.1 Introduction

Incisional hernia is a common occurring long-term complication following midline laparotomies, with a weighted mean rate at 2 years of 13% [1]. Recent randomized controlled trials show an incidence of 21–30% [2, 3]. In high-risk patients, including patients with an abdominal aortic aneurysm and high BMI ≥ 27, the incidence is estimated up to 69% after long-term follow-up [4]. Risk factors for the development of incisional hernia may be divided into patient-related risk factors and surgery-related risk factors. Patient-related risk factors are male sex, older age, smoking, malnourishment, poor diabetic control, coughing, use of steroid drugs, abdominal aortic aneurysm, malignancy, and history of chemotherapy. Also, impaired wound healing and reduced ratio of collagen type I/III are known risk factors. Surgical factors are the type of laparotomy incision (midline, transverse, or paramedian), operative status (elective or emergency), and peri- or postoperative wound problems, together called surgical site occurrence such as seroma formation, wound dehiscence, and surgical site infections [5]. An incisional hernia may cause obstruction and strangulation of the bowel, which can result in emergency surgery, with associated morbidity and mortality. Moreover, pain, discomfort, and cosmetic complaints caused by an incisional hernia may result in an impaired quality of life [6]. Additionally, the 10-year recurrence rates after incisional hernia repair are estimated up to 64% after primary repair and 32% with mesh repair [7]. Furthermore, incisional hernias do not only affect patients' health, it also creates a financial burden for public health. Optimizing surgical techniques and used materials to close abdominal wall incisions holds the potential of preventing the development of incisional hernias, reducing postoperative disability, and saving costs in the healthcare system. The prevention of incisional hernias is of paramount importance at both the individual and socioeconomic level. The surgical techniques and used suture materials for closing abdominal wall incisions are important determinative factors in preventing an incisional hernia and will be discussed in this chapter. Finally, the use of a prophylactic mesh placement for the prevention of incisional hernias and optimization of patients pre-, peri-, and postoperatively will be discussed.

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56.2 Suturing Technique

In the first-century AD, Aulus Cornelius Celsus was the first to document about the significance of surgical closure of the abdominal wall. A century later, the Greek surgeon Galen of Pergamon wrote about the mass closure of the abdominal wall. He also suggested to enter the abdominal cavity by paramedian incisions where possible in order to prevent incisional hernias. In the Middle Ages (AD 500–1500), scientific knowledge in hernia prevention and repair was mostly lost. In the nineteenth century, abdominal surgery became more common and survivable due to the discovery of asepsis and general and local anesthesia. In the last century, Read and other researchers focused on a collagen disorder as an explanation for hernia formation, which is called herniosis. On the other hand, another surgeon, Jenkins, pondered upon the mechanical cause of the development of incisional hernias. After surgery, an abdominal girth and the xiphoid-pubic distance may lengthen up to 30% during abdominal distension [8]. To allow this lengthening to occur and ensure a minimal rise in tension between the sutures and the tissues, an adequate reserve of suture length is necessary. A suture length (SL) to wound length (WL) ratio of 4:1 is calculated based on an increase of 30% of the wound length due to postoperative abdominal distension. Various clinical studies have shown that the suture length to wound length ratio of <4 resulted in a higher incidence of incisional hernias after midline laparotomy and a suture length to wound length ratio of ≥4 is recommended after midline laparotomy (Fig. 56.1) [9, 10]. Besides a suture length to wound length ratio of ≥4, it is recommended to use a continuous technique (versus interrupted) with slowly or nonabsorbable sutures (versus rapidly absorbable) as shown in various meta-analyses [11, 12]. In addition, continuous suturing is significantly faster to perform. The Swedish research group of Israelsson has developed the small bites technique (stitches 5–8 mm from the wound edge while only including the aponeurosis in the stitches) for the closure of midline incisions. A continuous, single-layer monofilament suture closed the incision, and self-locking anchor knots

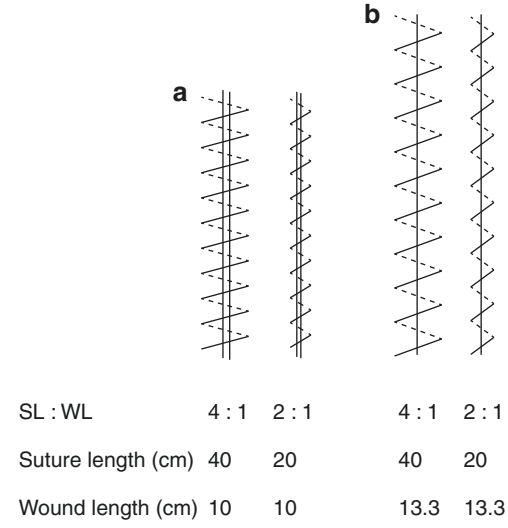

Fig. 56.1 Suture length to wound ratio (**a**) and suture length to wound ratio after 30% abdominal distension (**b**). Source: Adapted from Jenkins TP. The burst abdominal wound: a mechanical approach. Br J Surg. 1976;63(11):873-6

were used in this study. This technique was confirmed in the STITCH trial, which is a recent randomized controlled study, where the common conventional large bites technique (i.e., 10 mm every 10 mm from the wound edge; long stitch) is compared with the small bites technique (i.e., 5 mm every 5 mm from the wound edge; short stitch) (Fig. 56.2). After a follow-up of 1 year, it is shown that the small bites suture technique is more effective for the prevention of incisional hernia in midline incisions, without a higher rate of adverse events [2]. Moreover, single, aponeurotic layer closure is recommended in elective midline abdominal wall incisions. Suturing all layers separately and peritoneal closure is not recommended [13]. In the European Hernia Society (EHS) guidelines, it is recommended to avoid midline incisions if possible. The occurrence of incisional hernias after both transverse and paramedian incisions are significantly lower compared with midline abdominal wall incisions, but without a difference in burst abdomen rates [14]. However, a midline incision is still the most common used incision to access the abdominal cavity. This type of incision allows the surgeon to be quick and provides an expansive view of the abdominal cavity, with minimal harm to the nerves, vessels, and muscles.

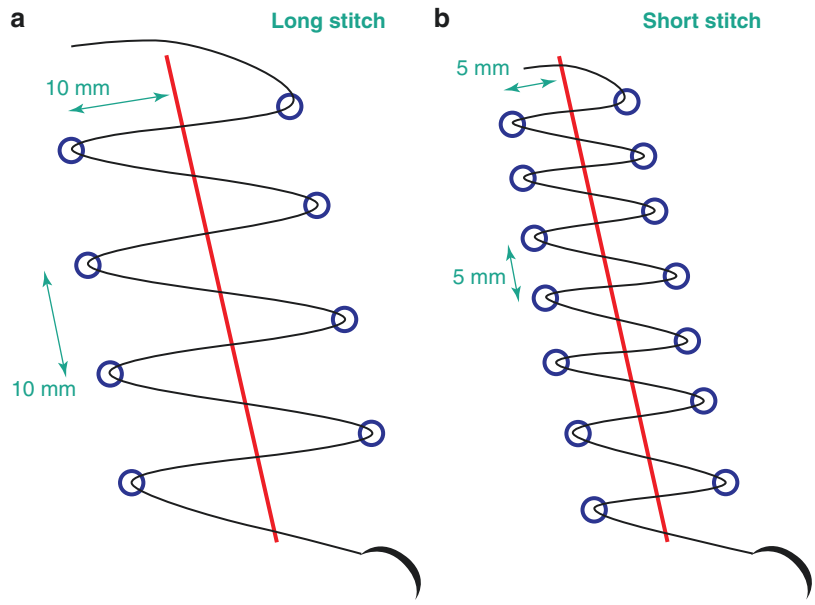

Fig. 56.2 Large bites technique with long stitch (**a**) and small bites technique with short stitch (**b**). Source: Meijer E-J et al. The principles of Abdominal Wound Closure. Acta Chir Belg 2013;113(4):239-244

56.3 Suture Materials

The rapid growth in abdominal surgery over the past centuries has led to a rising global demand for suture materials. The Roman Galen of Pergamon is considered the first person to use catgut sutures. Catgut sutures were fabricated by the twisted intestines of herbivorous animals and are degradable in the human body by proteolytic enzymes in approximately 90 days. In this period, silk and cotton were used when nonabsorbable material was needed. During and after the Second World War, stainless wire and polymers were constructed. Now, various suture materials are available, i.e., braided versus monofilament and rapidly, slowly, versus nonabsorbable materials. Using a slowly or nonabsorbable suture to suture the fascia seems more reasonable compared to rapidly absorbable materials, since fascia healing needs at least 14 days to recover its strength. Using a fast-absorbable suture will not provide long enough support during fascia healing [15]. Fascia healing can be divided into three phases. The first exudative phase starts with recruiting inflammatory cells. In the proliferation phase, fascia gains tensile strength via fibroblast proliferation and starts producing collagen. Mainly collagen type III is produced, which will be replaced by strong and thick type I collagen in the maturation phase. No significant differences between slow-absorbable suture material (polydioxanone) and nonabsorbable suture material (polypropylene, Prolene) are found. However, nonabsorbable suture is associated with increased incidence of prolonged wound pain and suture sinus formation, which can possibly lead to long-term wound care and reoperation. Overall, these results indicate that using slowly absorbable suture material is the most wise choice [11, 16–18]. Sutures impregnated with antibiotics, for example, with triclosan, have been postulated in order to decrease the rate of surgical site infection, which is a well-known risk factor for the development of incisional hernias. In a randomized controlled trial performed by Diener and colleagues, sutures impregnated with triclosan were compared with sutures without coating, and no significant difference in the rate of surgical site infections was shown [19]. Similarly, this outcome is supported by another recent meta-analysis. Henriksen and colleagues did not find a significant decrease in surgical site infections

when triclosan-coated sutures were used for abdominal fascial closure. In the same study, a significant decrease in surgical site infections was seen when triclosan-coated Vicryl (absorbable) sutures were used. However, absorbable sutures are not recommended as discussed earlier in this chapter [20]. Nevertheless, the occurrence of a surgical site infection after midline laparotomy is multifactorial, and suture material is only one possible contributing parameter. In the guidelines for the closure of the abdominal wall by the European Hernia Society, it is not advised to use sutures impregnated with antibiotics since no data is available on the development of incisional hernias [14]. Also, it is recommended to use monofilament suture materials, because those are associated with a lower surgical site infection rate compared with multifilament sutures [21]. In conclusion, a continuous, single aponeurotic layer with slowly absorbable monofilament sutures is recommended for the closure of the fascia.

56.4 Surgical Site Infections

Surgical site infection (SSI) is a common complication, occurring between 3% and 40% after surgery and associated with increased morbidity, readmission rates, length of hospitalization, and healthcare costs. The highest SSI rates occur mostly after major abdominal and colorectal surgery. Moreover, SSIs are a well-known risk factor for the development of incisional hernias. It is shown that patients with a SSI were two times more likely to develop an incisional hernia compared with patients without a SSI [22]. Various strategies are studied in order to prevent the occurrence of surgical site infections. Studied determinants were maintaining intraoperative normothermia, using barrier protectors or fresh closing trays in order to reduce bacterial load within the wound, euvolemia, and increasing perioperative oxygen tension, for example. However, single interventions do not reduce the occurrence of SSIs; bundling of interventions is required.

56.5 Prophylactic Mesh Augmentation

Since 1995 studies have been performed to prove the effect of prophylactic mesh augmentation after laparotomy. To date, a number of randomized studies have confirmed the effectiveness of the use of a prophylactic mesh for the closure of the abdominal wall in high-risk patients. There is growing evidence for prophylactic mesh augmentation for the prevention of incisional hernia. A recent example is the PRIMA trial; in this large international multicenter and randomized controlled trial, a comparison was made between preventive prophylactic onlay or sublay mesh reinforcement and primary closure with sutures in elective midline laparotomies [3]. This study is performed in patients with a higher risk of developing an incisional hernia, i.e., patients in this study had either an abdominal aortic aneurysm or a body mass index of 27 kg/m^2 or higher. After a follow-up period of 2 years, an incidence of incisional hernia of 30% was found in the non-mesh group, 13% in the onlay mesh group, and 18% in the sublay mesh group. Also, a recent meta-analysis confirmed that reinforcement of the abdominal wall by using a prophylactic mesh results in a decreased incidence of incisional hernias compared with primary repair with sutures [23]. Despite the strong evidence in the literature by now for the use of prophylactic mesh augmentation, several questions remain unanswered at present. Firstly, the exact patient population who will need a prophylactic mesh still needs to be determined. There is a variation in selected high-risk patients in the performed studies. Secondly, the optimal anatomical location for the placement of a mesh is still under discussion. Both locations, on- and sublay, are proven safe in the PRIMA trial. The onlay position is a less complex surgical technique compared with the sublay position. Nevertheless, seromas are more frequently seen in patients with an onlay placed mesh, which is associated with a higher rate of surgical site infections. However, in the PRIMA trial, a higher rate in seromas did not result in an increased incidence of surgical site infections or

other complications. On the other hand is the sublay position a technically more difficult surgical technique for surgeons that do not perform hernia repair (i.e., vascular surgeons, gynecologists, and urologists). An important question in this case is what risk of developing an incisional hernia legitimizes the placement of a prophylactic mesh. A better understanding of complication rates of a prophylactic mesh in contrast with the risk of developing an incisional hernia and patient selection is needed.

56.6 Patient Optimization

Unfortunately, genetic susceptibility or connective tissue disorders are risk factors in the development of an incisional hernia, which cannot be influenced. On the contrary, numerous susceptible patient-related risk factors have been shown to play a major role in incisional hernia occurrence. Physicians should try to optimize modifiable risk factors such as smoking, obesity, malnutrition, glycemic levels, coughing, and use of steroid drugs. Obesity is a known factor for the occurrence of incisional hernia after laparotomy and also for recurrence after initial repair. Decreased vascularity of adipose tissue, leading to local hypoxia and impaired collagen synthesis, may lead to impaired wound healing. Another factor is an increased intra-abdominal pressure resulting in more stress on the suture line. Although obesity is a complex multifactorial disease and extremely difficult to affect, weight loss should be encouraged. On the contrary, malnourishment may result in more postoperative complications such as surgical site infections. Also, higher HbA1C than 7% is associated with an increase in infectious complications subsequently resulting in higher rates of incisional hernias [24]. It is clear that in the perioperative period, diabetes regulation should be improved. Smoking is a well-known adversely influencing factor for tissue healing and should be strongly discouraged [25]. The use of steroids is a known risk factor for wound complications, and the need for steroids should be carefully reviewed pre- and postoperatively. Also, chronic pulmonary obstructive disease (COPD) should be well-controlled preoperatively in order to reduce postoperative coughing, pneumonia, and steroid use.

Conclusion

Taken together, this chapter shows the complexity of the prevention of an incisional hernia. The two important determinants emerged from this chapter for the prevention of an incisional hernia are surgical techniques and susceptible patient-related characteristics. Surgical techniques such as suture length to wound length ratio, consequently the stitch size and suture materials are influential for the development of an incisional hernia. Modifiable patient-related risk factors include for example obesity and smoking. In order to prevent an incisional hernia, these risk factors and surgical techniques should be optimized based on recently published guidelines.

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57 Laparoscopic Ventral Hernia Repair: Where Is the Border?

Francesco Corcione

57.1 What Does the Literature Say?

As for all the analysis that can be made from the literature, even for ventral hernia treatment, everything and its opposite can be found, such as experiences with completely different results, "consensus conferences" where, except for some aspects, it is very difficult to give indications and to establish which the best treatment in terms of outcomes is.

On the other hand, it is equally relevant to underline that all the major papers have a follow-up of a maximum of 2/3 years! That is a too short period for a disease that can give complications as infections and recurrences after many years.

Going over the most prestigious literature, we can find:

1. […] The open approach remains the standard treatment for incarcerated hernia, although laparoscopic surgery may be considered in selected patients… Many meshes have been specifically manufactured to avoid adhesion formation with the abdominal viscera to be implanted intraperitoneally…. The safety of the intraperitoneal mesh implant is supported by the results of more than 20 years of laparoscopic surgery for the abdominal wall hernias…. There is a sufficient follow-up to state that most of the barrier mesh prostheses determine a very low risk when placed intraperitoneally…. A recent Cochrane review showed heterogeneity among studies analyzed with respect to the type of the intraperitoneal mesh used, even within the same study. As a matter of fact, the purpose of the study was generally to confirm the feasibility of laparoscopic repair and not to analyze the immediate and long term results of different types of mesh…. Adhesions are relatively frequent after the intraperitoneal placement, they may potentially cause some complications and make reoperations challenging. Some authors reported null or minimal omental adhesions in 89% of cases with polyester absorbable barrier mesh implant. Other authors found null or minimal adhesions involving omentum in 82% of cases with EPtfe implant and observed that adhesions occurred mainly against exposed elements (tacks, edge of the mesh) [1].

If we affirm that the safety of the intraperitoneal meshes is supported by the results of more than 20 years of laparoscopic surgery in abdominal wall surgery, it's difficult to understand why the companies has developed always new meshes, even replacing the previous ones, saying that the new one is the best one; and some meshes have been recalled from the market by the companies themselves! The

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adhesions are practically always present after any kind of mesh implant, regardless of the type of material used, and we can be sure that a real anti-adherent mesh still doesn't exist.

2. […] The introduction of a foreign body such as mesh can lead to serious adverse results, such as pain, infection, fistula, bowel injury and bowel adhesions….The efficiency and efficacy of laparoscopic repair compared to open technique is lacking. It is still unclear if one method repair is superior to the other…. the laparoscopic repair carries higher rate of bowel injury with 2.9 compared to only 0.9 in the open group….Laparoscopic approach took longer than open surgery in terms of operation time…No difference in length of hospital stay…The risk of infection was almost five times lower for laparoscopy than open surgery [2].

57.2 Background

In the last 25 years, ventral hernia surgery has faced a real revolution with the impulse of new products and new technologies. Related to this, it is surely a surgery that today involves many arguments and deserves more in-depth analysis.

Going back to what was this surgery in the 1980s will surely help to understand what happened.

Approximately 30 years ago, for a ventral hernia, there was still the so-called traditional Paletot technique, which was a direct suture, and three mesh techniques which practically used the same prosthesis in three different sites: the technique of Chevrel suffusion (onlay), the technique of Rives-Stoppa (inlay), and the Arnaud (sublay) technique. The used prosthesis, due to the lack of other meshes, was the Dacron-Mersilene defined by Jean Rives "la moin mauvais."

It was an handful very soft mesh prosthesis with good fibroblastic reaction but not very resistant to infections.

As contradictory as it might sound, it has to be highlighted that in those years, the surgeons, having little confidence in the mesh, resorted in most cases to traditional techniques, and only in a few centers were used with such print prostheses.

The Chevrel technique consisted a direct parietal repair, a wide dissection of the subcutaneous tissue up to the costal margin, and the placement of a large mesh.

Few surgeons have in the past followed this technique because of the two main criticisms:

The first was that the mesh was placed in the subcutaneous space and therefore susceptible to infection and rejection also for a simple subcutaneous infection. The second was that standing outside the parietal wall had poor resistance capacity to endoabdominal pressures.

The Arnaud's technique consisted in placing a Dacron mesh in the abdomen in contact with the endoabdominal organs and peripherally attached to the peritoneum.

Conceptually, it was definitely more effective than being placed behind the abdominal wall, but the great criticism to this technique was related to the severe potential visceral complications.

The technique of Rives, then resumed with some modifications by Stoppa, and therefore defined as Rives-Stoppa, provided instead the positioning of the mesh inside the abdominal wall between the peritoneum and posterior rectus sheath, in a retromuscular position.

It was fixed on the low side on the Cooper ligaments and near the fatty triangle retroxiphoid or on the iliac spine laterally in relation to the type of ventral hernia.

The sandwich technique, as defined by J. Rives, had mainly positive results and was the most used by surgeons all around the world. It became the standard reference technique for the treatment ventral hernias.

The disease was parietal and the mesh "remained" parietal with a good ingrowth because it was placed in an aponeurotic, retromuscular space, far from subcutaneous complications and especially away from visceral complications.

In addition, the Rives-Stoppa technique responded to the requirements for the treatment of a complex pathology such as ventral hernia.

"Incisional hernia" is not a simple hernia of the abdominal wall: it often follows a more or less wide laparotomy and represents a true pathology involving organs and system. It is a parietal disease that, as demonstrated decades

ago, however, affects the respiratory, visceral, vascular, and psychological system of the patient. With the increase in size of wall defect, there is a flattening of the diaphragm resulting in a reduction in the ventilatory capacity of the patient; with a slowing down of visceral peristalsis and with a reduction in the venous return to the heart, last but not the least, the patient feels psychologically disturbed and most often is ashamed of his body and avoids exposure to others by locking into a world. Therefore, surgical treatment should aim at restoring all these problems while avoiding recurrences and complications even at a long-term follow-up.

For these reasons, the Rives-Stoppa technique has been the treatment of choice of incisional hernia treatment for years because it responded to all the crucial questions of the pathology: recreate a parietal tension, favoring the mobility of the diaphragm and the intestine and the venous return to the heart. Additionally, it does not add any wounds or incisions that, however small, can be evident. The mesh is inlay, and even if it goes to infection and/or refusal, it does not involve endoabdominal organs.

In a monothematic article on ventral hernias published by GREPA in 1985, the three techniques described by the respective surgeons were reported sequentially with the results obtained.

What emerged from the analysis of the literature of that monography is that Arnaud's technique had been used by the same developer in less than 100 cases with many complications and in the bibliography there were no reports of work with similar experiences.

Chevrel's technique reported substantially overlapping numbers but with better results and some other sporadic literature experience.

The technique of Rives was reported with an experience of almost 300 cases and with many cases reported in literature. Therefore it seemed that there could be no further discussions of this disease and its treatment. The introduction of the Goretex mesh started a new era for the surgeons, although the mesh being very expensive. As a matter of fact, it has to be said that the Rives technique was difficult to be perceived by surgeons, who probably thought it was more logical, quick, and equally safe placing a mesh in the abdomen that was described as anti-adherent.

But only few surgeons systematically used this prosthesis, which soon revealed to be "adherent," causing a large number of obstructive complications and cases of migration into the digiunum, bladder, colon, etc.

Then the laparoscopic surgery spread with enthusiasm, with its novelties, with the impetus of industry-leading technologies in the interest of patients.

However it has to be said that in the first period of this approach, ventral hernia surgery did not change. Only a few surgeons started this new adventure consisting of using only Goretex mesh or some mesh composite that began to appear worldwide, with the doubts aforementioned.

Then there was the explosive spread of new prostheses and new devices useful for this surgery, amplifying the initial enthusiasm of the surgeons always in search of novelties and new performances.

At that time it was very common for companies (with different market impact) to introduce what was called "a best prosthesis" and then replace it after a few years with another, stating that it was better than the previous one.

After that there was the uncontrolled spread of a surgery that although considered important and difficult was almost minimized by the laparoscopic approach: three or four trocars, dissection, and placement of prostheses (That always considered the best) more or less effective fixation. Moreover growth of the surgeon's self-confidence is derived by the perception of being good because of the use of a modern and technological approach to satisfaction (at least temporarily) of the patient who is obviously pleased to receive modern and technological treatment.

Now it is time for reflection and maturity.

Beyond the experiences reported in the literature, the surgeon has become more reflexive and less aggressive. Therefore the narrow boundary between open and laparoscopic techniques can now be better defined.

57.3 Our Experience: An Evolution of Ideas

Although we are among the first to understand the importance and efficacy of the laparoscopic approach to almost all pathologies, for years, we have had some doubt and dread of treating ventral hernias laparoscopically. This could sound a paradox; in fact we have faced laparoscopy for perhaps even more challenging pathologies such as hiatal hernia, achalasia, colon, and adrenal surgery. Why? Because of the inclination given by the school of great rationality of J. Rives and persuaded by the goodness, effectiveness, and security of its technique, which we did not think we could improve with different approaches and techniques.

Then a few factors changed our vision and we started our adventure.

Among these factors there were the very positive experiences in the literature; the incentive of the industry that in the few years, as already mentioned, invaded the marketplaces with prostheses and devices of all kinds; and the enthusiasm of colleagues who had already approached laparoscopy.

At the beginning we consciously believed that although in the literature experience with important cases had already been reported, we could only deal with small ventral hernias.

After the first cases and the first positive results, we were also excited about laparoscopic ventral hernia approach.

It was also the time when the value of new technology was to be forcedly stated, and at the same time we wanted to show ourselves evolved in the ideas and in the way of performing the procedures.

But the first failures quickly arrived: an early recurrence (never seen before in a Rives technique!!); a parietal abscess infection, supported by the mesh partially migrated into the defect (for which a laparotomy was needed to remove the mesh infected!); and occlusion on the mesh (obviously the best anti-adherent!!). All this has led us to reconsider the problem and ask us some questions.

57.4 Personal Observations About the Laparoscopical Approach to Ventral Hernias

Having as a benchmark the technique of Rives and having the mature experience achieved the most positive results, with the laparoscopic approach, we wanted to achieve the goal of improving even if only in some aspects the results obtained with Rives technique.

But first of all, an error has to be highlighted at the start. Already from cholecystectomy there was a need to compare the open technique with the laparoscopic technique. Error!! The surgical technique remains the same; what changes is only the approach. Indeed the technique is the same, the same steps as well, so the question was whether changing the approach was improving the results or not.

We must say that in a few years, the superiority of laparoscopic surgery on the open one has been shown for most diseases.

But the abdominal wall surgery started by an impassable bias: compare an intraparietal technique with an intra-abdominal technique.

Even for the inguinal hernia, the same problem has arisen even though there was the Wantz-Stoppa technique with which laparoscopy could be confronted but not the same for ventral hernia. And so this consideration doubts the validity of an unmatched comparison. In theory, the Arnaud technique had to be compared to the laparoscopic technique that represented the exact mini-invasive reproduction. But Arnaud's technique was not used by anyone or at least a few surgeons.

57.5 Costs

Laparoscopic surgery has direct intraoperative costs depending on the interventions, the used devices, and the pathologies to be treated. On average they are higher than those of open surgery.

For ventral hernia surgery, this difference becomes almost unbearable for the high cost of

"better" meshes and for devices used when compared to the truly minimal costs of open surgery. But perhaps the costs issue can be overcome by the benefit for a technology surgeon: you need to know them, know how to hold it, but if it gives you a surprising result, you still have to put it aside. In these cases, no! The costs of such surgery increase for the morbidity and complications that unfortunately are present with the laparoscopic approach. Visceral lesions, occlusions, and migration of the mesh involve interventions, long hospital stay, not to say long sequelae, and often persistence of the disease. But has someone ever calculated the cost of removing an infected mesh with ileal resection and the need of VAC therapy? These types of complications are really rare with Rives technique, almost unthinkable.

57.6 End Point of the Treatment

What does treating a ventral hernia mean? What are the goals we must try to achieve? We think it can be briefly summarized in restitution of parietal integrity, restoring of the physiological abdominal tension, quality of life that must not prevent a minimum of sports activity, and reduction of complications, sequelae and recurrences over time.

Another issue of considering the differences between the two approaches is the onset time of the possible complications.

I have personally experienced intra-abdominal mesh-related complications at a distance of 1–15 years from their implant.

I saw the formation of a parietal abscess 7 years after laparoscopic ventral hernia repair, sustained by a very late infection of the mesh.

I have seen recurrences appeared 1 month (probably technical error) and 20 years after the surgery.

I have treated many intra-abdominal prostheses migrations.

I also saw migration of a mesh into the esophagus after hiatal hernia repair that required an esophagectomy.

For laparoscopic ventral hernia repair, we can trust only immediate results, while for long-distance one, the patient, no longer followed up by us, generally is operated elsewhere. This could be considered the biggest bias in this assessment.

While for oncology there is a 5-year limit, for ventral hernia repair follow-up, there are no time limits. It seems that for the ventral hernia repair outcomes, any evaluation is necessarily based on short-term follow-up with all the associated considerations.

But even if we want to consider only short-term results, a difference between Rives technique and laparoscopic is undeniable: laparoscopic complications are certainly more important and require more serious and expensive treatments. Returning to the end points, it has to be said that in our experience (that has evolved over time and has been enriched with substantive technical details such as closing the defect [3] and a more careful and correct fixation of the mesh), we fail to restore in laparoscopy a good parietal tension except for small ventral hernia (<7–8 cm) [4].

We must also consider the possibility of hernia on the trocars sites. This puts the patient in a disagreeable position, and the surgeon must be often more invasive to place a mesh to repair a trocar hernia located between the lateral muscles [5].

57.7 Beyond Literature

I like to emphasize a concept that almost never appears in conferences or statistical evaluations.

I am referring to anecdotic but frequent stories of colleagues who in the corridors of conferences or other hospitals secretly whisper to you about a case that went wrong for some reason or those cases in which unfortunately the surgeon is involved in some legal action (only in the past 3 years I have defended three surgeons who had had complications for laparoscopic ventral hernia repair).

57.8 What Can We Learn from These Experiences?

Ventral hernia repair is falsely considered suitable for all. Its criteria, unfortunately still not defined, leave much space to free personal interpretation. A demonstration of this concept is provided by our experience over the last 5 years (see Table 57.1).

For decades a lot of patients (particularly complex cases and complications very difficult to deal with) referred to our hospital. As can be seen from the table, we have treated 37 patients with complex and risky interventions, with long postoperative stay. In the table the complication due to the previous mesh are described. These cases do not and will not be part of any "published" case.

Undoubtedly, they will be part of our case studies on complications, but we will not have any reports in the literature by operating surgeons who often work in small and peripheral hospitals. They sometimes do not even know the complications of their patients.

57.8.1 What Is the border?

Considering the above someone could believe that for the treatment of ventral hernia, there is nothing more effective than the Rives-Stoppa technique. However this is not completely true.

In fact in our experience and in the experience of other surgeons, the indications for a laparoscopic repair of ventral hernia have been restricted, but I believe there will always be a space for the laparoscopic approach.

Laparoscopic surgery, which in our experience is largely adopted for the treatment of most major abdominal diseases, has now strict and limited indications for the treatment of ventral hernia.

It is in our opinion an alternative to the "traditional" technique nowadays enriched by the component separation techniques, which has so helped to "shift" again the interests toward parietal surgery. Nowadays it represents an extra weapon for the surgeon for the ventral hernia treatment:

A list of selected indications for the laparoscopic approach is the following:

1. Small defects (less than 5/6 cm), on a big scar, with a preserved tension of the abdominal wall
2. Recurrences after a Rives repair

The concept is the same as recommended in the guidelines of the treatment of inguinal hernia. In case of recurrence after anterior repair, the posterior approach (laparoscopic) is recommended; in case of recurrence after laparoscopy, an anterior repair is recommended [6].

Of course at the end of the procedure, it is essential to close the trocar sites to avoid further recurrences.

Table 57.1 37 Redo-surgery after intraperitoneal mesh repair of ventral hernia

		%
Mesh adhesion	37/37	100
Recurrence	13/27	35.1
Bowel occlusion(secondary to recurrence)	4/37	11
Infection	19/37	52
Entero-cutaneous fistula	8/37	18.5
Seroma	4/37	11
Mesh migration	2/37	7.4
Mesh shrinkage	36/37	96

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IPOM and IPOM Plus

58

Jan F. Kukleta

A tree that falls makes more noise than the whole forest growing—Tibetan quote

58.1 Preface

By my gut feeling, I expect this book to become a book of recipes – recipes for possibly best surgical cuisine at the time (2017–2018). As I don't have much experience with Gault Millau or Michelin Stars, I expect you to read my contribution to this book as my personal understanding of the topic trying to highlight the best available solution for each individual patient.

The following text describes the actual laparoscopic techniques of abdominal wall defect repair (classic IPOM and IPOM plus) although I am aware of the fact or even convinced that the days of these "modern" techniques are already counted.

58.2 Introduction

Primary abdominal wall (AW) hernias (misleadingly called ventral hernias) and incisional AW hernias (secondary or recurrent) are frequent. The latter being the most common complication of a laparotomy. Three years after laparotomy closure, over 22% of patients develop an incisional hernia [1]. The results of sutured repair of this "trivial condition" are quite poor [2]. The high recurrence rate of suture repair on one side and the growing acceptance of prosthetic meshes in groin hernia repair on the other side both led to a switch of opinion.

Several mesh repair techniques were proposed: The *onlay* repair, as popularized by Chevrel [3], sutures a prosthetic mesh to the anterior rectus sheath after conventional closure. It was used often due to its simplicity. The *inlay* technique sutured the mesh margin with the hernia margin. This technique was abandoned, because of its very high recurrence rates.

The open *intraperitoneal underlay* technique was introduced by McCarthy and Twiest [4] in 1981. The intra-abdominal position of plain polypropylene mesh turned out to be a significant disadvantage due to severe intestine-prosthetic adhesions [5]. The open retro-rectus mesh repair *sublay* published in 1989 by Stoppa [6] became later the standard of treatment of primary or incisional midline hernias. The recurrence rate improved, but the wound complications with or without the mesh withdrawal remained.

The enthusiasm of the success of minimal invasive cholecystectomy prepared the ground for the introduction of minimal invasive AW repair. Karl LeBlanc et al. published their first experience with a laparoscopic technique called IPOM (intraperitoneal onlay mesh) in 1993 [7].

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58.3 IPOM

In order to diminish the wound complications and shorten up the length of hospital stay, the laparoscopic repair reduces significantly the dissection tissue trauma. Nevertheless it is a painful procedure. Laparoscopic IPOM (L-IPOM) consists of the following steps: creation of pneumoperitoneum, adhesiolysis, reposition of hernia contents and removal of the preperitoneal fat prolapse, resection of the "fatty street" in the prospective landing zone (expected mesh position/hernia defect plus the overlap of 3–7 cm), and fixation of a specially designed mesh to the abdominal wall. The defect is not closed and respective hernia sack not inverted or resected. In order to align the mesh with the area to be covered, solid fixation of mesh to fascial or muscular structures by the means of staples, tacks, sutures, transfascial sutures and glues, or combinations of some is necessary. Laparoscopic intraperitoneal onlay mesh repair is a bridging repair, with its entire pros and cons.

58.3.1 Limits and Limitations

Besides physical and medical conditions which restrict the indication range of this approach, L-IPOM is an advanced laparoscopic procedure. It requires specific skills, knowledge, concentration, experience, and a lot of patience.

Limits are physical boundaries (e.g., size); limitations are technical- or patient-related circumstances or risk factors (BMI, adhesions, infection, previous surgeries, poor tool box, etc.).

58.3.1.1 Contraindications

Incarcerated, irreducible hernia, infected intra-abdominal environment, inflammatory bowel disease, excessive adhesions, child-bearing age in females, ascites, and severe coagulopathy are relative contraindications for L-IPOM.

The hernia type, hernia location, and hernia size dictate adaptations and modifications of this otherwise simple procedure.

58.3.1.2 Hernia Type

Solitary hernia vs. Swiss cheese defect (Figs. 58.1, 58.2 and 58.3). In multiple small hernias of the midline, the lateral forces of the oblique musculature are neutralized by the remaining bridges of linea alba. The augmentation mesh is much less exposed to these shear forces, and the mesh fixation devices (sutures, tacks) are less or not mechanically stressed. In contrary in larger solitary defects, the fixed mesh margins are under tension each time the intra-abdominal pressure rises. More stable fixation is required.

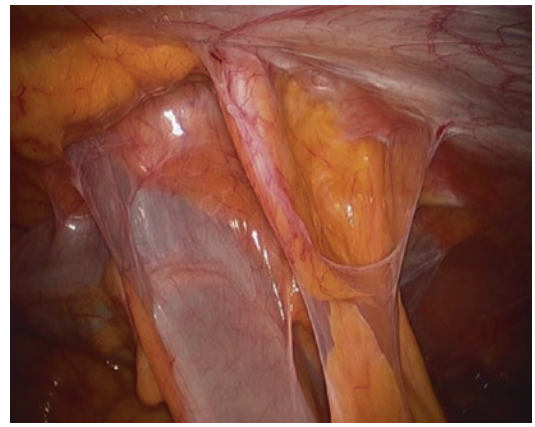

Fig. 58.1 Swiss cheese defect

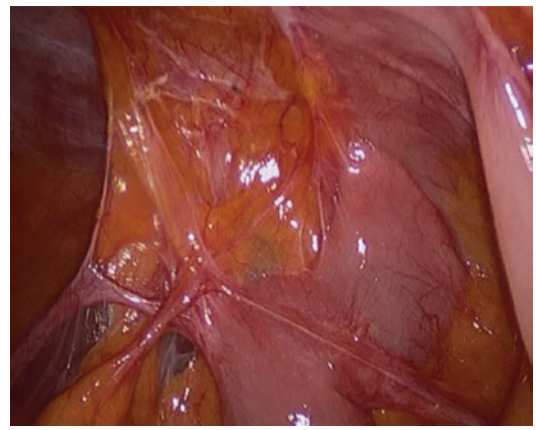

Fig. 58.2 Small solitary hernia

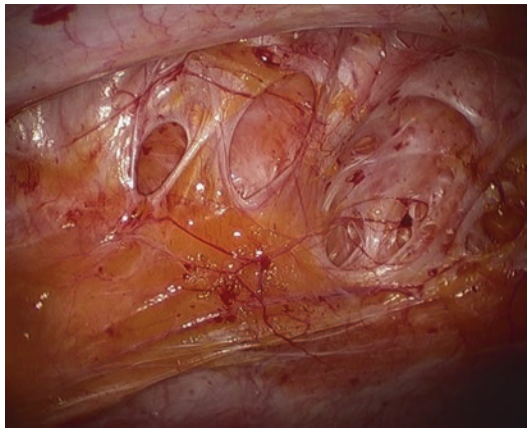

Fig. 58.3 Left subcostal incisional hernia

58.3.1.3 Hernia Location

Periumbilical or epigastric vs. suprapubic or subxiphoidal hernia! Midline vs. lumbar hernia! All these different locations represent an entity themselves regarding the degree of difficulty of repair and their individual prognosis. The classification of primary and incisional abdominal wall hernias reflected this impact under lead of Muysoms F. in 2009 [8]. The proximity of bone structures makes the procedure more complex. It may require bone anchors to guarantee a solid fixation or suture mesh retention in the region of diaphragm.

58.3.1.4 Hernia Size

Size should be understood as a relation of the defect and the remaining abdominal wall (not in absolute cm but "relative cm"). Hernia size is not equal defect size. Hernia size measured in cm^3 volume says how much material has to be accommodated in abdominal cavity. Defect size is measured in cm^2 or cm width and length.

Width is important [8]. Surface of 150 cm^2 may be 10, 15, or 30 cm wide = 10 × 15 cm or 15 × 10 cm or 5 × 30 cm. In hernias of >10 cm width, L-IPOM can be feasible but functionally not the best solution. Bulging, seromas, mesh eventerations, and functional deficit of the displaced abdominal muscles are the consequences.

58.3.1.5 Hernia History

Primary midline hernia vs. incisional hernia after perforated diverticulitis vs. abdominal wall defect after open abdomen treatment in multi-organ injury patients are different entities and require different repair strategies.

58.3.1.6 Patient's Risk Factors

BMI, diabetes, smoking, immunosuppression, and many others increase the risk of complications and recurrence. Weight loss or cessation of smoking at least 2 weeks before and up to 6 weeks after the intervention (better for ever) improves the chances for durable repair.

All above parameters constitute a so-called complexity scale.

Limited surgeon's experience should reflect this subjective scale in order to tailor the best surgical solution for each individual patient according to given circumstances.

58.3.2 Technique

58.3.2.1 Patient's Position

In the majority of cases, the patient is in supine position with arms tucked to the trunk. The arm rests should not elevate the arms in order not to interfere with the free motion of lateral instruments. Depending on the hernia location, partial tilt or lateral decubitus may be of help.

58.3.2.2 Preoperative Measures

Single-shot antibiotic prophylaxis (cephalosporin second generation) is used. If longer operation time is expected or in interventions in lower abdomen or suprapubic area, Foley catheter decompresses the bladder and may be useful for retrograde instillation of a dye in order to localize or rule out a possible bladder injury. Thromboembolic prophylaxis is a routine in Switzerland starting either the evening before the surgery or 4 h postoperatively. Antithrombotic stockings or pneumatic compression stockings per- and postoperatively may be indicated.

58.3.2.3 Safe Pneumoperitoneum

Establishing pneumoperitoneum is the first delicate step. The Hasson's open access, Veress needle, or the use of optical trocar (with or without the previous gas insufflation) is associated with low but realistic risk of injury (Figs. 58.4 and 58.5). Far from the previous scars, far from potential fields of adhesions, and far from big vessels is the cautious strategy. My preferred location of Veress needle puncture is in case of midline hernias left subcostal (lateral of Palmer's point). Preoperative imaging (e.g., CT scan) helps to respect the intra-abdominal anatomy (e.g., large spleen). In difficult conditions a minilaparotomy is the safer procedure [9, 10].

58.3.2.4 First Trocar Insertion

In case of Hasson's approach, blunt trocar is used.

After reaching the intra-abdominal pressure of 12 mmHg when insufflating through Veress needle, I routinely use an optical trocar in the left flank and penetrate the lateral wall in small steps under direct vision. If obstacles are expected, 0° scope and/or safer location may be chosen. After the cavity is safely reached, we change to the 30° endoscope. In any suspicion the entry of the first trocar should be visualized from the inside in order not to miss a possible bowel injury [11].

58.3.2.5 Working Ports

The number and location of further working ports relate to the location and size of the hernia. The majority of ports are 5 mm size, since the quality of visualization of 5 mm scopes improved so far. In case of introducing a very large mesh, bigger trocars can be used. Pulling the mesh with a grasper inserted from the opposite side is easier than pushing it through the trocar. Removing the trocar and pushing the mesh through the wound can lead to contamination and therefore should be avoided.

58.3.2.6 Adhesiolysis

The probability of severe adhesions or the risk of injury when establishing pneumoperitoneum is in primary hernias very low. In contrary in incisional hernias with history of open abdomen, entero-cutaneous fistulas or failed intra-abdominal mesh repair the risk of intestinal injury rises. The extent of adhesions may change the procedure from feasible to maybe not reasonable.

The adhesiolysis carries the risk of vascular or intestinal injury. The worst form of all is the

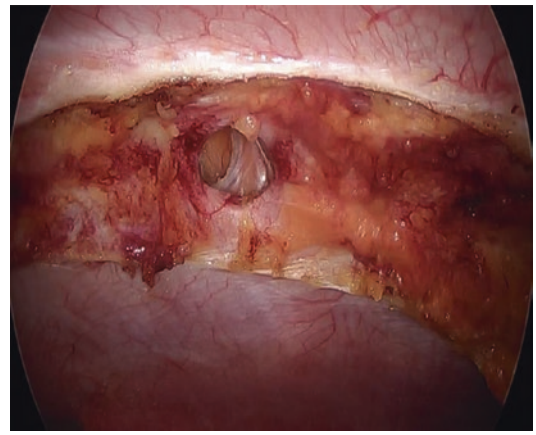

Fig. 58.4 "Classic view"

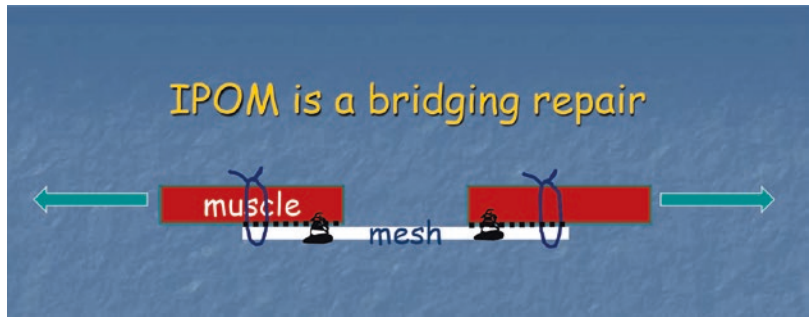

Fig. 58.5 Extensive adhesiolysis required

missed, not recognized, or delayed enterotomy. Gross contamination and spillage of big bowel content may delay the planed intra-abdominal mesh procedure if recognized and treated.

The thermic injury of intestinal wall can delay the onset of peritonitis and all its catastrophic consequences. "Cold scissors"—this was the answer. "No energy source" was the apodictic rule. Despite all videos on social media using Ultrascission®, LigaSure®, or Thunderbeat®, they are great to use, but with caution, being aware of the inherent risk.

The adhesiolysis must clean the abdominal wall for the future mesh position. In general the medial umbilical ligaments, the ligamentum teres hepatis, and ligamentum falciforme are transected and the fatty street in the midline removed in order to guarantee a good mesh contact with aponeurotic structures.

Serosal injuries should be treated by seromuscular sutures immediately. It's often difficult to localize them several minutes later. Due to the elevated intra-abdominal pressure, the spillage of intestinal content is less probable than in open surgery. As the missed enterotomy can have fatal consequences, any doubt must be ruled out.

58.3.2.7 Defect Size Assessment

In order to accomplish a sufficient mesh overlap, the defect size must be known. The measurements should be taken at very low intra-abdominal pressure; the external methods are less accurate than the internal ones (ruler). Realistic measurements enable a wrinkle-free mesh placement with the best available surface contact with the underlying tissue as a capital predisposition for a good tissue in-growth and mesh incorporation.

58.3.2.8 Mesh Choice

There are various mesh products in the market designed for one and only purpose: to enable the tissue in-growth in the parietal mesh surface and to prevent omental or intestinal adhesions to the abdominal interface. The parietal side of such mesh is in general a macroporous nonabsorbable structure (polypropylene or polyester) to facilitate a fast in-growth. If the contact of the parietal mesh side with the abdominal wall is not guaranteed in the first phase of healing (e.g., single-crown fixation, seroma), the later mesh attachment will be incomplete. Some meshes shrink more than the others. Such centripetal traction can cause chronic discomfort or even rip out the marginal fixation (tack hernia, transfascial suture hernia). The individual mesh properties must be considered when planning the repair.

58.3.2.9 Mesh Size

Depending on the defect size and type (see previous text), the mesh should cover and overlap the whole scar or defect by 3–7 cm. The larger the defect, the bigger should be the overlap. Take in account that too small mesh is simply too small although faster and easier to be fixed and too big mesh is more difficult to be adequately fixed. Important advantage of IPOM c is sufficient working space especially when dealing with very large meshes.

58.3.2.10 Mesh Fixation

Mesh fixation in L-IPOM c is still very controversial.

It is necessary to keep up the mesh contact with the underlying "landing zone" at least until the scar tissue in-growth is consolidated. When using microporous meshes, the fixation has to have a life-long character.

Fixation is painful. The bigger the mesh, the more fixation points are necessary. A mesh size of 25 × 15 cm has 80 cm of mesh margin. In order to prevent gaps between the tacks (etc.) and possible small bowel obstruction, some authors recommend tacking steps each 1–1.5 cm. Van't Riet demonstrated that fixing in less than 1.8 cm distance from the next tack doesn't add any additional mechanical stability but pain and cost [12]. Even though it makes roughly 50 tacks in single-crown technique and much more than that in double crown technique, this causes a significant pain, besides the costs.

Next aspect of fixation to be considered is the different length of fixing devices. Spiral tack is 3.9 mm long, AbsorbaTack® 4.1 mm (functionally), Sorbafix® 6.4 mm, and Securestrap® 7.1 mm. The device should reach a solid tissue

(not only the preperitoneal fat), but should not endanger the neighboring structures like pericardium when using the longest device at diaphragm. In such location superficial sutures are the only adequate although tedious solution [11].

The quality of the solid fixation may be related to the size of mesh, number of working ports, the device itself, and the functional distance of the working port and the mesh margin to be fixed. The most difficult to be achieved is the closest margin to the endoscope, generally the 3 o'clock or east position (when standing left of the patient). It is recommendable to place one or two contralateral trocars in order to achieve solid fixation (the major goal of the procedure) of the "difficult margin" rather than making "shortcuts." The tacking fixation is accomplished at the lowest possible intra-abdominal pressure (IAP) >6 mmHg.

Another still disputed issue is the use of transfascial sutures, tacks, or combination of both. Transfascial sutures have much higher tear-off strength than tacks or staples, but they may injure vessels or entrap nerves. Over the time we have learned to use gently tied transfascial sutures to prevent early dislocations still avoiding the chronic pain. In order to guarantee symmetrical overlap (not pushing the mesh away from you), I start the fixation by placing the "north" and "south" in the midline and then tying the transfascial "east." My cardinal transfascial sutures (≥4) are 2-0 PDS—absorbable. In larger meshes (and in patients with significant risk factors), more such sutures are advisable. All other transfascial sutures are tied at the IAP less 6 mmHg or after disinflation.

58.3.2.11 Trocar Incisions Closure

Any working port incision bigger than 5 mm is closed in layers in order to prevent a trocar hernia. In obese patients a mass closure with fascial closure device is attempted. Skin is closed with an absorbable intracutaneous running suture.

58.3.2.12 Postoperative Measures

Abdominal belt is placed before the extubating. Very important step is to avoid massive cough attacks or massive abdominal contractions at the end of the general anesthesia. Adequate pain control is one of the "musts" of this procedure.

58.3.3 Temporary Conclusion

Choosing the name of IPOM was twice misleading. (1) IPOM for abdominal wall hernia repair was a new technique of growing attention; IPOM for groin hernia repair had a short life being abandoned early and rejected in later years. (2) After using the expression "onlay" for epifascial (supraaponeurotic) mesh position and "sublay" for a retro-rectus or preperitoneal mesh position, the laparoscopic IPOM should probably have been called "underlay." The rational of IPOM technique was to diminish the dissection tissue trauma, to lower the risk of infection and to gain the so-called minimal invasive bonus by being faithful to the "tension-free repair" principle. This tension-free strategy/philosophy was a key to success of mesh-based groin hernia repairs both in open and in laparo-endoscopic ones. Not closing the defect but bridging it by vast overlapping prosthetic mesh is a successful concept in TAPP or TEP repair. Applying the same concept to AW hernias experienced several limitations and deficits mostly being caused by the type, the size, and the location of the defect [13].

For better understanding of the following text, I will call this tension-free/bridging repair IPOM classic (*IPOM c*, Fig. 58.6) [9]. Leaving the defect/defects open and cover/overlap them by large prosthetic material gives up the chance of reconstruction of linea alba (LA), not repositioning the muscles to their original anatomy and accepting the functional deficit (lower strength of the trunk, losing the balance between front and back, not protecting the vertebral column from force overload). Bridging repair increases the incidence of seromas, bulging, and eventerations. The bridged area is a dynamic and as such suffers from additional mechanical stress (e.g., bulging or central mesh ruptures). The unloaded oblique muscles are functionally less effective, undergo changes in their muscle fiber type, and tend to become fibrotic (less elastic) over the time. The

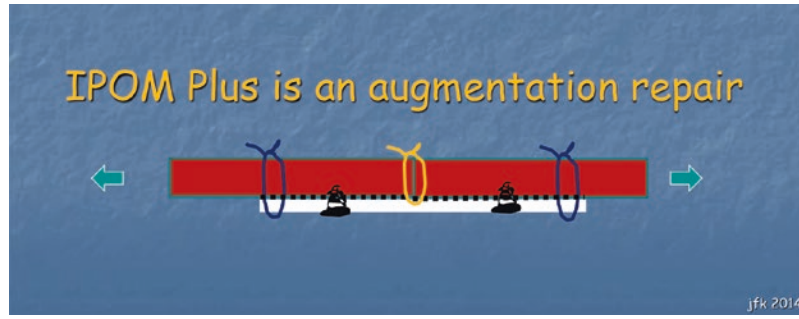

Fig. 58.6 IPOM c—limited contact with abdominal wall

bridging mesh prevents herniation and restitutes the abdominal wall integrity, but not the functionality [13]. The necessary firm fixation of an IPOM c mesh is the guarantee of the repair, but it is painful and costly [11].

Probably the most controversial issue of IPOM is the intraperitoneal position (IP) of the mesh. The meshes appropriate for its intraperitoneal position require different properties than the ones for preperitoneal/extraperitoneal repairs. Such materials have to enable the tissue in-growth on the parietal side and prevent tissue attachments on its visceral side (omental or visceral adhesions). The mesh porosity, responsible for the variable extent of mesh shrinkage, should guarantee a solid tissue in-growth to stabilize the mesh but limit the shrinkage and maintain the physiological elasticity of abdominal wall.

The weakest point of these IP meshes is its visceral interface. The surface is either a nonabsorbable microporous permanent barrier (e.g., e-PTFE) or an absorbable barrier which is absorbed after the natural reperitonealization takes place. IP meshes are expected to prevent adhesions, but they are far from achieving this goal. IP meshes are expensive, they require an expensive and painful fixation (absorbable in case of macroporous meshes, permanent in case of e-PTFE meshes), and they represent a potential risk for late complications (small bowel obstruction, erosion, fistulas, or migration). Any later abdominal reentry requires extreme caution due to possible adherence of viscera to the mesh.

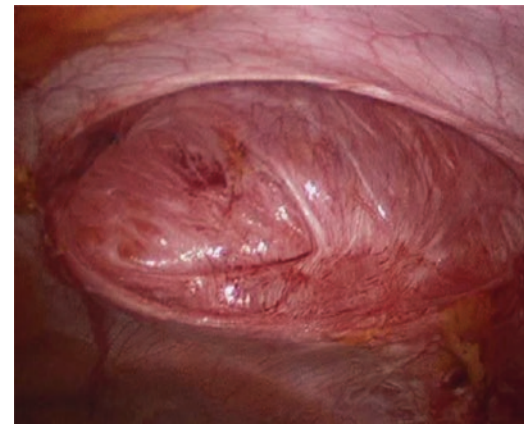

Fig. 58.7 IPOM Plus—full surface mesh contact with abdominal wall

58.4 IPOM Plus

In contrary to IPOM c, the IPOM Plus is an augmentation repair (Fig. 58.7). The author is neither mother nor father of the invention but certainly the facilitator of this procedure and the origin of this designation (2011) [13].

The laparoscopic IPOM Plus is the response to the criticism of the proponents of the open repair. The "plus" is the answer to a justified argument. The reconstruction of linea alba (obvious objective of open repair) aims to reposition the displaced muscles to their original anatomy, enabling its original function. The IPOM Plus technique reconstructs the linea alba by closing the defect first and then adds the mesh support (augmentation repair).

Linea alba is the central tendon of abdominal wall. It represents a primary attachment of rectus muscle and secondary attachment of oblique muscle group. The lateralization of recti in case of diastasis or a true hernia lets the oblique and transverse muscles lose their original tension and turn their action ineffective. This leads to muscular disbalance, pelvic instability, and lower back pain. The re-stretched lateral muscles after reconstruction of the midline regain its physiologic tension which contributes to improved stability of the trunk.

Closing the gap forms a flat lattice which allows full surface contact of the mesh with tissue, avoids the mesh bulging like in IPOM c, and reduces the dead spaces by incorporating parts of the hernia sac in the defect-closing suture (Figs. 58.3, 58.8, 58.9, and 58.10). This decreases the incidence of seroma formation.

Reducing the gap to zero a much wider mesh overlap can be applied, and larger surface contact of mesh with abdominal wall will be achieved. The bigger the overlap, the smaller is the risk of recurrence. The distribution of the tension forces between the suture reconstructing linea alba and the lateral mesh fixation diminishes the resulting shear force.

IPOM Plus is not a tension-free repair. Nevertheless the expected elevated pain perception could not be confirmed in clinical practice [14].

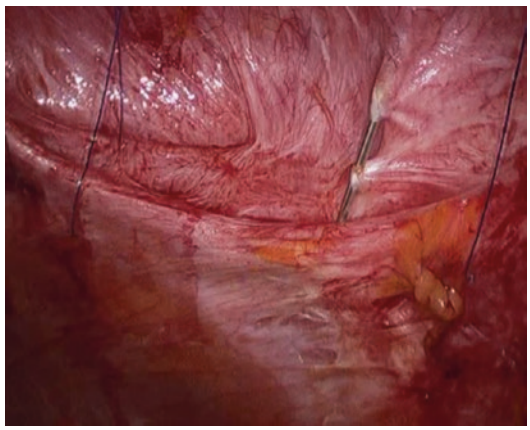

Fig. 58.8 Transcutaneous suturing

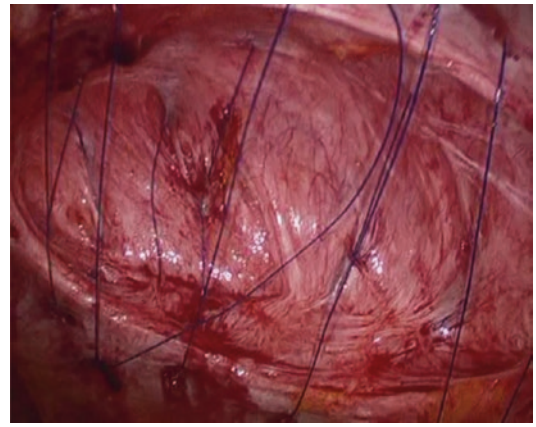

Fig. 58.9 Partial incorporation of hernia sac

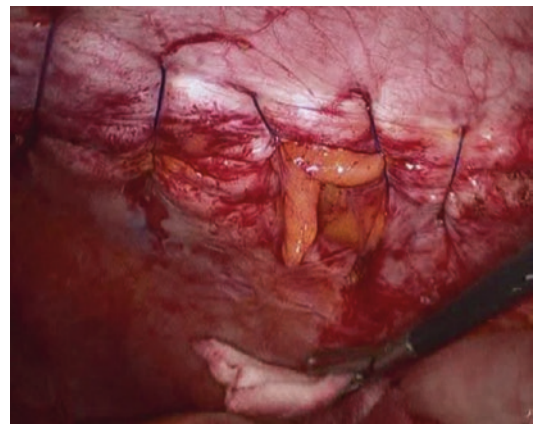

Fig. 58.10 Defect closure at reduced pressure

IPOM Plus is a more solid repair. It reduces the recurrence rate [14–21].

There are different ways on how to close the defect. Transcutaneous transfascial interrupted suture using a suture passer [15, 16, 19, 20] or a large curved needle [17], intracorporeal transperitoneal interrupted sutures with extracorporeal knotting [20], intracorporeal transperitoneal running suture [21], extraperitoneal running suture in MILOS [22], in e-Rives-Stoppa, and in e-Chevrel [23] (Figs. 58.11 and 58.12).

Suturing under endoscopic view can be technically quite demanding. Top-down or bottom-up (surgeon stands behind patient's shoulder or between the legs) suturing of the midline makes the task much easier [21]. This technical hurdle gave space for a proliferation of robotic proce-

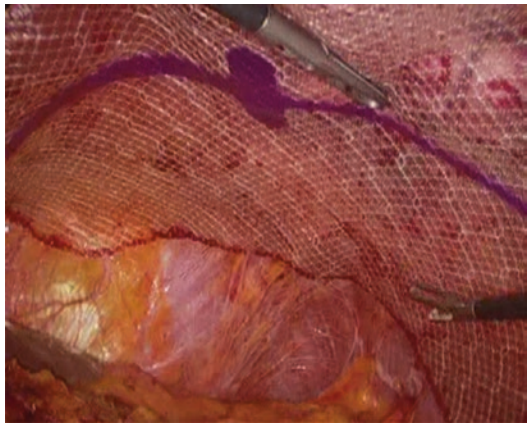

Fig. 58.11 Augmentation mesh

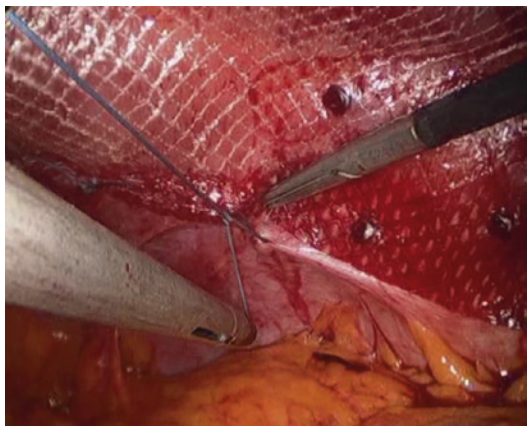

Fig. 58.12 Tack and suture fixation

dures not concerning the true necessity and the cost. One of the most recent developments is a laparoscopic-assisted stapled sublay [24]. The linear stapler separates the linea alba into anterior and posterior planes and closes the defect after it's been freed from content. Conventional macroporous mesh is extended in sublay position and secured with glue, sutures, or tacks. The limit of tensile strength of such repair is not defined yet.

A very unique group of patients, which benefits from IPOM Plus repair, are young women who suffer from postpartum abdominal wall deficiency. The majority of them have well-trained abdominal muscles but increasing low-abdominal bulging the more they exercise. The divarication recti in lower abdomen (>25 mm 2 cm below umbilicus) is a result of incomplete physiological regression to the prepregnancy constellation. The consequence of split recti is a loss of natural stretch of the oblique muscle group. Its stabilizing contraction becomes ineffective, leading to a muscular disbalance of the trunk, pelvic instability, and changes of habitus and posture, and facilitates back pain.

The ideal technique would separate subcutaneous layer from the aponeurotic one in order to advance the muscles to midline without pushing the corresponding subcutis to the midline too and avoid creating a central bulge [25, 26]. In retromuscular dissection the posterior rectus sheath is separated from the anterior one. In this manner a retro-muscular space from above the xiphoid and down to the pubis can be endoscopically developed. Re-sutured peritoneum and the posterior rectus sheath build a floor for simple macroporous mesh deposition without a significant need for fixation (glue or stay sutures). If there is too much tension at closure time and the overlap seems to be inadequate, the transversus abdominis release (TAR) can be added.

The final reconstruction of the anterior rectus sheath should suture only the aponeurotic tissue and not the rectus muscle. Should this most important suture stand under tension, stronger lateral fixation of the mesh with transfascial sutures and tacks are recommended (e-Rives-Stoppa).

In order to differentiate this techniques from the "postmodern" IPOM and IPOM Plus, we can summarize them as "*M*inimally *I*nvasive *N*on-*I*ntraperitoneal *M*esh Repair" *MINIM Repair*.

58.4.1 Discussion

Franklin [15, 16] and Chelala [12] reported early of closing the defect prior to intraperitoneal mesh placement as an obvious element of their repair technique. Kukleta [13] highlighted the importance of reconstruction of Linea alba during the laparoscopic abdominal wall repair within the IEHS guidelines (International Endohernia Society)—guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias [11]. His literature search in 2012 identified 27

relevant articles about defect closure or augmentation repair, but the overall evidence level was low. Nguyen [18] published a systematic review on primary fascial closure with laparoscopic ventral hernia in 2014. Eleven articles met the inclusion criteria. He found no randomized controlled trial, three comparative studies, five of them retrospective, and six prospective. The comparative studies showed that IPOM Plus resulted in lower recurrence rate (0–5.7% vs. 4.8–16.7%) when compared with classic non-closure IPOM. Seroma formation rates were lower in closure group (5.6–11.4% vs. 4.3–27.8%). Clapp et al. [19] examined additionally bulging, chronic pain, functional status. and patient satisfaction. The bulging rate in closure—vs. non-closure group—was 8.3% vs. 69.4%. The scores for patient satisfaction and functional status were higher in the closure group.

The recently published review of IPOM Plus literature of Suwa et al. [27] in 2016 identified 16 reports in which the recurrence rate, incidence of seroma formation, and incidence of mesh bulging were clearly lower in the defect closure group.

Conclusion

Laparoscopic intraperitoneal onlay mesh (IPOM c) was a clear step forward to patient's outcome-centered surgery. Better outcome was the direction to go. As usually when new techniques are introduced, it takes years to refine them and to define the ideal indication and its limits. IPOM Plus is an improvement of IPOM c in certain indications. It is more than logical to close the defects before reinforcing it with mesh. The objective of such repair is not only to prevent further herniation but to restore the functionality of abdominal wall. Again, it has created new "best indications" and recognized the limits.

The available data and its evidence level are still insufficient to draw definitive conclusions. Nevertheless the comparison between standard IPOM and IPOM Plus seems to suggest that IPOM Plus is associated with more favorable surgical outcomes [27]. Until larger-scale studies are conducted, we have to make very thorough patient selection and collect the data prospectively to make our indications and tailoring more precise. Despite the functional advantages of IPOM Plus, the technique is not applicable to all abdominal wall defects.

Both IPOM classic and IPOM Plus have a common weak point: the intraperitoneal mesh and its fixation. There are several techniques how to use an augmenting mesh in extraperitoneal position using minimally invasive approach. Until we'll learn to differentiate their potential and to find out which one fits best to which condition, I would propose to name this new group—"*M*inimally *I*nvasive *N*on-*I*ntraperitoneal *M*esh *R*epair"—*MINIM Repair*.

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59 Incisional Hernia: The Open Approach, Introducing MILA Technique (Minimally Invasive Laparotomy Approach)

Giampiero Campanelli, Piero Giovanni Bruni, Andrea Morlacchi, Francesca Lombardo, and Marta Cavalli

59.1 Introduction

Before the advent of minimally invasive techniques for ventral hernia surgery, optimal access for an open retromuscular repair (Rives-Stoppa-Wantz technique) could only be achieved at the expense of large high morbidity incisions [1]. It should be the aim of the surgeon to employ the type of incision considered to be the most suitable for that particular hernia repair to be performed. In doing so, three essentials should be achieved: accessibility, extensibility, and security [1]. The incision must not only give ready access to the abdominal wall anatomy to be investigated but also provide sufficient room for the operation to be performed [2]. The incision should be extensible in a direction that allow for any probable enlargement of the scope of the operation, but it should interfere as little as possible with functions of the abdominal wall surgery. The surgical incision and the resultant wound represent a major part of the morbidity of the abdominal wall surgery. The incision must be tailored to the patients need but is strongly influenced by the surgeon's preference and experience. For any open incisional hernia repair, the best is to go through the previous laparotomy incision, because this minimizes further loss of tensile strength of the abdominal wall by avoiding the creation of additional fascial defects [3]. Care must be taken to avoid "tramline" or "acute angle" incisions, which could lead to devascularization of tissues. Cosmetic end results of any incision in the body are most important from patient's point of view. Consideration should be given wherever possible, to siting the incisions in natural skin creases or along Langer's lines. Good cosmesis helps patient morale. Much of the decision about the direction and the length of the incision depends on the type of hernia defect and the previous scar position but also on the shape of the abdominal wall. Traditionally, for an open retromuscular ventral hernia repair, a generous midline laparotomy is required, but there are some cases in which it is possible to adopt our MILA (minimally invasive laparotomy approach) technique with the same excellent results. Elliptical incisions can be used to incorporate previous scars, skin ulcerations, and/or defects.

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For most, and especially morbidity obese, patients with large midline hernias, an excision of the umbilicus to minimize postoperative wound morbidity is possible.

One of the goals of the minimally invasive laparotomy approach (MILA) is to avoid dissecting the subcutaneous tissue overlying the anterior rectus sheath and the vessels that penetrate the rectus abdominis muscle, thereby minimizing subcutaneous dead space and improving vascularity and innervation of the overlying skin. The inferior epigastric vessels penetrate the inferior lateral aspect of the rectus abdominis muscle and travel through the muscle, branching off into myocutaneous perforating vessels that provide vascular supply to the overlying abdominal skin and subcutaneous tissue.

Through MILA, the surgeon can also perform a minimally invasive open-component separation (MIOCS) with a posterior approach (Fig. 59.1), for gaining more advantage in closing the anterior compartment (anterior rectus sheath and rectus abdominis) in the midline over the implanted mesh without any dissection of the subcutaneous tissues, allowing at the same time a careful nerve sparing (Fig. 59.2). The external oblique, internal oblique, and transversus muscles insert laterally into the rectus abdominis complex. With a MIOCS, the anterior compartment is released without disrupting the subcutaneous tissue attachments to the anterior rectus sheath and the rectus abdominis perforating vessels within the anterior rectus sheath. The transversus and internal oblique musculature remains attached to the posterior compartment (posterior rectus sheath and transversalis fascia; Figs. 59.3 and 59.4) and vascularized and innervated by the intercostal neurovascular bundles [4].

Also a transversus abdominis release (TAR) can be performed through a minimally invasive laparotomy approach: this additional technique can be very helpful when a real loss of substance is found in the posterior compartment of the abdominal wall (Fig. 59.5), to fill the gap between the two posterior rectus sheaths in the midline without tension on the suture.

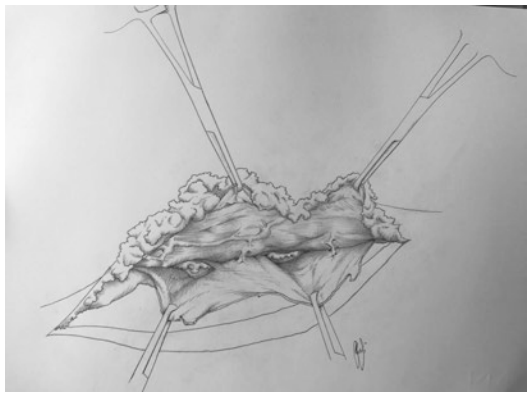

Fig. 59.1 Open anterior component separation by posterior approach with sparing of the subrectal neurovascular bundles

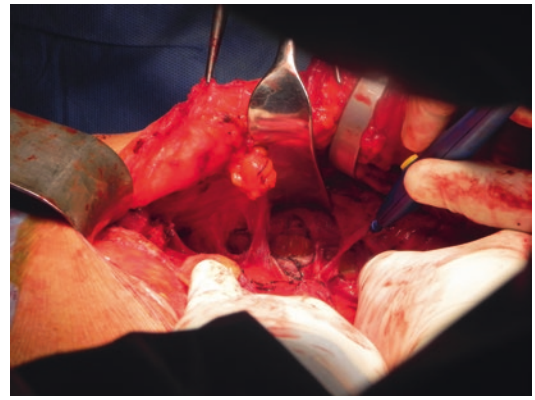

Fig. 59.2 Sparing of the neurovascular bundles under the lower face of rectus abdominis muscle, close to the linea semilunaris, during open anterior component separation

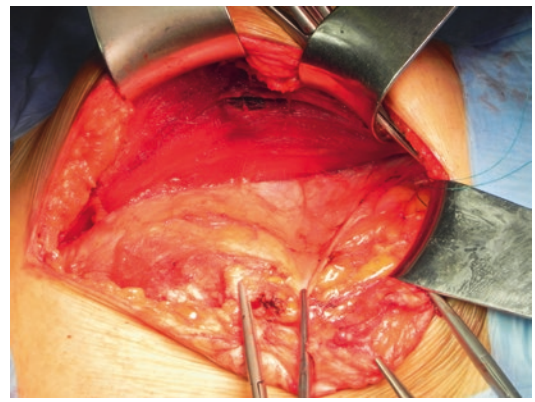

Fig. 59.3 View after isolation of posterior rectus sheath

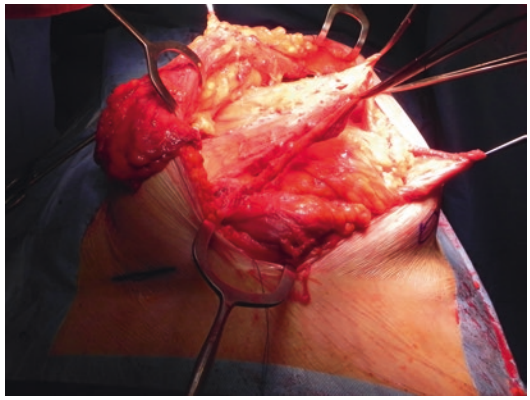

Fig. 59.4 After its isolation, the posterior compartment is pulled to the midline

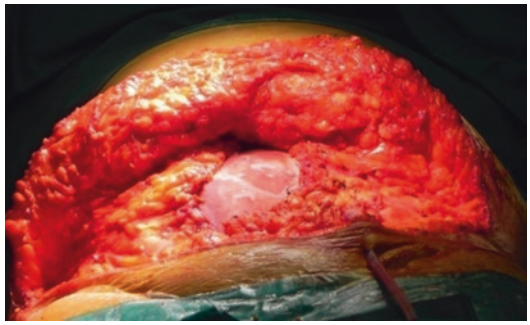

Fig. 59.5 Real loss of substance in the posterior compartment

EHS Incisional Hernia Classification			
Midline	subxiphoidal	M1	
	epigastric	M2	
	umbilical	M3	
	infraumbilical	M4	
	suprapubic	M5	
Lateral	subcostal	L1	
	flank	L2	
	iliac	L3	
	lumbar	L4	
Recurrent incisional hernia?		Yes O	No O
length:	cm	**width:**	cm
width: cm	**W1** <4cm O	**W2** ≥4-10cm O	**W3** ≥10cm O

Fig. 59.6 EHS incisional hernia classification

59.2 Surgical Indications

The MILA is an advanced technique that can be adopted for the repair of any small-/medium-sized midline incisional hernia (with a maximum diameter of less than 10 cm: W1-2 by EHS classification; Fig. 59.6), primary or recurrent ventral hernia defects (as umbilical and epigastric hernia), and diastasis recti in a normal BMI patient.

59.3 Surgical Technique

The surgeon is sitting on a surgical chair at the side of the patient and may benefit from using an endoscope and/or a frontal source of light in order to have a better view of the operation field through a smaller incision.

After incision of the skin, which length shall be of approximately 3–5 cm for smaller hernia defects in thin patients, up to about 8–10 cm for more voluminous ones and for less thin patients (Fig. 59.7), a complete lysis of all visceral adhesions to the anterior abdominal and pelvic wall is performed. This is particularly important in those cases where dissection lateral to the linea semilunaris (TAR) is foreseen. Interloop adhesions are typically ignored.

The next step is identification of the fascial edges in the midline; this could be performed by undermining the skin and subcutaneous fat until healthy rectus abdominis anterior fascia is found or by approaching posteriorly the junction between the anterior and posterior rectus sheet. It is important to do this very carefully and not to confuse dense scar tissue from healthy fascia.

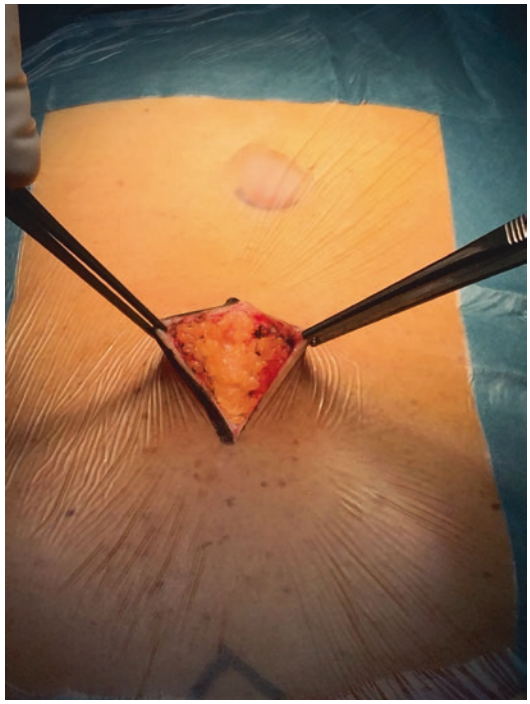

Fig. 59.7 Size of skin incision during MILA

After this step, undermining should continue until the lateral edge of the rectus abdominis is seen. The incision of the anterior rectus sheath at the midline shall be made after a careful isolation of the hernia defect and the lysis of adhesions between the sac and the subcutaneous space; its extension must be generous cranially and caudally to the defect itself and can be adapted case by case with a tailored approach. A complete or partial excision of all previously placed mesh is not always necessary.

To dissect the retromuscular space to the linea semilunaris, the posterior rectus sheath is incised sharply about 0.5 cm from its edge. The retromuscular plane is than developed using a combination of blunt dissection and electrocautery. The lateral extent of this dissection is the linea semilunaris, confirmed by visualizing the junction between the posterior and anterior rectus sheaths and the lateral face edge of rectus muscle. Careful identification of the intercostal nerves and vessels and all neurovascular bundles is critical to maintaining an innervated functional abdominal wall (Fig. 59.8).

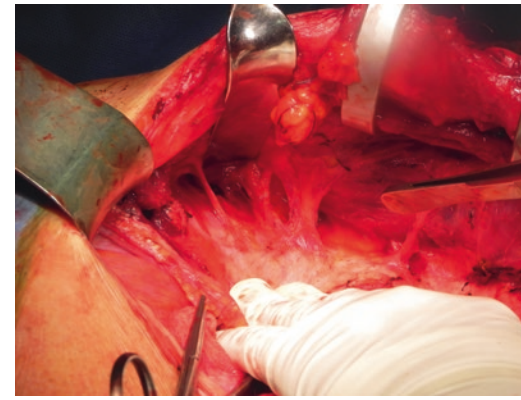

Fig. 59.8 Nerve sparing during open incisional ventral hernia repair

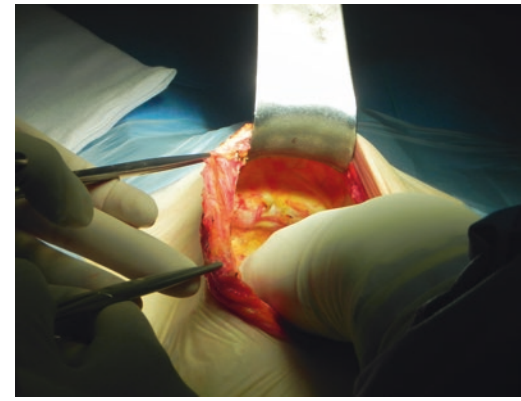

Fig. 59.9 Exposure of the pubis symphysis and both Cooper's ligaments during MILA

Inferiorly, the space of Retzius can be entered to expose the pubis symphysis and both Cooper's ligaments (Fig. 59.9). The dissection is blunt in what is typically a bloodless plane. Since this area is below the arcuate line, posterior layer includes peritoneum and transversalis fascia only. Because both of these layers are thin, fenestrations of peritoneum are not uncommon and should be repaired. Care should be taken to identify and preserve inferior epigastric vessels that course along the deep surface of the rectus muscles protected by transversalis fascia: both must remain toward the muscle during dissection of preperitoneal space. Up to the subxiphoid space (Fig. 59.10), the retromuscular plane can be extended cranially to the costal arch (going

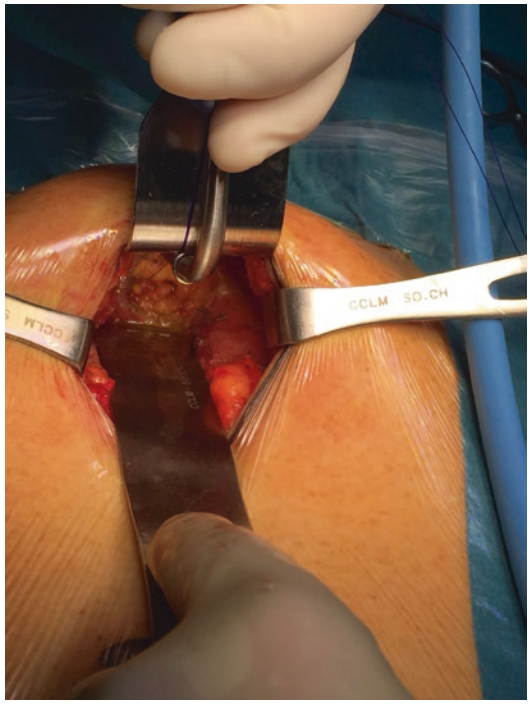

Fig. 59.10 Exposure of the "fatty triangle" in the subxiphoid space during MILA

behind it) and to the retroxiphoid/retrosternal areas until the "fatty triangle" will be seen [5] and 5 cm of xiphoid will be exposed.

Laterally, the surgeon can perform an extension of the retromuscular plane with a minimally invasive anterior open-component separation (MIOCS) made by a posterior approach, for a better anterior compartment mobilization: the lateral edge of the posterior rectus sheath and the common insertion of oblique muscles are incised, realizing a complete anterior compartment separation by retrorectus approach avoiding the subcutaneous dissection. The neurovascular bundles dividing to the abdominal musculature and traversing this plane must be always preserved to prevent denervation of the rectus muscles. This technique provides a significant anterior compartment release and its advancement to the midline, firstly avoiding too much tension on the suture after closing the linea alba but also allowing a better medialization of the rectus muscles (correcting the diastasis) and the placement of a larger prosthetic reinforcement [6] (Figs. 59.11 and 59.12).

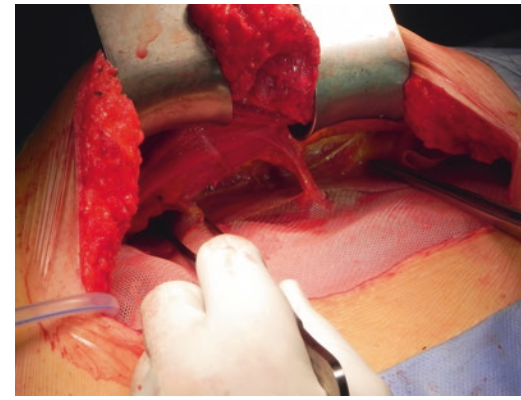

Fig. 59.11 Lateral extension of the mesh after open anterior component separation

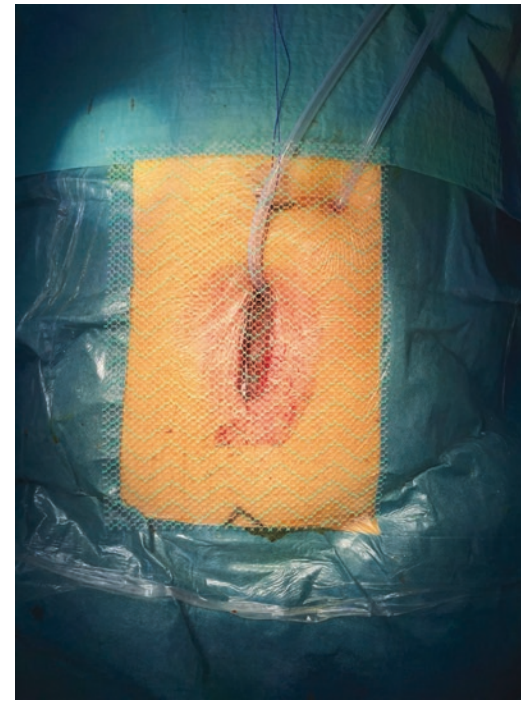

Fig. 59.12 Mesh size before implantation during MILA

A posterior component separation with transversus abdominis release (TAR) (Fig. 59.13) can be performed at the aim to achieve a significant medial advancement of the posterior compartment [7], particularly indicated for those patients undergoing major abdominal wall reconstructions for incisional hernia with real loss of substance in the poste-

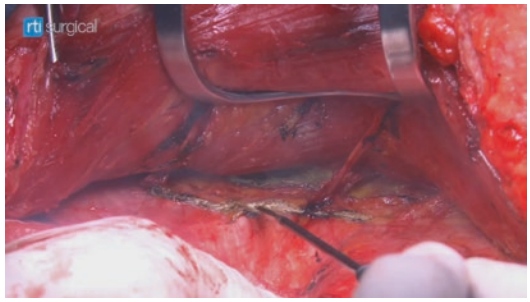

Fig. 59.13 Posterior rectus sheath incision during TAR

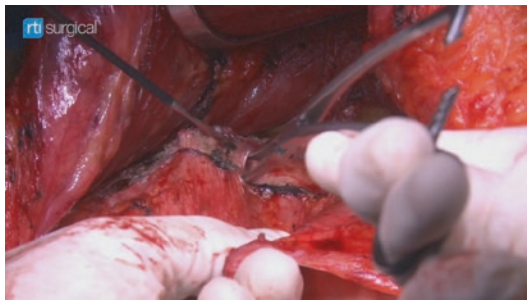

Fig. 59.14 Open transversus abdominis release

rior compartment: starting in the upper third of the abdomen, about 0.5 cm medial to the neurovascular bundles close to the anterior/posterior rectus sheath junction (linea semilunaris), the posterior rectus sheath is incised to expose the underlying transversus abdominis muscle (Fig. 59.14). The muscle is than divided along its entire medial edge using electrocautery. The use of a right-angled dissector significantly minimizes injury to the underlying transversalis fascia and peritoneum. TAR also has the aim to release the circumferential muscle tension, facilitating a better expansion of the abdominal cavity and decreasing the intraabdominal pressure [7].

Once release is performed on both sides, the posterior compartment is reapproximated in the midline with a running monofilament suture.

The mesh is placed in the retrorectal space under appropriate physiologic tension (Rives-Stoppa technique) for all those cases that can be managed without the need of a MIOCS; if a MIOCS has been performed, the prosthesis can be inserted laterally to the linea semilunaris between external and internal oblique muscles (Fig. 59.15) or in the subcutaneous space anteriorly to the external oblique aponeurosis (Fig. 59.16), with enough overlap (>5 cm). If a TAR has been done, the lateral edge of the mesh should be extended under the transversus muscle (Fig. 59.17), at least 5 cm laterally to the line of incision of TAR. A good overlap laterally to linea semilunaris is of crucial importance to avoid the destabilization of the abdominal wall when a MIOCS and a TAR are both required.

For large abdominal wall reinforcements, inferiorly, the prosthesis can be secured to Cooper's ligaments using two interrupted monofilament absorbable sutures, and superiorly it could be placed in beyond the costal margin and in the retroxiphoid space, secured with interrupted absorbable sutures in the xiphoid process (placed 4–5 cm off the edge of the mesh itself to allow for enough overlap).

Both synthetic and biologic meshes can be used in complex repairs (when a real loss of substance is found) even if posterior component release has been performed [8]. Indeed to avoid the consequences of adhesions, microporous synthetic mesh should not be placed directly onto the intraperitoneal viscera. A biological mesh can be used to fill the gap when a real loss of substance is found on the posterior compartment and secured to the posterior rectus sheath with a circumferential bridging suture (Fig. 59.18). A second, nonabsorbable mesh will lie on it in the retromuscular space, and it could be fixed only with fibrin glue sealant [9] (Fig. 59.19).

Drains are placed ventral to the mesh; subcutaneous drains are used selectively after reconstruction of the linea alba with a running, slowly absorbable suture.

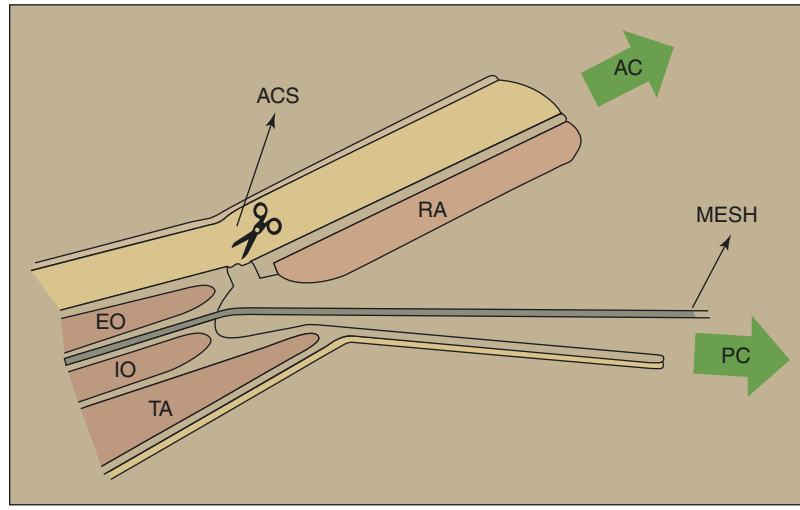

Fig. 59.15 Mesh laterally inserted between external and internal oblique muscles after open anterior component separation

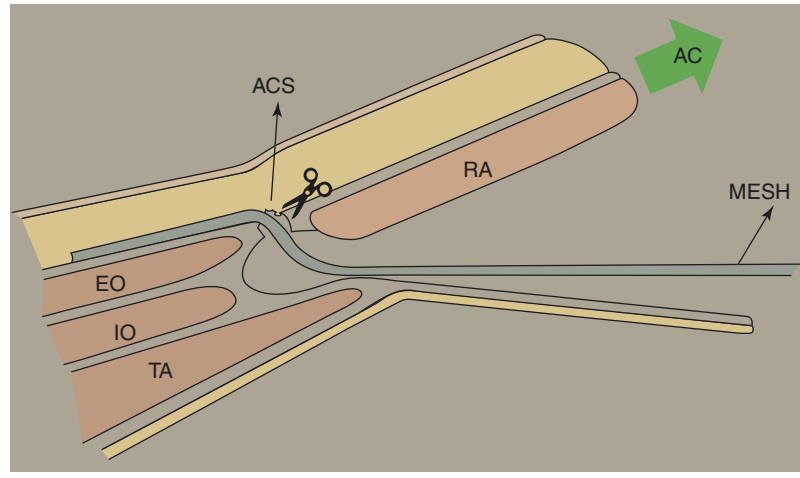

Fig. 59.16 Mesh laterally inserted over the external oblique aponeurosis, in the subcutaneous space, after open anterior component separation

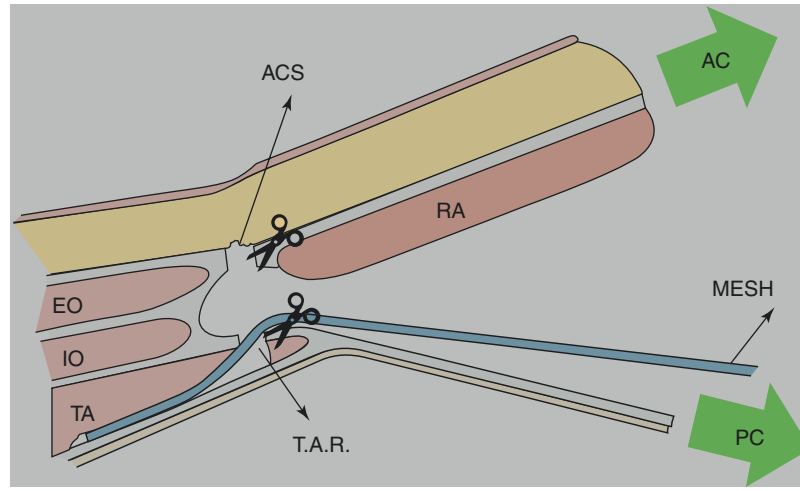

Fig. 59.17 Mesh laterally inserted under the transversus abdominis muscle, after open anterior component separation and TAR

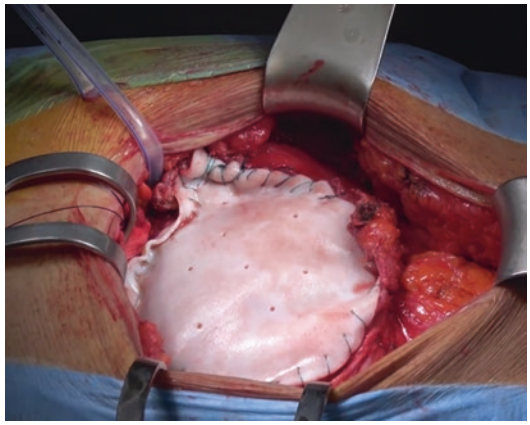

Fig. 59.18 Biological mesh filling a real loss of substance into the posterior compartment

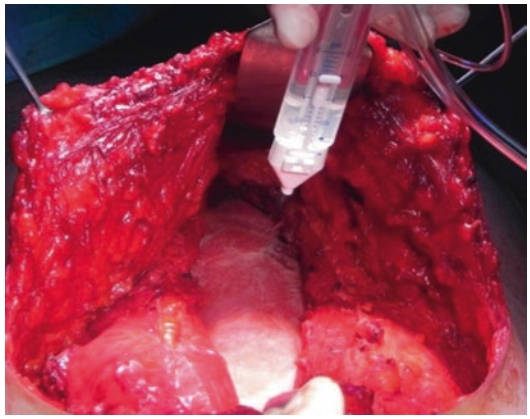

Fig. 59.19 Mesh fixation with fibrin glue during open incisional hernia repair

59.4 Tips and Tricks

- Component separation should be performed only when useful and quite necessary.
- Especially for the repair of diastasis recti, it's suggested to run an inverting monofilament suture for closing the anterior rectus sheaths in the midline by posterior way along all the length of wall: this allows to obtain a better reapproximation of the two muscles and to restore the linea alba further reducing dead spaces above the implanted prosthesis.
- After minimally invasive anterior component separation (MIOCS) performed by posterior approach, small tailored windows should be cut on the lateral edge of the mesh at the aim to preserve the spared neurovascular bundles supplying rectus muscles near the linea semilunaris to be touched by the prosthesis itself after implantation (Fig. 59.20).

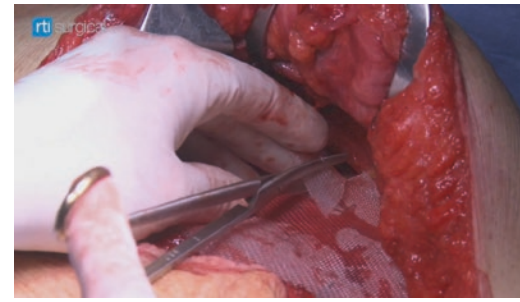

Fig. 59.20 Tailored cutouts on the lateral edge of the mesh

59.5 Outcomes

Retromuscular (Rives-Stoppa-Wantz) repair has been shown to result in an effective repair of most ventral hernias. The reported recurrence rates are low (from 3% to 6% at mid- to long-term follow-ups), and this approach has been proclaimed to be the golden standard for open ventral hernia repair worldwide [10, 11].

MILA represents an evolution of this concept of repair and gives the chance not only to achieve the same reliable long-term outcomes but even better results by further reducing the postoperative overall impact on the patients, morbidity, aesthetical aspects, and hospitalization costs included.

Moreover, MILA is a new concept of abdominal wall repair challenging IPOM-LAP approach, with the great advantage of a safe positioning (out cavity) of mesh, such as MILOS and EMILOS techniques [12, 13].

Perfect and deep knowledge of abdominal wall anatomy is mandatory.

Particular care should be given to the correct preoperative evaluation of each single case. Indeed the hernia surgeon shall always consider the age of the patients, their lifestyle,

and expectations, that particular constitution, the exact type of hernia defect he has to repair, the presence of comorbidities or contraindications, and even psychological and cosmetic factors, in order to realize a perfect tailored approach.

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Component Separation: Options and Techniques

60

Ivy N. Haskins and Michael J. Rosen

60.1 Introduction

The management of large abdominal wall defects remains a clinical challenge for both general and plastic surgeons. In order to be effective, abdominal wall reconstruction must achieve four goals, including (1) prevention of visceral eventration, (2) dynamic and functional muscle support, (3) adequate soft tissue coverage, and (4) tension-free repair [1]. Prior to the original component separation technique described by Ramirez in 1990, the closure of large abdominal wall defects relied on the transfer of myocutaneous flaps, free tissue transfer, or a bridged repair with mesh [2]. Myocutaneous flaps and free tissue transfer adequately achieve the four goals of abdominal wall reconstruction but at the expense of additional morbidity at the tissue donor site, prolonged hospital lengths of stay, and ventral hernia recurrence rates as high as 40% [1, 3–5]. Routine bridging hernia repair is unable to achieve the four goals of abdominal wall reconstruction as it cannot reproduce the dynamic and functional support provided by the abdominal wall musculature and it, too, is associated with high recurrence rates [1, 6].

In response to these observations, Ramirez proposed the component separation technique as a means to facilitate complex abdominal wall reconstruction with the use of autologous abdominal wall tissue [2]. Since the original description of the component separation technique, several modifications have been proposed to this technique. Herein, we will detail the key steps, advantages, and disadvantages of the anterior component separation technique, the periumbilical perforator-sparing component separation technique, the laparoscopic component separation technique, and the posterior component separation technique.

60.2 Anterior Component Separation Technique

60.2.1 Key Steps to the Procedure

1. The procedure begins with midline entrance into the abdominal wall cavity with lysis of adhesions performed, as needed.
2. Elevation of the skin and subcutaneous tissue off of the abdominal wall musculature is performed. This proceeds from a medial to lateral direction on both sides of the abdominal wall and should extend to the anterior axillary line.
3. The linea semilunaris is identified by manually palpating the lateral edge of the rectus muscle belly. A vertical incision is made approximately 2 centimeters (cm) lateral to the linea semilunaris into the external oblique aponeuro-

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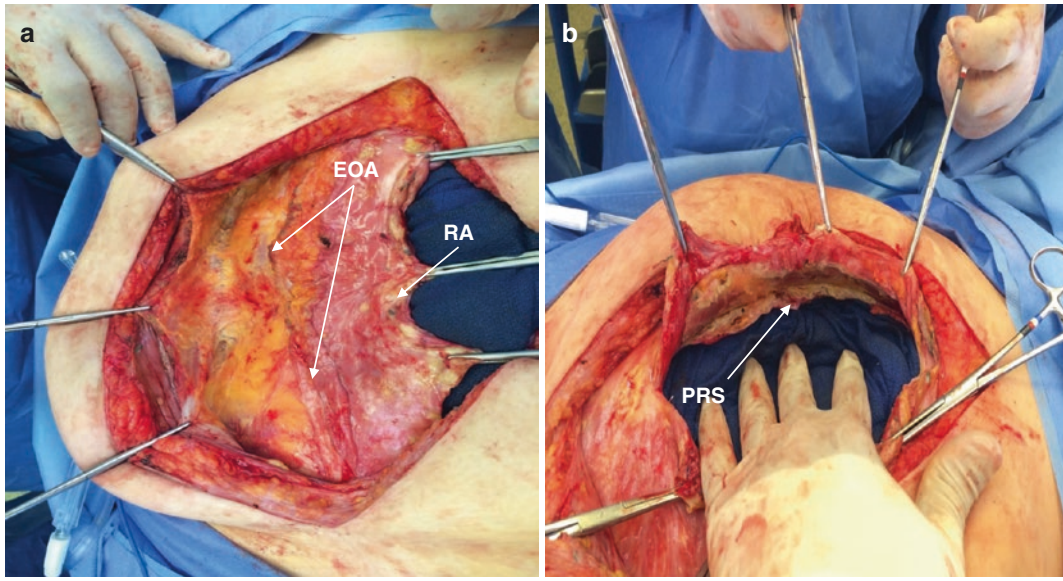

Fig. 60.1 Anterior components separation technique. (**a**) The external oblique aponeurosis (EOA) is incised from the costal margin to the inguinal ligament, allowing for medial movement of the rectus abdominis (RA) muscle for closure of the hernia defect. (**b**) Demonstration of posterior rectus sheath (PRS) incision that can be performed if the hernia defect cannot be closed with incision of the EOA only

sis. Care should be taken at this point to identify and preserve the internal oblique muscle. This incision is advanced from the costal margin to the inguinal ligament (Fig. 60.1a).

4. The avascular plane between the external and internal oblique muscles is developed using blunt dissection, with extension to the anterior axillary line.
5. If additional mobilization is needed, the posterior rectus sheath should be incised approximately 0.5 cm from its edge, with dissection of the rectus muscle off of the posterior rectus sheath (Fig. 60.1b).
6. At this point, the ability to close the abdominal wall is tested. To do this, Kocher clamps are applied to the anterior rectus fascia on either side of the abdominal wall and pulled toward the midline. The anterior component separation technique, with separation of the external oblique from the internal oblique and separation of the posterior rectus sheath from the rectus abdominis muscle, should allow for closure of defects up to 20 cm wide at the umbilicus in patients with a compliant abdomen [2].
7. The decision for mesh reinforcement and the location of mesh placement is determined. The options for mesh placement include intraperitoneally, in the retrorectus space, or as an onlay. For retrorectus mesh placement, additional mobilization of the posterior rectus sheath is often required. Once the pocket for the mesh has been developed, the posterior rectus sheath should be closed using a running, absorbable suture and the mesh placed into the retrorectus space above the posterior rectus sheath but below the rectus abdominis muscle. The mesh is then secured using multiple interrupted transfascial absorbable sutures. For intraperitoneal mesh placement, one should keep in mind that the mesh should be secured laterally on the abdominal wall in order to prevent wrinkling of the mesh when the midline is brought back together. Furthermore, since this mesh is in contact with the abdominal viscera, one should use either a protected synthetic mesh, a bioabsorbable mesh, or a biologic graft depending on the hernia type and wound classification. For onlay mesh placement, the

linea alba is re-approximated first with a running, slowly absorbable suture after which the mesh is placed on top of the anterior rectus sheath. When mesh is used for reinforcement of the hernia repair, irrespective of the location, one should ensure adequate coverage of the linea alba (at least 5 cm on either side) to reduce the risk of hernia recurrence [7, 8]. Furthermore, some surgeons advocate reinforcing the external oblique releases which may require placement of a larger mesh.

8. Placement of closed suction drains for management of postoperative seroma/dead space in the setting of mobilization of large lipocutaneous flaps. These drains are often placed at the site of component separation in addition to a midline drain, for a total of three drains placed. However, the number and location of drain placement is surgeon dependent.
9. The midline skin incision is closed in layers in the usual fashion.
10. Placement of an abdominal binder is routinely performed, which is worn throughout the perioperative period up to 6 weeks postoperatively.

60.2.2 Advantages and Disadvantages of This Procedure

The anterior component separation must be given appropriate credit for achieving the goals of abdominal wall reconstruction while circumventing the morbidity encountered with myocutaneous flaps, free tissue transfer, and bridging mesh repair. Nevertheless, the anterior component separation technique is associated with wound morbidity rates as high as 40% due to the large subcutaneous flaps created and sacrifice of abdominal wall vasculature that is inherent to this procedure [9, 10]. Furthermore, this procedure has been associated with hernia recurrence rates as high as 20% [11, 12]. While this recurrence rate is lower than the historical rates of primary tissue repair, myocutaneous flaps, free tissue flaps, and bridging mesh repair, a long-term ventral hernia recurrence rate of 20% is still high to most surgeons and patients. This high recurrence rate is likely multifactorial and related to (1) the associated wound morbidity of this procedure and (2) the common use of biologic grafts at the time that this procedure was first adopted [13, 14].

60.3 Periumbilical Perforator-Sparing Anterior Component Separation Technique

60.3.1 Key Steps to the Procedure

1. The procedure begins with midline entrance into the abdominal wall cavity with lysis of adhesions performed, as needed.
2. The primary tenet of this procedure is to preserve the periumbilical perforating vessels that branch off the deep inferior epigastric vessels which supply the medial aspect of the abdominal wall. They typically occur within 3–5 cm of the umbilicus. Elevation of the skin and subcutaneous tissue off of the abdominal wall musculature is performed. *This part of the procedure is different from the originally described anterior component separation* and involves division of the subcutaneous tissue planes on either side of the midline into two parts—one superior to the umbilicus and one inferior to the umbilicus. The superior subcutaneous tissue plane is developed first. This begins at the superior aspect of the wound and ends approximately 5 cm above the umbilicus. The inferior subcutaneous tissue plane is then developed, starting at least 5 cm below the umbilicus and extending to just above the pubis. Both the superior and inferior subcutaneous flaps are extended to the anterior axillary line and connected at least 5 cm lateral to the umbilicus to allow for complete exposure of the linea semilunaris and external oblique aponeurosis (Fig. 60.2).
3. The linea semilunaris is identified. A vertical incision is made approximately 2 cm lateral to the linea semilunaris into the external

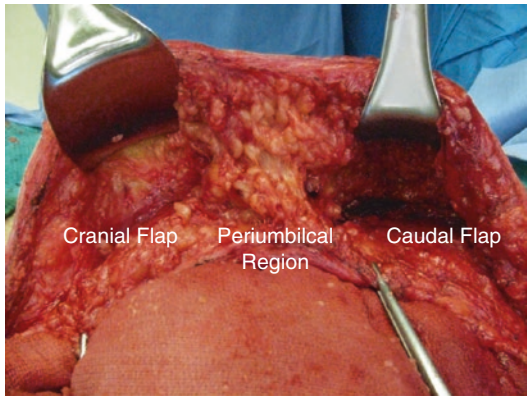

Fig. 60.2 Periumbilical perforator sparing anterior components separation technique. The skin and subcutaneous tissue within a 5 cm radius of the umbilicus is left intact with creation of a cranial and caudal flap. These flaps are connected along the lateral aspect of the abdominal wall in order to expose the linea semilunaris and the external oblique aponeurosis

oblique aponeurosis. This incision is advanced from the costal margin to the inguinal ligament.

4. The avascular plane between the external and internal oblique muscles is developed using blunt dissection, with extension to the anterior axillary line.
5. If additional mobilization is needed, the posterior rectus sheath should be incised approximately 0.5 cm from its edge, with dissection of the rectus muscle off of the posterior rectus sheath.
6. At this point, that ability to close the abdominal wall is tested. To do this, Kocher clamps are applied to the anterior rectus fascia on either side of the abdomen and pulled toward the midline. This modification to the original anterior component separation technique still separates the external oblique from the internal oblique and the posterior rectus sheath from the rectus abdominis muscle, which should allow for closure of defects up to 20 cm wide [15].
7. The decision for mesh reinforcement and the location of mesh placement is determined. The options for mesh placement and the considerations for mesh overlap of the linea alba are the same as for that of the anterior component separation technique.
8. Placement of closed suction drains for management of postoperative seroma/dead space in the setting of mobilization of lipocutaneous flaps. These drains are often placed at the site of component separation in addition to a midline drain, for a total of three drains placed. However, the number and location of drain placement is surgeon dependent.
9. The midline incision is closed in layers in the usual fashion.
10. Placement of an abdominal binder is routinely performed, which is worn throughout the perioperative period up to 6 weeks postoperatively.
11. There are other modifications that can be used during periumbilical perforator-sparing component separation, including making small counter incisions in the upper abdomen near the costal margin to gain access to the lateral abdominal wall in order to further decrease the subcutaneous flap size.

60.3.2 Advantages and Disadvantages of This Procedure

The periumbilical perforator-sparing anterior component separation was proposed as a means to decrease the ischemic midline wound morbidity associated with the original anterior component separation technique [15]. The theory behind this technique is that by preserving the perforator vessels to the umbilicus, there is a potential for improved midline wound healing due to adequate perfusion of the umbilicus, subcutaneous tissue, and underlying rectus muscle [16]. Nevertheless, large lateral subcutaneous flaps are still created in order to facilitate the component separation aspect of this procedure which is associated with significant dead space, and therefore the risk of seroma formation is relatively unchanged [9, 17]. Furthermore, the preserved perforator vessels can be within the redundant skin that is often excised during this procedure [16, 18].

60.4 Laparoscopic/Endoscopic Component Separation Technique

60.4.1 Key Steps to the Procedure

1. The procedure begins with midline entrance into the abdominal wall cavity with lysis of adhesions performed, as needed.
2. The surgeon and assistant then move to the same side of the operating room table in order to perform the laparoscopic component separation.
3. A 1 cm incision is made just inferior to the costal margin lateral to the rectus abdominis muscle.
4. Blunt dissection is used to divide the subcutaneous tissues until the external oblique muscle is identified.
5. The external oblique muscle is grasped with two Kocher clamps and incised in the direction of its fibers.
6. The fibers of the external oblique are divided until the internal oblique muscle is identified.
7. The avascular space between the internal and external oblique muscles is then developed using a laparoscopic inguinal hernia balloon dissector. Once this space is developed, a 10 millimeter (mm) balloon port is inserted through the original incision to maintain insufflation of 12 mm of mercury (Hg).
8. Two 5 mm ports are placed, one lateral to the umbilicus along the posterior axillary line and one just superior to inguinal ligament and lateral to the rectus abdominis muscle.
9. Using blunt dissection with laparoscopic tools, the space between the external and internal oblique muscles is developed lateral to the rectus abdominis muscle and medial to the posterior axillary line.
10. Once this space is developed, the linea semilunaris and the external oblique aponeurosis can be appropriately visualized. Using coagulating scissors, the external oblique aponeurosis is incised and released, beginning at the costal margin and extending to the inguinal ligament.
11. If additional mobilization is needed, the posterior rectus sheath should be incised approximately 0.5 cm from its edge, with dissection of the rectus muscle off of the posterior rectus sheath.
12. The original description of this procedure used intraperitoneal mesh placement for reinforcement of the hernia repair [9]. As previously discussed, one should keep in mind that the mesh will be in contact with the abdominal viscera and that it should be secured laterally on the abdominal wall under tension in order to prevent wrinkling of the mesh when the midline is brought back together.
13. Placement of closed suction drains is performed, often at the site of lateral component separation and one in the midline, for a total of three drains placed. However, the number and location of drain placement are surgeon dependent.
14. The midline and linea alba is recreated using a running, slowly absorbable suture.
15. The midline incision is closed in layers in the usual fashion.
16. Placement of an abdominal binder, which is worn throughout the perioperative period.

60.4.2 Advantages and Disadvantages of This Procedure

The major advantage to the endoscopic component separation technique is that the lateral compartment, including the external oblique and internal oblique muscles, can be directly accessed using minimally invasive techniques without the creation of large subcutaneous flaps [9, 17, 19, 20]. Direct access to the site of component separation preserves the perforator blood supply to the abdominal wall and minimizes dead space formation, effectively reducing the risk of postoperative wound events. Indeed, a recent meta-analysis comparing open component separation to endoscopic component separation revealed a statistically significant decrease in

postoperative wound events following endoscopic component separation, with rates as low as 6% [18]. Furthermore, the endoscopic component separation technique is a viable option for patients with stomas since there is no shifting of the rectus abdominis muscle relative to the overlying skin [9, 19].

On the other hand, the endoscopic component separation technique has some disadvantages. First and foremost, the endoscopic component separation procedure requires advanced laparoscopic skills, which not all surgeons have or will adopt. Furthermore, mesh placement in an underlay or intraperitoneal position is more challenging that the commonly performed onlay position used in the open, anterior component separation procedure. Finally, when compared to the open, anterior component separation procedure, the endoscopic component separation technique can only achieve approximately 85% of the total fascial advancement achieved from the open, anterior component separation procedure [9].

60.5 Posterior Component Separation Technique

60.5.1 Key Steps to the Procedure

1. The procedure begins with midline entrance into the abdominal wall cavity with lysis of adhesions performed, as needed. For this portion of the procedure, it is more important than during the previously described techniques to preserve the peritoneum and posterior rectus sheath for recreation of the retrorectus/preperitoneal space later in the operation.
2. The posterior rectus sheath is incised, approximately 0.5 cm from its edge. This incision is typically started at the level of the umbilicus and carried superiorly to the costal margin and inferiorly to the pubis. Incision into the posterior rectus sheath is confirmed with identification of the rectus muscle through the incision (Fig. 60.3).

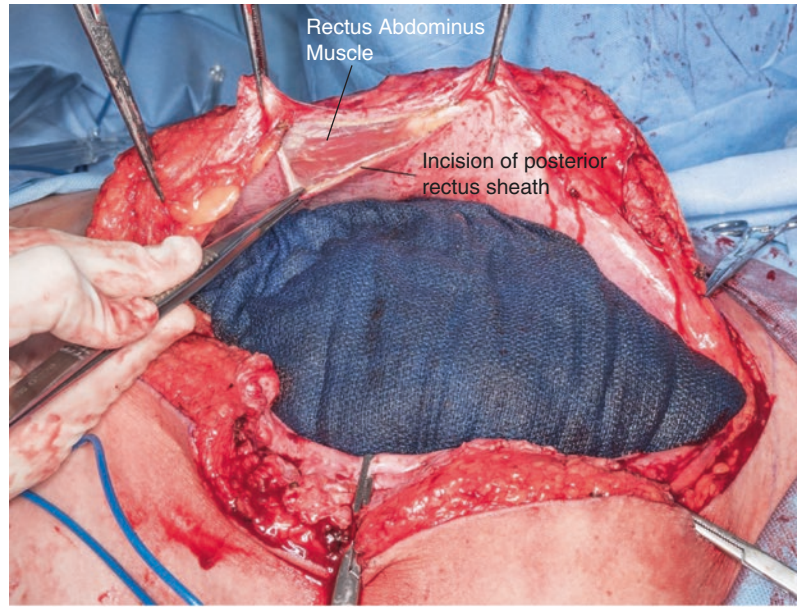

Fig. 60.3 Posterior components separation: incision of the posterior rectus sheath. Incision into the posterior rectus sheath, which is confirmed with identification of rectus abdominis muscle through the incision

3. Lateral dissection of the posterior rectus sheath is performed, using the tenants of traction and countertraction. Dissection of the posterior rectus sheath off of the rectus abdominis muscle occurs in this plane until the linea semilunaris is identified. Just medial to the linea semilunaris runs the neurovascular bundles and care must be taken during this portion of the dissection to preserve these bundles in order to maintain abdominal wall functionality and to prevent rectus muscular atrophy (Fig. 60.4) [21].
4. Mobilization of the posterior rectus sheath at the cephalad and caudad aspects of the dissection. The posterior rectus sheath joins with the anterior rectus sheath in the midline to create the linea alba. This insertion of the posterior rectus sheath at the midline must be released in order to facilitate communication of the retrorectus space across the midline.
5. Additional mobilization is performed into the pelvis, down to the space of Retzius, in order to join the posterior rectus sheath across the midline. The inferior epigastric vessels are used as landmarks during this aspect of the dissection. Dissection in this area proceeds similar to the dissection performed during a laparoscopic transabdominal preperitoneal inguinal hernia repair [21]. The lateral aspect of the dissection ends once the psoas muscle is identified.
6. At this point, one must determine if mobilization of the posterior rectus sheath is sufficient for abdominal wall closure. In order to do this, Kocher clamps are placed on either side of the posterior rectus sheath and brought to the midline. If the midline is reapproximated without excessive tension, the posterior rectus sheath is closed using a running absorbable suture. However, if there is undue tension with this maneuver, a transverse abdominis/posterior component separation is performed.
7. We typically begin the posterior component separation in the lower third of the abdomen. In this area, the posterior rectus sheath is

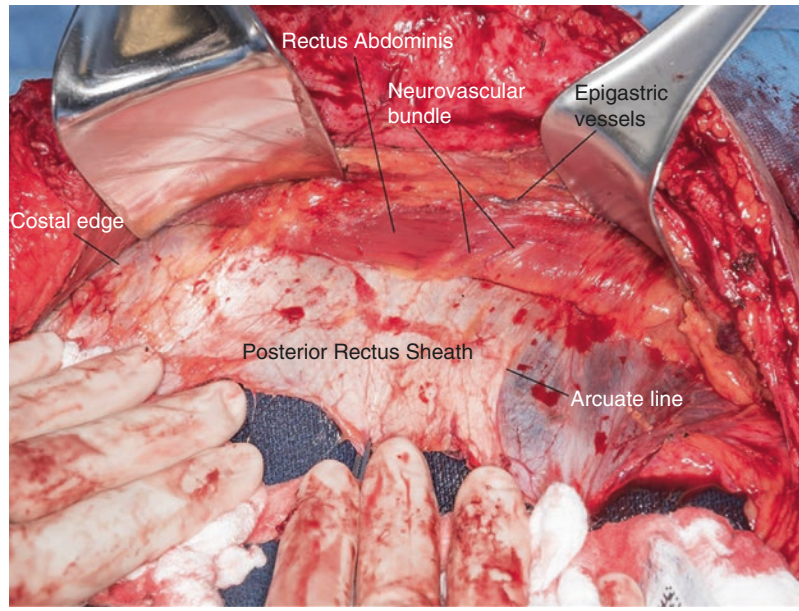

Fig. 60.4 Lateral extent of posterior rectus sheath dissection. The posterior rectus sheath is dissection off of the rectus abdominis muscle up to the linea semilunaris. This dissection exposes the neurovascular bundles which must be preserved in order to prevent rectus muscular atrophy

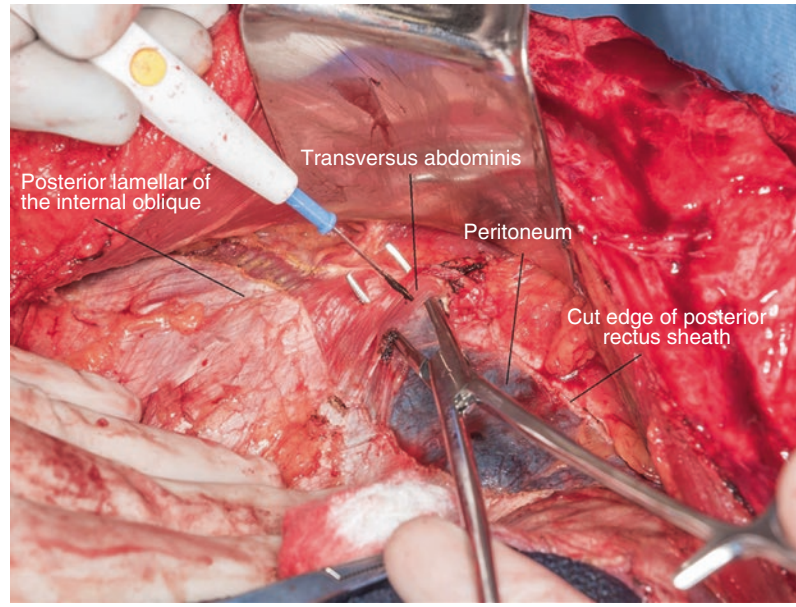

Fig. 60.5 Posterior components separation technique. If the hernia defect cannot be closed with mobilization of the posterior rectus sheath only, a posterior components separation is performed. This dissection begins in the lower third of the abdomen. Violation of the peritoneum is prevented using the tenants of traction and counter-traction and division of the fascia layer by later with the use of a right angle clamp

comprised of the transversalis fascia and the peritoneum. The incision begins just medial to the linea semilunaris and the neurovascular bundles, exposing the underlying peritoneum (Fig. 60.5). In order to prevent violation of the peritoneum, we use the tenants of traction and countertraction and divide the fascia layer by layer in a controlled fashion using a right angle clamp.

8. Once the release has been performed in the lower third of the abdomen, attention is turned toward division in the upper third of the abdomen. In this area, the posterior rectus sheath is actually comprised of the posterior lamella of the internal oblique and the transversus abdominis muscle. Beginning at the costal margin, both of these muscle structures are divided until the peritoneum is encountered. Again, the tenants of traction, countertraction, and controlled division of the musculature are performed in order to prevent violation of the peritoneum.
9. The posterior component separation is joined in the middle third of the abdomen, with dissection of the transverse abdominis muscle until the peritoneum is visualized.
10. A Kittner dissector is used to develop the preperitoneal plane laterally to the retroperitoneal space, superiorly to the diaphragm, and inferiorly to the psoas muscle and space of Retzius.
11. Once the posterior component separation is completed, abdominal wall closure is again tested. This is again performed by placing Kocher clamps on either side of the posterior rectus sheath and bringing them toward the midline. The posterior component separation should provide for closure of abdominal wall defects that are similar in size to those closed using the anterior component separation technique [11].
12. The posterior rectus sheath is closed using a running, absorbable suture.
13. Mesh reinforcement is performed with placement of mesh into the retrorectus space, above the posterior rectus sheath but below the rectus muscle. The mesh is often placed into a diamond configuration, and multiple transabdominal sutures are used to secure the mesh superiorly to the xiphoid, inferiorly to Cooper's ligament, and laterally.
14. Two closed suction drains are placed, one on either side of the abdomen, into the retrorectus space, above the mesh but below the rectus abdominis muscle.

15. The anterior rectus sheath is closed with a running, slowly absorbable suture for recreation of the linea alba.
16. The midline incision is closed in layers in the usual fashion.
17. Placement of an abdominal binder, which is worn throughout the perioperative period.

60.5.2 Advantages and Disadvantages of This Procedure

The posterior component separation technique provides for a durable hernia repair, with long-term recurrence rates of less than 10% reported in the literature [21]. The long-term durability of the posterior component separation technique is likely multifactorial and related to (1) decreased wound morbidity as the creation of large subcutaneous flaps is avoided and the perforating abdominal wall vessels are preserved and (2) the ability to place a large piece of prosthetic mesh in a well-vascularized plane [21, 22]. Nevertheless, the transverse abdominis muscle is intimately involved in core stability of the abdominal wall and the spine, and the long-term effect of this procedure on core stability remains unknown [23–25]. Additionally, the posterior component separation procedure is technically a demanding procedure and requires an advanced abdominal wall reconstructive skill set that not all general surgeons have.

Conclusion

Significant advances have been made in the field of complex abdominal wall reconstruction since the originally described component separation technique in 1990. Because each technique described has advantages and disadvantages, it is important for surgeons treating patients with large abdominal wall hernias to consider each repair on a case-by-case basis. Furthermore, despite the popularity of these procedures, these surgeries are not without morbidity, and they should be reserved for patients whose abdominal wall cannot be repaired in a standard fashion without the mobilization of myofascial components.

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The Transversus Abdominis Muscle Release (TAR) Procedure

61

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61.1 Introduction

Modern hernia surgery has evolved to rely on tissue-based reconstruction with concurrent prosthetic reinforcement to provide more durable repairs. Over the past decades, the utilization of various methods to gain myofascial advancement has steadily increased. In the late 1960s, French surgeons Rives and Stoppa pioneered the principles of preperitoneal retromuscular repairs with "giant prosthetic reinforcement of the visceral sac" [1, 2]. This principle has withstood the test of time for moderate-sized defects and classic Rives-Stoppa retrorectus repairs continue to provide durable outcomes with low morbidity [3, 4]. However, the major disadvantages of retrorectus-only repairs are twofold: they limit the degree of myofascial advancement while also preventing the placement of large prosthetic meshes required for reliable overlap of the visceral sac in complex hernias. Although techniques to overcome the mesh-size limitations created by the rectus sheath such as preperitoneal or intramuscular repairs have been described, both are criticized for either limited myofascial medialization or damage to rectus muscle perforator nerves.

To address the shortfalls of the traditional retromuscular repairs, posterior component separation using transversus abdominis muscle release (TAR) was developed in 2006 by Novitsky. Initially presented at the 2009 World Hernia Congress, the TAR procedure received mixed reviews, with skepticism about its efficacy, reproducibility, and potential for deleterious effects to the trunk. However, following our publication of the technical details with further evidence of safety and efficacy of this approach [5], we have witnessed a steady increase in the acceptance and utilization of TAR by the surgical community worldwide. Advantages of this method include preservation of neurovascular bundles, significant myofascial medialization, and creation of a well-vascularized plane for sublay mesh placement. Recently, the safety as well as long-term clinical efficacy of the TAR technique has also been reported. In this chapter, we will elaborate on the anatomical/physiological basis, technical nuances, postoperative aspects and indications of the TAR procedure.

61.2 Anatomical Basis for TAR

Given its unique anatomy and function, the transversus abdominis (TA) muscle is the ideal target for posterior component separation. The TA plays a key role in maintaining the intra-abdominal pressure, and its contribution to the tone of the lateral abdominal wall makes it the "corset" of the abdomen. Due to the horizontal direction of its fibers, release of the TA provides the desired medial mobilization of the rectus complex.

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As opposed to what has been taught in many anatomy and surgical textbooks, the muscular portion of the TA extends medially far beyond the linea semilunaris in the upper third of the abdomen to insert in the edge of the costal margin and xiphoid process. At the level of the umbilicus and below, most of the TA medial to the linea semilunaris will be aponeurotic with almost no muscle fibers. This key anatomical feature allows the surgeon to identify the target areas that safely allow for TA division and access to the TAR plane after releasing the lateral force generated by the transversus abdominis muscle and aponeurosis.

61.3 Indications

The most frequent scenario for TAR is large midline defects (usually ˃10 cm) where a traditional Rives-Stoppa repair fails to provide reapproximation of the posterior layers and linea alba reconstruction or create space for sufficient mesh overlap. The TAR procedure is a versatile technique that has been shown to work in challenging hernia locations such as subcostal, subxiphoid, flank, parastomal, suprapubic, and donor site hernias after flap-based (TRAM) breast reconstruction [6–8].

With the rapid development of minimally invasive techniques for abdominal wall reconstruction, algorithms for procedure selection are constantly changing. Our current practice is to offer an open approach to patients with a hostile abdomen, contaminated scenarios, those who require removal of mesh or soft tissue excision and for very large defects (˃20 cm).

Relative contraindications for TAR include previous preperitoneal and retromuscular repair, the need for panniculectomy/abdominoplasty, and history of severe necrotizing pancreatitis with retroperitoneal scarring. Although we have described the use of TAR for recurrences after anterior component separation techniques [9], TAR should not be performed concomitantly with an anterior component separation as this would create lateral abdominal wall instability and bulging [10].

61.4 Preoperative Considerations

Planning of the operation is a very important step in complex hernia repair. We routinely perform non-contrast-enhanced abdomen and pelvis CT imaging to delineate all abdominal wall defects, to define intra-abdominal anatomy, and to uncover occult intra-abdominal pathology. Screening colonoscopy is performed if indicated.

Provided that the patient has no obstructive symptoms that would prompt for a semi-emergent repair, preoperative optimization is paramount to maximize surgical outcomes in elective abdominal wall reconstruction. Our complete enhanced recovery pathway for ventral hernia repair [10] includes preoperative interventions such as optimization of diabetes management (HbA1c ˂8%), as well as weight loss and nutrition counseling. Although we always aim for preoperative weight loss, a BMI $\geq$ 45 kg/m^2 is considered as the upper limit for elective abdominal wall reconstruction. Smoking cessation for at least 4 weeks is imperative for all open repairs.

61.5 Technical Aspects

The patient is placed in a supine position. The abdomen is prepped from the nipples to midthigh and laterally to the posterior axillary lines.

Incision: Unless additional soft tissue resection is planned, most cases will be addressed through a midline laparotomy. After careful access to the abdominal cavity is obtained, complete lysis of adhesions from the anterior abdominal wall is obtained to protect the viscera during the release and to facilitate medialization of the posterior components. Meticulous dissection is required to avoid injury to the bowel and preserve the peritoneum as much as possible. Interloop intestinal adhesions are selectively lysed in patients with a history of obstructive symptoms. The falciform ligament is routinely freed in proximity to the liver to keep it in continuity with the posterior layers while allowing for placement of a towel that will protect the entire visceral contents extending from the hiatus to the pelvis and laterally to the gutters.

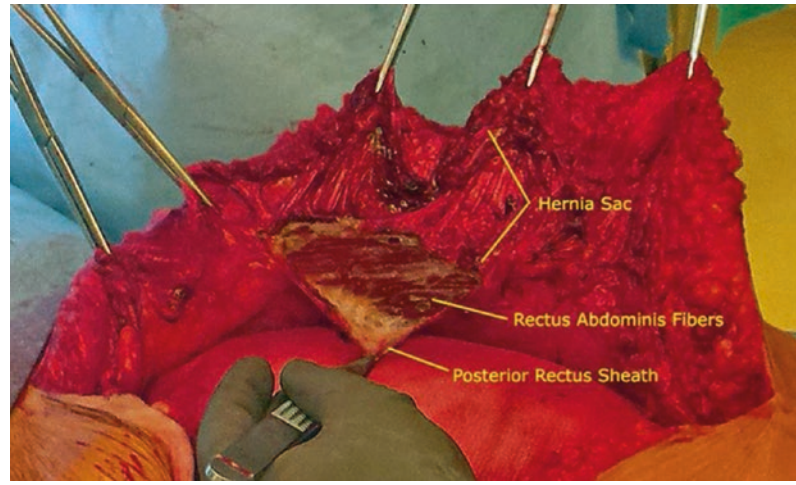

Fig. 61.1 Incision of the posterior rectus sheet in its medial-most portion. The correct location can be confirmed by visualizing fibers of the rectus muscle

Retrorectus dissection: An incision is created in posterior rectus sheath close to its medial edge. It is critical that the fibers of rectus abdominis are clearly visualized to avoid mistakenly entering the subcutaneous plane (Fig. 61.1). The retromuscular plane is then developed toward the linea semilunaris with constant traction on the anterior fascia using Kocher clamps or Richardson retractors under the rectus muscle, combined with countertraction with multiple Allis clamps on the medial edge of the posterior layer. The plane can be dissected using blunt instruments in combination with monopolar energy to divide the fine areolar tissue and small perforating branches of the epigastric artery. The lateral limit of this mobilization is the perforators to the rectus muscle just medial to linea semilunaris. The retrorectus plane is extended cephalad toward the costal margin while preserving the attachments of the falciform ligament to the posterior rectus sheath, as they will be useful for closure of the posterior layers.

Caudally, the transition from the retromuscular plane within the rectus sheath to the pelvis involves the division of the medial attachments of the arcuate line of Douglas to the linea alba. Following that, the preperitoneal plane must be entered to allow dissection to the space of Retzius and exposure of the pubis symphysis and Cooper's ligaments. True access to the preperitoneal plane at this level will facilitate dissection and prevent injury to the epigastric vessels.

Division of the TA: Once the limits of the traditional Rives-Stoppa repair have been reached, the division of the transversus abdominis and subsequent posterior component separation are undertaken. Our preferred area to expose the TA is the upper abdomen, where the posterior rectus sheath will be incised just medially to the perforating neurovascular bundles to identify the underlying fibers of the TA. If this incision is created too medially, the muscle fibers may be difficult to visualize and the peritoneum may be cut. Similarly, if this step is done in the mid or lower abdomen, the muscular portion of the TA is more lateralized in those areas and, as a result, more difficult to identify properly. The posterior rectus sheath is then incised in the cranial-caudal direction. The lateral aspect of the arcuate line is divided at its junction with the semilunar line.

The division of the TA muscle itself is then undertaken, ideally starting in the upper third of the abdomen where medial fibers of the transversus abdominis muscle are easiest to identify and separate from the underlying transversalis fascia. The use of a right-angled dissector helps to avoid penetrating the underlying transversalis fascia and peritoneum (Fig. 61.2). This release allows entrance to the space between the transversalis fascia and the divided transversus abdominis muscle (pre-transversalis plane). Alternate access to this area can be obtained inferiorly with the so-called bottom-up TAR, where division of the posterior rectus sheath and

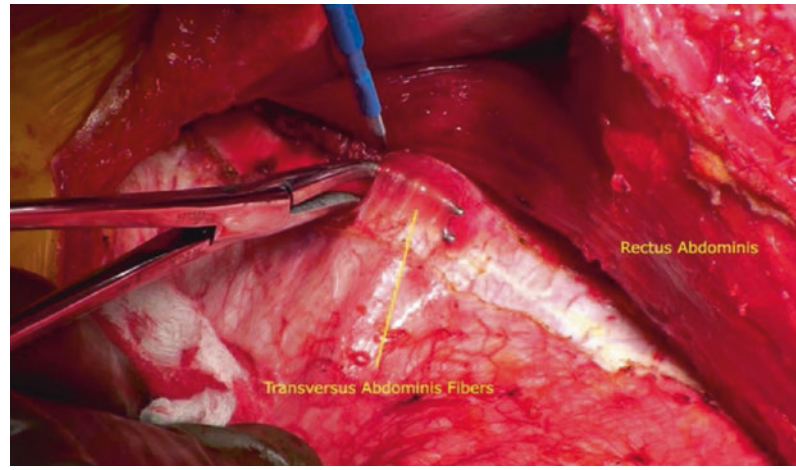

Fig. 61.2 Division of the transversus abdominis muscle fibers is performed medial to the neurovascular bundles. This is facilitated by starting caudally where muscle fibers are present medial to the semilunar line

the aponeurotic portion of the TA is started at the arcuate line or superiorly with lateral to medial division of the posterior rectus sheath in proximity to preperitoneal fat at the level of the falciform ligament.

Lateral dissection: After division of the TA, the plane deep to it is developed in the medial to lateral direction. We usually accomplish this by providing traction on the TA with a right-angled dissector and countertraction in the posterior layer with Allis clamps and gentle use of the Kittner dissector. Bleeding at this point should alert to the possibility of erroneous entry into the intramuscular plane, and it should be noted that the correct retromuscular plane is posterior to the ribs. If fenestrations occur, they can be sutured with 2-0 Vicryl running or figure-of-eight sutures. This is done in the transverse direction to avoid tension on the suture lines.

The transition from the pre-transversalis/preperitoneal plane to the retroperitoneum is often defined by visualization of retroperitoneal fatty tissue. The lateral edge of the psoas muscle is used as safety landmark for the lateral extent of the retroperitoneal dissection.

Inferior dissection: After exposure of Cooper's ligaments and pubis, the dissection is extended laterally across the entire myopectineal orifice. In women, the round ligament is divided routinely. In men, the spermatic cord is identified and separated from the peritoneum in a fashion similar to a laparoscopic inguinal hernia repair.

If inguinal or femoral hernias were identified, the dissection can be extended to expose at least 5 cm of the distal psoas muscle with subsequent preformed mesh coverage of myopectineal orifice. For this step, our preference is to use preformed synthetic mesh with no mesh fixation.

Superior dissection: Depending on the location of the hernia, the superior dissection may extend to the upper epigastrium or above the xiphoid process to the retrosternal space for hernias that extend superiorly. This step is easier after dissection is completed on both sides.

To prevent recurrent herniation off the superior edge of the dissection, the linea alba is maintained in continuity ventral to the mesh for at least 5 cm by dividing the insertion of the posterior rectus sheaths into the linea alba. This is accomplished by cutting the insertion of each posterior sheath in the cranial direction about 0.5 cm lateral to the linea alba with subsequent reconnection of the plane between posterior rectus sheath, preperitoneal space, and posterior rectus sheath.

For the majority of mid and upper abdominal defects, cephalad dissection to the retrosternal space is critical to minimize superior/subxiphoid recurrences. First, the linea alba is divided to the xiphoid process, and then, posterior insertion of the posterior rectus sheath into the xiphoid process is also incised. This provides access to a fatty triangle that is extended cephalad in a substernal plane. Finally, the continuity of this space

with the retromuscular dissection is created. The incision line at the lateral aspect of the posterior rectus sheath is extended to and slightly above the costal margin. This is followed by complete division of the uppermost fibers of the transversus abdominis muscle just off the lateral edge of the xiphoid, making sure not to create an iatrogenic Morgagni hernia by injuring diaphragm fibers. In order to provide adequate mesh overlap, the retromuscular plane can be extended to expose the upper aspect of the central tendon of the diaphragm (Fig. 61.3).

Closure of posterior layers: This step is critical to avoid visceral contact with the mesh and to prevent intraparietal herniation. Reapproximation of posterior rectus sheaths is performed from the cephalad and caudal ends separately with running 2-0 Vicryl or PDS suture. In rare circumstances, this will not be possible, and buttressing with omentum, Vicryl or biologic mesh can be done. In order to prevent visceral injury, the countable towel is removed shortly before completing the posterior layer closure. The intraperitoneal contents will be isolated afterward.

We routinely irrigate the visceral sac with saline in all clean cases. The use of antibiotic pressurized pulse lavage significantly reduces the bioburden and it is our preference in clean-contaminated and contaminated cases [11].

Mesh placement: The mesh is placed in the retromuscular space based on the principle of "giant reinforcement of the visceral sac" (Fig. 61.4) that is paramount for durability of the repair.

For hernias that extend inferiorly, we secure the mesh to Cooper's ligaments to ensure mesh overlap in the retropubic space. This is typically done with one interrupted suture on each of Cooper's ligament, passing the tail through the mesh so that the knots will be tied at the dorsal surface of the mesh. Superiorly, the mesh could be secured with interrupted sutures around the xiphoid process and 4–5 cm off the edge of the mesh to provide large superior overlap. We minimize/avoid lateral fixation, only using it selectively for lateral defects and cases where the linea alba cannot be completely reapproximated.

The vast majority of prosthetic reinforcements in our series are done using synthetic mesh [12]. Mid-weight, macroporous polypropylene is my preferred material, reserving heavyweight polypropylene for cases where the linea alba cannot be reapproximated and for lateral defects. We strongly discourage the use of lightweight monofilament polyester for abdominal wall reconstruction [13]. Furthermore, our experience with biologic mesh has been somewhat disappointing [14]. We also recently demonstrated a biologic

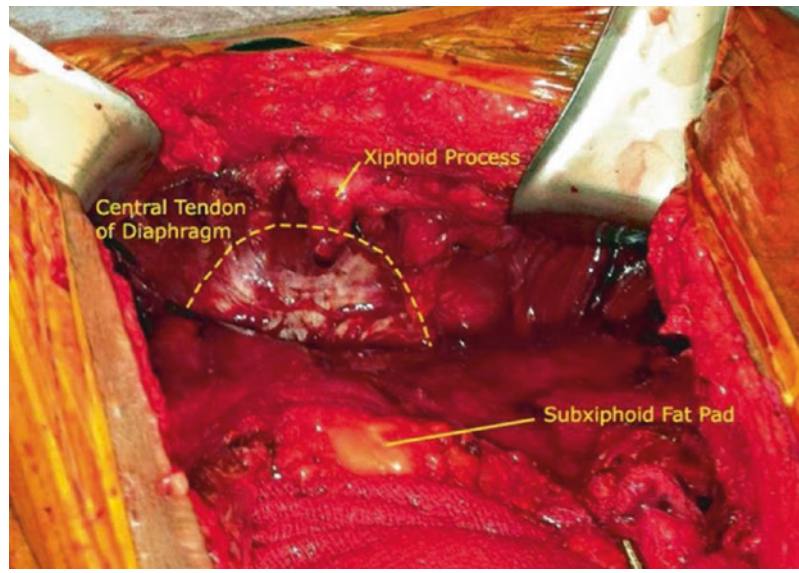

Fig. 61.3 Dissection can extend to the retrosternal space for hernias that extend superiorly

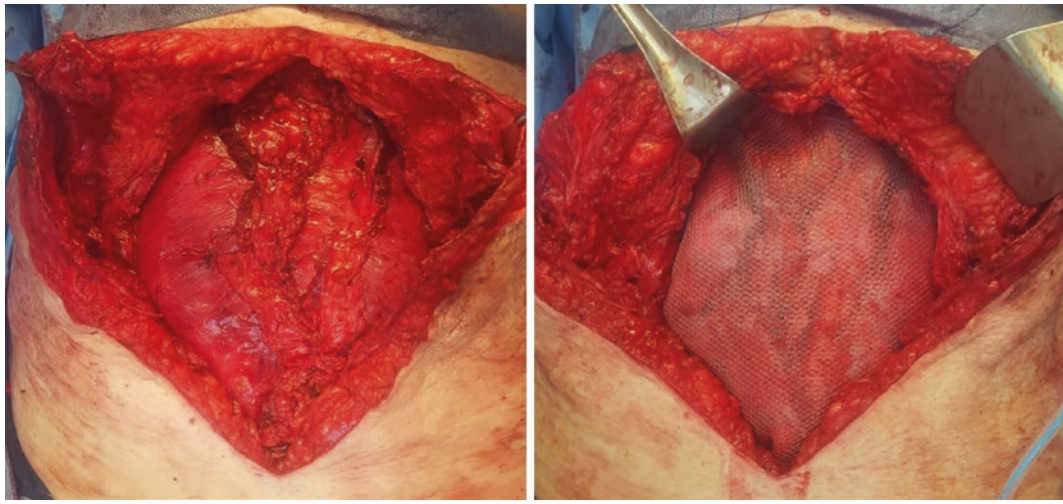

Fig. 61.4 Closure of the posterior layer and mesh implantation to obtain giant reinforcement of the visceral sac

mesh to be an independent predictor of wound complications and recurrences in a comparative series with matched synthetic repairs [15].

Linea alba reconstruction: We routinely place closed suction drains over the mesh after open TAR. The combination of muscle releases and component separation performed in this operation will allow for medial advancement of the rectus abdominis.

Linea alba reapproximation is performed with running PDS suture, with occasional use of interrupted figure-of-eight suture. After resection of hernia sac, redundant soft tissue, and attenuated skin, closure of superficial layers is performed with selective use of subcutaneous drains.

61.6 Physiologic Basis of TAR

TAR is a series of operative maneuvers beginning from laparotomy to eventual division and reflection of the transversus abdominis muscle off the underlying peritoneum and transversalis fascia. We recently performed a cadaveric study to further elucidate how each of these steps contributes to medialization of both the posterior and the anterior layers [16].

The procedure itself is an extension of the original retrorectus Rives-Stoppa, followed by incision of the posterior sheath, transversus abdominis division, and retromuscular dissection. Although every step has a contribution, the critical maneuver in this operation is retromuscular dissection deep to the transversus abdominis muscle following its division. The end result after retromuscular dissection is approximately 10 cm of myofascial advancement for the anterior sheath and just over 11 cm for the posterior layer. Thus, the sequence of steps required to complete a posterior component separation via TAR allows for linea alba reapproximation and develops a well-vascularized bilaminar plane for mesh placement.

61.7 Postoperative Care

Although not frequent, patients who experience an increase of pulmonary plateau pressure above 6 mmHg will need to stay intubated, at least overnight. Those patients with increase in plateau airway pressures >11 mmHg are kept paralyzed for 24 h postoperatively. Abdominal compliance usually improves within 12–24 h postoperatively, and pulmonary physiology returns to baseline allowing for safe extubation [17].

As part of a continuous quality improvement project at our institution, we developed a hernia-specific enhanced recovery after surgery (ERAS) pathway to standardize care and improve postoperative outcomes for this group of patients (Table 61.1) [10]. Implementation of this ERAS

pathway resulted in earlier introduction of enteral nutrition, reduction of IV narcotic use, shorter length of stay, and significantly reduced 90-day readmissions. Intrinsic to our multimodal approach for postoperative management, a transversus abdominis plane (TAP) block is performed during TAR by directly accessing the TAP plane through the cut edge of the transversus abdominis muscle. Our comparative data using volume-expanded liposomal bupivacaine at 4–5 vertical levels bilaterally showed that the addition of a TAP block during TAR improved pain control, allowed for earlier discontinuation of IV narcotics, and reduced the length of stay [18]. Drains are usually kept in place until the output is <30–50 cm^3 per day and most patients will wear a binder during at least 1 week.

Table 61.1 Enhanced recovery after surgery pathway for ventral hernia repair

Preoperative	Weight loss counseling
	Diabetic control (HbA1c <8%)
	Smoking cessation (≥4 weeks)
	OSA screening
	IMPACT preoperative nutrition shake
	MRSA screening
Perioperative	SQ heparin 5000 × 1 dose + SCDs
	PO alvimopan 12 mg × 1 dose
	PO gabapentin 100–300 mg × 1 dose
	First-generation cephalosporin + vancomycin for positive MRSA screen
Intraoperative	
Pain control	Minimization of narcotics/paralytics
	Intraoperative TAP block: 20 mL liposomal bupivacaine diluted to 200 mL (100 mL per side)
Postoperative	
Pain control	IV hydromorphone PCA: 0.2 mg q 6–10 min, no breakthrough dose; no basal rate; stopped on POD 2 once on clears
	PO oxycodone 5–10 mg q 4 h PRN started once off IV PCA
	PO acetaminophen 650 mg q 6 h scheduled started immediately post-op
	PO gabapentin 100–300 mg TID started on POD 1
	IV/po diazepam 5 mg q 6 h PRN: 2.5 mg dose for patients >65 years old; hold for OSA patients, sedation, or any respiratory compromise
	PO NSAIDs 600–800 mg q 6–8 h PRN: hold for renal dysfunction; can use IV toradol 15–30 mg q 6 h
Intestinal recovery	No routine nasogastric tube placement
	NPO except meds on operative day only
	Scheduled diet advancement: POD 1, limited clears (<250 mL/shift); POD 2, clear liquids ad lib' POD 3, regular diet
	PO alvimopan 12 mg BID until discharge or POD 7
Fluids	Fluid conservative strategy: LR at 100 mL/h on operative day; D5 ½NS at 75 mL/h on POD 1; Hep-Lock IVF on POD 2

61.8 Outcomes

Recent data from our 428 consecutive TAR with synthetic reinforcement showed a 3.7% recurrence rate after a mean follow-up of 31 months. This study included wound classes I, II, and III and the overall surgical site event rate was 18.7%. This wound morbidity is significantly lower than the rate observed in comparative studies with both posterior and anterior component separation [19]. Similar results have been achieved in other centers in the USA [20]. More recently, the TAR procedure has been embraced internationally, with emerging promising results showing comparable wound morbidity in Mexico [21] and durable repairs in a series from the UK [22], Russia [23], and Romania [24].

Despite initial concerns regarding potential deleterious consequences of division of the transversus abdominis muscle, radiological analysis has confirmed that linea alba reconstruction after TAR leads to compensatory hypertrophy of the rectus and both oblique muscles [25]. Restoration of the linea alba following TAR also improves core functionality and quality of life metrics [26].

Conclusion

Retromuscular hernia repair is a safe and durable method for complex hernia repair. The transversus abdominis muscle release technique has gained popularity in the recent era due to its ability to address hernias where the traditional Rives-Stoppa repair cannot provide

a tension-free medialization of the anterior and/or posterior sheath or the rectus. TAR permits giant reinforcement of the visceral sac in a retromuscular plane while providing mobilization of the abdominal wall that allows to reconstruct the linea alba. TAR is a versatile technique that can address many scenarios of complex ventral hernia. A thorough understanding of the anatomy and technical steps is paramount for performing this operation.

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Parietal Disaster

62

Chowbey Pradeep

Incisional hernia (IH) is defined by the European Hernia Society (EHS) as "any abdominal wall gap with or without bulge in the area of postoperative scar perceptible or palpable by clinical examination or imaging" [1]. The incidence of incisional hernia is around 20% after abdominal wall surgeries [2]. The risk factors associated with development of IH include patient-related factors, nature of primary surgery, and biological factors. Patient-related factors include age >60 years, male gender, [3–6] obesity with increased BMI > 25 kg/m^2 [5], and patient comorbidities (diabetes, chronic lung disease, immunosuppression in organ transplant patient, chemotherapy, and steroid therapy) [7–10]. Surgery related risk factors for incisional hernia include emergency operations [9], bowel surgery, re-laparotomy, burst abdomen with evisceration [11–14], wound infection, wound dehiscence, midline abdominal incision has higher risk for developing IH compared to transverse and oblique incisions, respectively [4, 11]. Biological factors include enzyme defects, smoking, and nutritional deficiencies [15]. The occurrence of IH is multifactorial in nature. Laparoscopic approaches have also contributed to the development of incisional hernia. Laparoscopy-related factors are diameter of the port size >10 mm, multiple insertions, long duration of surgery, inadequate evacuation of pneumoperitoneum, unrelaxed abdominal wall at the end of the procedure, and increased abdominal pressure at the end of surgery [16].

Complex incisional hernias are described by the following: large hernia defect, hernia in difficult locations, large abdominal wall/soft tissue defect and/or enterocutaneous fistula, loss of domain, re-recurrence, and local infection [16]. The management of complex incisional hernia is extensive and challenging. All common surgical techniques and methods can be used for the repair of complex incisional hernias, like sublay, onlay, laparoscopic, and open IPOM. This chapter will mainly describe the management of complex incisional hernias.

62.1 Strangulated Incisional Hernia

Strangulated incisional hernia is the predominant cause of intestinal obstruction. These hernias are referred for emergency management. Few authors have reported morbidity and mortality rate of 1.4–13.4% and 19–30%, respectively [17, 18]. Bowel necrosis secondary to strangulation is associated with morbidity and mortality. Strangulated hernia is an operative challenge, which is sometimes difficult to diagnose specially in obese patient and requires immediate surgical

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intervention. Strangulated hernia causes bowel obstruction, bacterial translocation, and intestinal wall necrosis leading to bowel perforation. Bowel resection has been reportedly required in 10–15% of the patients with strangulated abdominal wall hernias [19]. Literature has also reported increased need for bowel resection and higher mortality rates with advancing age, concomitant disease, and delayed referrals [20, 21].

Wound contamination during bowel resection in the treatment of strangulated hernia is the subject of debate whether to use nonabsorbable prosthesis with obstructed or gangrenous bowel in potentially or truly infected operating fields [22]. Majority of surgeons believe that permanent prosthetic materials for incisional hernia repair are contraindicated in contaminated field, due to risk of infection as high as 10–35% [23]. Morris et al. [24] has suggested to defer the placement of mesh for repairs in which open bowel is encountered. In a study conducted by Temudom et al. [25] on 50 complex giant ventral hernia repairs, two patients with simultaneous bowel injury required mesh removal. Few authors recommend staged treatment with intestinal resection to be done first and hernia repair postponed for later. On the contrary, Campanelli et al. [26] reported no major or minor complications after 21 months of follow-up, when ten prosthetic hernia repairs were performed in potentially contaminated area. Mc Lanahn et al. [27] reported no increased risk of infection in incisional hernia repairs with prosthetic placement in a series of clean contaminated wounds. There are discrepancies in literature and conflicting reports which advise prosthetic meshes not indicated in contaminated settings. However, biological mesh prosthesis is used in infected fields for complex incisional hernia repair. The biological mesh is remodeled into autogenous tissue after implantation and is related to low morbidity. It has proven to be a good alternative to prosthetic mesh with good results in immunocompromised patients [28].

The major concern for strangulated hernia has been bowel ischemia. Figures 62.1 and 62.2 describe the strangulated and incarcerated hernias. ICG (indocyanine green) fluorescence technique has been a newer modality to evaluate the intestinal blood flow and limiting the number of bowel resections. With this technique, blood flow can be observed on injecting the ICG dye. It allows a wide area of observation and is convenient for the surgeon for assessment of strangulated hernia [29].

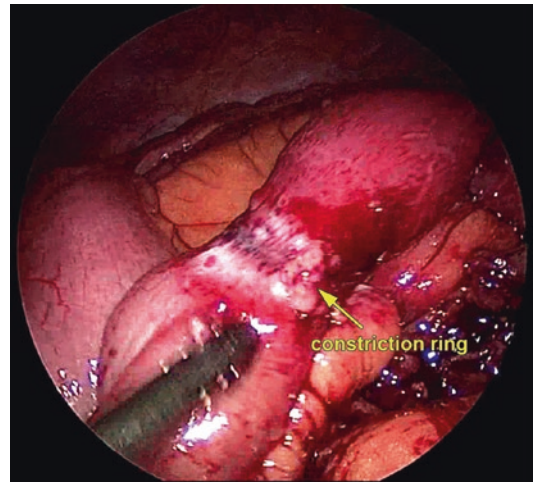

Fig. 62.1 Constricted ring in strangulated hernia

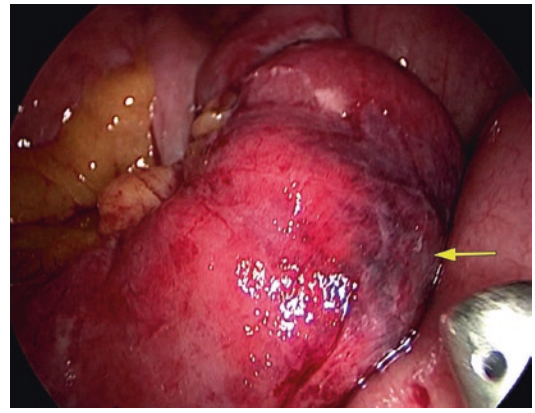

Fig. 62.2 Incarcerated hernia

Goals for the management of strangulated hernia:

- To achieve lower morbidity, mortality, and recurrence rates
- To diagnose before the onset of strangulation and hernia repair under elective condition
- To ensure antibiotic prophylaxis for decreasing surgical site infection

- Emergency surgery with no delays to be performed to prevent the impairment of organ blood supply
- ICG fluorescence-guided laparoscopic evaluation to limit the number of bowel resections
- To measure the risk of contamination during bowel resection and the safe application of meshes

62.2 Iatrogenic Enterotomy (IE)

It is a fairly common complication during laparoscopic incisional hernia repair. It is the inadvertent transmural penetration of any part of the bowel during laparoscopic incisional hernia repair. The incidence of IE varies from 0% to 14% [30]. Mechanical injury during adhesiolysis, use of high external energy source, recurrent hernias, and dense bowel adhesions are the contributing factors for IE [31, 32]. A study conducted by Van Der Krabben et al. [6] has reported risk of IE to be ten times more in patients with previous surgeries.

There are two types of IE, one which is recognized during operation and the other which is unrecognized enterotomy. Enterotomies which are recognized intraoperatively are repaired immediately to minimize contamination [33, 34]. The spillage of intestinal contents during IE converts the surgical field from "clean to clean contaminated." Figure 62.3 describes the iatrogenic enterotomy which was recognized intraoperatively.

According to Leblanc et al. [30], a recognized enterotomy is repaired by conversion to an open method in 43% of cases. Bowel is returned to abdominal cavity on recognition of IE, and laparoscopic hernia repair is accomplished after 1 week. Postoperative enterotomy in this study was seen in approximately 18% of cases and was managed by re-exploration in an open or laparoscopic procedure [30]. The rate of mortality from iatrogenic injuries varies from 0.05% to 3.4% [35]. Sharma et al. [36] reported that IE was recognized intraoperatively in 28 out of 33 patients, and Leblanc [32] reported an intraoperative recognition rate of 82%.

In literature, there are varied methods and opinions by authors for management of IE. Some

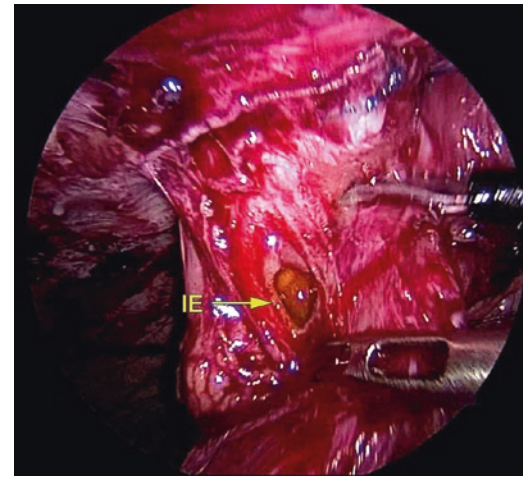

Fig. 62.3 Describes the incident of Iatrogenic enterotomy (peritoneal spillage)

studies are in favor of placement of prosthetic mesh for complete hernia repair after IE, and few are contradicting due to fear of subsequent mesh infection. In a study, 50–90% of cases needed removal of synthetic mesh when mesh was placed in contaminated field [37, 38]. Surgeons prefer to delay the placement of mesh with median interval of 4 weeks (3 days to 6 months). However, Gray et al. [39] has preferred placement of mesh irrespective of contamination during enterotomy. It is advisable to defer the placement of prosthetic mesh in case of significant contamination [30]. The poorest surgical outcome is observed during postoperative recognition of enterotomy with mortality 40% and morbidity 100% [31].

62.2.1 Key Points for Iatrogenic Enterotomy (IE)

- Careful inspection of bowel is recommended after adhesiolysis to recognize the enterotomy and serosal tear intraoperatively.
- To avoid energy devices for hemostasis and ensure to include full length of old scar for mesh placement.
- Good case history evaluation to preclude the risk factors of previous laparotomies, morbid

obesity, and recurrent hernia associated with enterotomy.
- Amount of peritoneal spillage is a crucial factor for deploying prosthetic material at the same time or defer it for the second stage.

62.3 Recurrence

Repair of large abdominal wall incisional hernia is a surgical challenge, with recurrence rates between 30% and 50% after primary hernia repair without the use of prosthetic material [40–42]. With the emergence of tension-free mesh repairs and laparoscopic techniques, the rate recurrence has drastically fallen. Laparoscopic ventral hernia repairs have been effective with minimal postoperative morbidity, shorter hospital stays, and earlier return to normal activity [43]. However, the contributing factors for recurrence include mesh overlap less than 3 cm, mesh contraction, and invagination into the hernia defect [44]. Recurrence is also associated with improperly placed transfascial sutures with large suture bites of mesh causing excessive tension [45].

Preoperative risk factors for recurrence:

- Larger hernia defect size >10 cm
- Obesity, chronic COPD, diabetes more prone to recurrence [46, 47]
- Smokers with previous failed attempts [48]
- History of previous failed hernia repair
- Insufficient coverage of incisional scar after laparoscopic incisional hernia repair
- Dual mesh is reported to increase risk of recurrence [49]

Postoperative risk factors recurrence [50]:

- Surgical site infections
- Mesh infection
- Wound infection, deep abscess
- Gastrointestinal complications
- Mesh overlap <3 cm, displacement of mesh, mesh contraction
- Improperly placed transfascial sutures, overlay large bites of mesh causing tension which leads to hole in mesh

Prevention of ventral hernia recurrence:

- Mesh repair should be used in all eligible patients with hernia defect larger than 2 cm.
- Increasing the overlap of the biomaterial and using dual methods of fixation.
- The whole incision including the hernia defect should be repaired.
- Mesh overlap to be at least 5 cm with complete peritoneal space dissection for suprapubic hernias.

Laparoscopic repair of recurrent incisional hernia has been daunting due to adhesions, time-consuming, mesh shrinkage, defective biology [51], and occurrence of septic complications [52]. In a large review of 1242 patients, 252 recurrent incisional hernias were also repaired through laparoscopic approach. The analysis showed recurrence rate of 5.2% in recurrent incisional hernia and 4.2% of patients in primary hernia which was not statistically significant [44]. A study conducted by Sturt et al. [53] reported a review of 227 laparoscopic repairs with higher chance of recurrence rate of 15% vs. 8% with primary hernia repair. Literature has clearly shown results with higher recurrence rate in recurrent incisional hernia repairs. Figure 62.4 depicts the recurrence and previous mesh at the time of second operation.

Patient selection with potential risk factors of obesity, defect size greater than 10 cm, and multiple Swiss cheese appearance [54] which have a higher recurrence are to be taken into consideration to achieve the good clinical postoperative outcomes.

New evolution to current trends in management of recurrent incisional hernia repair is the hybrid technique which combines conventional and laparoscopic approaches. Hybrid techniques have been helpful in treating complex hernias, giant hernias, hernias with bowel incarceration, and recurrent hernias. Open part of the technique ensures extensive and safe adhesiolysis with proper placement of bowel loops into peritoneal cavity to avoid the risk of bowel injury [55]. Laparoscopic part involves proper mesh placement and detection of “Swiss cheese” type abdominal wall defects which are obscured in

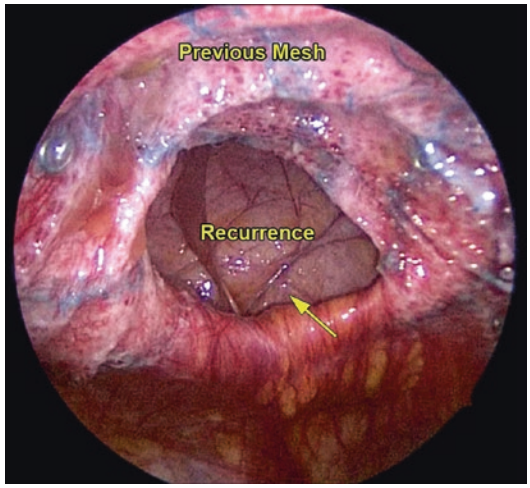

Fig. 62.4 Previous mesh and recurrence

open approach. There are very limited studies describing hybrid techniques. Stoikes et al. have performed hybrid technique on seven patients with complex hernia and was successful with no occurrence of recurrence with 3–63 month follow-up [56]. Long-term studies and surgical expertise are needed to implement combined techniques for management of difficult hernias.

62.4 Mesh Infection

The application of meshes in hernia repair has been a standard procedure throughout the world. Mesh implantation in hernia repair has reduced the recurrence rate considerably. Comparative studies found that recurrence rate 7% for non-mesh vs. 1% for mesh repair [57]. Mesh-related infections have been considered to be clinically important in practice. The incidence of mesh infection is 0.98% in laparoscopic hernia repairs as compared to 8% [58] open incisional repairs. The mesh infections post laparoscopic surgery are attributed to fallacy in the sterilization technique [59]. The associated causative agents with mesh infection following incisional herniorrhaphy, 63% of *Staphylococcus* species mainly *Staphylococcus aureus* which are methicillin resistant have been reported [58]. The consensus in literature has shown that the use of mesh during ventral hernia repair with a defect >10 cm in size is associated with increased number of wound complications [60]. The type of mesh has also influenced the rate of mesh infection. The results of the study have showed the use of multifilament polyester mesh had higher risk of mesh infection than the use of knitted monofilament polypropylene, polytetrafluoroethylene, or woven polypropylene [61].

The occurrence of mesh infection is clinically diagnosed in operated patients who have fever of unknown etiology or any signs of infection of the abdominal wall. Mesh infections can be symptomatic, chronic, or completely absent until the progression of sepsis. The imaging modalities like ultrasonography and computerized tomography are used to confirm the mesh infection. The imaging methods are also helpful in assessing the presence of a fistula or an abscess [62]. Early surgical intervention is the active method for treatment during extensive infection and abscess.

Measures to prevent mesh infection have been effective and useful. The implantation of antimicrobial impregnated mesh helps to prevent bacterial adhesion and colonization and reduce the occurrence of mesh infection. The wound at the intraoperative site can also be rinsed with antibiotic solutions after dissection of hernia sac and intermittently before the skin is sutured. This approach has inhibited the adhesion of bacteria to the surface of mesh [63].

The conservative approach for mesh infection has been suggested by Aguila et al. [64] and Trunzo et al. [65]. The authors proposed percutaneous drainage of accumulated pus around the mesh and insertion of drain through which irrigation with gentamycin 80 mg in 20 ml of saline solution is carried out thrice daily along with intravenous antibiotic treatments. The treatment of mesh infection is also dependent on prosthetic material used. Peterson et al. [66] conducted a comparative study which showed the incidence of mesh infection greater after use of ePTFE (polytetrafluoroethylene 8%) than in cases of PP (polypropylene 3.9%). All infected PP meshes were preserved, and ePTFE meshes had to be removed. Hence, the mesh salvage is advocated in cases of PP meshes.

The revolution and emerging trends of newer generation meshes are supportive of placement of mesh in contaminated operating fields. The new meshes are lightweight, monofilamentous, and macroporous in nature for improved surgical outcomes [31, 32]. Multifilament meshes have smaller pore sizes, typically 10 μm or less thus inhibiting rich collagenous in growth and immune cell surveillance [32]. Thus, new meshes deliver good clinical outcomes.

62.5 Recommendations

- To maintain sterile and asepsis condition to avoid any mesh infection.
- An infected ePTFE mesh after laparoscopic ventral and incisional hernia repair should be removed.
- To defer the mesh placement during significant contamination, dense adhesions, and strangulated hernia with bowel obstruction.
- Percutaneous drainage of accumulated pus, intravenous antibiotic therapy, and insertion of drain with irrigation of gentamycin are conservative managements of mesh infection.
- On failure of conservative treatment, established options for treatment of mesh infections after open repair should be used.

62.6 Loss of Domain

Large incisional hernias with significant loss of domain represent a significant problem [67]. A loss of domain situation can be identified on physical examination, the inability to reduce herniated contents below the fascia level when the patient is lying in supine position [68]. CT examination is the basis for diagnosis for knowing the extent of herniation, the contents of hernia sac and perfusion of the intestinal wall. The large volume of hernia content is managed by lengthening the musculature via mechanical expansion, anatomic alteration, synthetic/biological replacement, or combination of techniques [68]. Tissue expanders and pre progressive pneumoperitoneum are used for mechanical expansion.

Abdominal wall reconstruction techniques are mainly used to achieve the following objectives:

- To relocate the hernial contents back to native abdominal cavity
- The ability to re-approximate the midline fascia overtop a retromuscular-implanted prosthetic mesh
- To increase the volume of abdominal cavity to re-accommodate the large volume of herniated contents
- Increasing the volume of abdominal cavity by lengthening the abdominal wall musculature

The lengthening of abdominal wall musculature is done via either mechanical traction, anatomic alteration, synthetic replacement, or combination techniques. Mechanical traction involves progressive preoperative pneumoperitoneum, and laparotomy with progressive mesh excision and tissue expanders. Progressive preoperative pneumoperitoneum is the insufflation of the peritoneal cavity that acts as mechanical tissue expander and lengthens the abdominal wall musculature, increasing the volume of the abdominal cavity. This allows for adequate accommodation for the herniated contents. Synthetic tissue expanders are placed between abdominal wall muscle layers which expand over the course of several weeks [18]. The expander balloon lengthens the abdominal muscles by exerting a mechanical traction. Anatomic alteration is the component separation technique which increases the abdominal circumference with the possibility of subsequent fascial closure by disconnecting musculofascial layers, which lengthen the overall abdominal wall musculature.

Large hernia defect requires staged procedure. Carbonell et al. [68] have proposed a strategic staged procedure for management of loss of domain.

Stage I

- Percutaneous vena cava filter and antithrombotic medication to preclude high risk for thromboembolic events.
- Explorative laparoscopy and placement of the insufflation catheter.
- Monitoring of pulse oximetry and vital signs.
- Full liquid diet with protein supplementation.
- The patient is instructed to utilize incentive spirometry and encouraged ambulation.

Stage II

- Beginning of PPP (progressive preoperative pneumoperitoneum).
- If the patient will begin to complain of abdominal tightness and mild flank discomfort, insufflation is stopped once the patient begins to experience some shortness of breath or mild anxiety (there is no specific volume of air that should be insufflated nor the intra-abdominal pressure measured; endpoint of insufflation will always be the patient's level of discomfort; if at any point the patient becomes hemodynamically unstable or the urine output decreases, the pneumoperitoneum can be evacuated).
- Patient is advised daily moisturizing of the skin because of dryness and cracking.
- After 7 days of PPP, CT scan is repeated to determine the suitability of the abdominal wall repair (if the bowel has not fallen back and the volume of the abdomen does not look to have increased significantly, the PPP should continue for more 4 to 5 days, and CT scan is repeated).

Stage III

- Rives-Stoppa retromuscular hernia repair technique with or without the addition of a posterior CS (component separation or
- IPOM (intraperitoneal onlay mesh)

The surgical management of complex and large abdominal wall hernias is challenging for different reasons [16]:

- Difficult anatomy (adhesions) (Fig. 62.5)
- Impaired nutritional status of patient
- Underlying disease comorbidities
- Large skin and soft tissue defects
- Psychological stress

Contraindications to laparoscopy for complex ventral/incisional hernias:

1. Multiple previous laparotomies. These patients are likely to have widespread severe adhesions of abdominal viscera to anterior abdominal wall. Safe initial intraperitoneal access may not be possible in these patients.

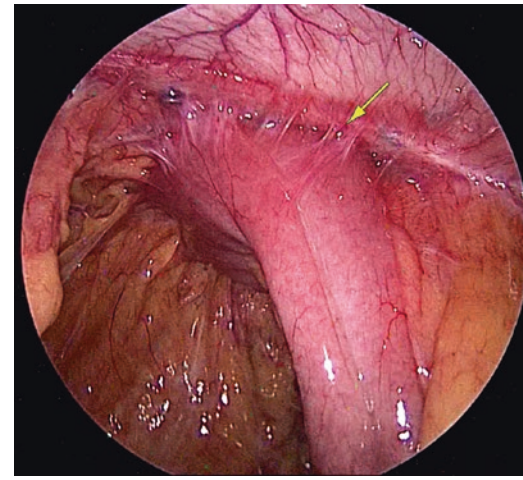

Fig. 62.5 Describes the adhesions in difficult hernias

2. Patients with excessive redundant abdominal wall and fat. These patients require abdominoplasty.
3. Patients with very large incarcerated hernias.
4. The presence of strangulated bowel within the hernial sac.

In conclusion to minimize the complication rate with difficult hernias:

1. Laparoscopic approach should not be considered in patients having strangulated bowel as hernial content.
2. There should be a low threshold for conversion intraoperatively during surgical repair of complex hernias.
3. There should be a high index of suspicion for an iatrogenic enterotomy during bowel reduction and adhesiolysis.
4. If iatrogenic enterotomy occurs, the surgeon should defer the placement of prosthetic mesh and complete the hernia repair primarily with sutures. The prosthetic mesh repair may be performed as second-stage procedure.

62.7 Wisdom of Strategic Surgical Retreat

Retreat is an act of moving back or signal for military force to withdraw and accept the reality of complex situation at the line of control. At the surgical front, it is the wisdom of a surgeon to

retreat in a complex condition during hernia repair intraoperatively. In these conditions like peritoneal spillage during enterotomy and dense adhesions, it is advisable to defer the mesh placement in case of significant contamination. It is best to delay the placement of mesh with median interval of 4 weeks (3 days to 6 months). In the episodes of strangulation with bowel obstruction, it is important to postpone the mesh hernia repair for the second operational setting to prevent risk of wound infection and subsequent removal of mesh. It is the wisdom of every clinician to weigh the risk of retreating from the operating surgical field comparative to risk of mesh infection, serious morbidity, recurrence, and possible mortality.

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Open Abdomen

63

Pier Luigi Ipponi

In the mind of a general surgeon, to leave the open abdomen at the end of a procedure might generate an unconscious discomfort due to the feeling of having accomplished an incomplete act. However, it represents one of the major innovations over the last 20 years as lifesaving solution and a strategic moment in minimal damage control surgery, which transposes the warfare experience into the management of major surgical emergencies.

63.1 Historical Aspects

In the second half of the nineteenth century, Dominique Jean Larrey (1766–1842), chief surgeon in Napoleon's Imperial Guard, argued the need for a rapid surgical procedure on severely wounded soldiers. Subsequently, the First and Second World War stated that survival was conditioned not only by the immediacy of care but also by the modality of injury treatment. Since then, we have learned that all septic wounds shouldn't be immediately sutured in order to reduce the risk of infection [1–4]. W. H. Ogilvie did [5, 6], during the Second World War, reported firstly his experience on the delayed abdominal closure in contaminated wounds, between 1 and 4 days after the surgical procedure.

Nevertheless, in civil practice, until the early 1970s of the last century, people suffering severe traumatic injuries or developing complex abdominal diseases underwent lengthy surgical procedures [7], aimed to permanently repair all types of visceral lesions observed. Despite the efforts, the fate of these patients, due to the long operating time, was affected by severe metabolic alterations, resulting in death more than incomplete or imperfect surgical execution.

In order to overcome the poor results, the open abdomen and packing techniques were used, more frequently than in the past, both in civil or military scenarios (like Vietnam War), but unfortunately the disclosure of these techniques was limited by serious and frequent complications, such as severe bleeding or infection. Only in the 1990s of the twentieth century, due to an improvement in intensive care [8], minimal damage control and open abdomen gradually became accepted in the surgical community and considered as last resort treatment in abdominal trauma and surgical emergencies, such as intra- or retroperitoneal bleeding, severe intra-abdominal sepsis, or acute pancreatitis, with acceptable results. The associated complications [9, 10], such as entero-atmospheric fistula, potential cavity contamination, complex post-incisional hernia, or wound management, were well counterbalanced by the better results in surviving rate, as demonstrated by countless authors [8, 11].

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63.2 Pathophysiological Aspects

The persistent state of vascular hypoperfusion, encountered during severe abdominal disorders, could negatively impact on tissue metabolism resulting in hypothermia, acidosis, and coagulopathy (Fig. 63.1), the fearsome killer triad [12–14]. Only its early diagnosis will lead to satisfactory therapeutic results.

Hypothermia, defined as body temperature lower than 35 °C, is frequently observed in victims of severe posttraumatic injury. It is ancillary to an impairment of heat production mechanisms and often associated with thermal dissipation, such as prolonged exposure to low environmental temperatures and administration of non-heated crystalloid or blood components, during resuscitation. Its deleterious effects have been widely demonstrated over the years [15–17] and highlighted by the strong correlation between body temperature and patients' survival rate. If compared with normothermic patients, the mortality index in hypothermic subjects is four times higher between 34 °C and 35 °C, eight times at 33 °C, and equal to 100% for lower values [18].

Metabolic acidosis (pH <7.3), consequential to an increase of lactic acid production due to an anaerobic metabolism, is triggered by a prolonged tissue hypoperfusion. At first, it promotes peripheral vasodilatation with oxygen releases by hemoglobin, improving the critical metabolism, but if prolonged over time leads to a severe cardiocirculatory insufficiency and multiple organ failure (MOF).

Coagulopathy represents an insidious component due to its multifactorial genesis, which makes its treatment really complex. In a hypovolemic shock, the attempt to restore the normal blood volume, administering high volumes of crystalloid and blood derivatives, leads to a substantial dilution of coagulation factors and platelets, thereby reducing their effectiveness. Hypothermia, arousing during resuscitation and exacerbated by non-heated fluid administration, plays a primary role inactivating some coagulation factors (e.g., von Willebrand factor) assigned to trigger platelet aggregation. Within this framework, we should also consider the side effects of extensive tissue damage, activating at first the coagulation factors and subsequently the fibrinolytic system, responsible for a disseminated intravascular coagulopathy (DIC).

The open abdomen itself, if incorrectly managed, could further worsen these disorders. The extended exposure of abdominal viscera, although under a protecting layer, can lead to a high loss of body fluids with hypovolemic effects and heat dispersion, worsening the hypothermia. Last but not the least, leaving the abdominal cavity open exposes to an increased risk of exogenous infections, especially in immunocompromised patients.

However, the open abdomen plays a strong preventive role against the insidious danger of an abdominal compartment syndrome (Fig. 63.2a, b),

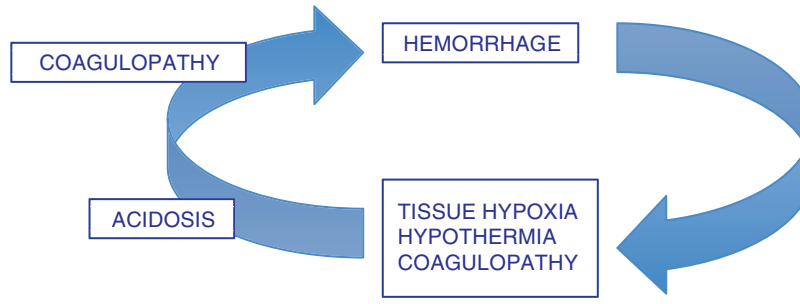

Fig. 63.1 The killer triad

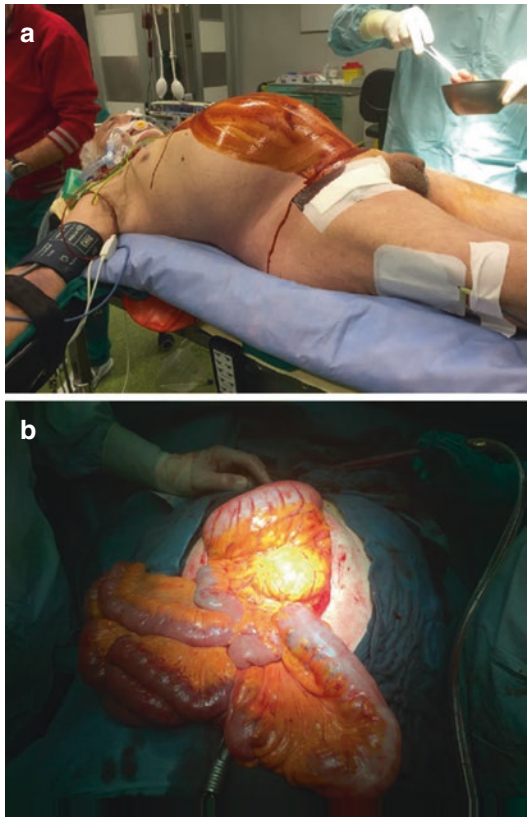

Fig. 63.2 (**a**) Abdominal compartmental syndrome, (**b**) ACS open abdomen

which may frequently affect critical care patients. By a pathophysiological point of view, it is similar to the limb compartment syndrome, well known by orthopedic surgeons. In an abdominal setting, the internal pressure, normally fluctuating between 5 and 7 mmHg in critically ill adults, can be significantly increased in such a way as to induce a visceral failure, proportional to the exerted pressure (Fig. 63.3). The measurement of intra-abdominal pressure (IAP), expressed in mmHg, is generally performed through a bladder catheter, which is the standard method worldwide due to its simplicity, low cost, and risk of complications. Ensuring accuracy and reproducibility in IAP measurements, the bladder should be fulfilled with a maximal instillation volume of 25 ml of sterile saline. In attempt to address any issues, it is recommended to take the values in complete supine position, with no abdominal wall muscles contraction, at end expiration, and with the transducer zeroed at the level of the midaxillary line (Fig. 63.4). The World Society of Abdominal Compartment Syndrome (WSACS) has clearly defined the intra-abdominal hypertension (IAH) [19] as a sustained or repeated pathologic elevation of IAP $\geq$ 12 mmHg. Intra-abdominal hypertension (IAH) develops a progressive reduction in microcirculatory blood perfusion, responsible for negative effects on the kidney, lung, splanchnic organs, and brain with musculoskeletal as well as cardiovascular activity seriously alternated. The intra-abdominal hypertension, with sustained value of IAP > 20 mmHg and associated with visceral dysfunction or failure, defines the abdominal compartment syndrome (ACS). ACS is characterized by "all-or-nothing" pathophysiological mechanism, with significant morbidity and mortality, if not recognized and treated in a timely manner. By etiological point of view, ACS may be classified as primary when it is following injury or disease in abdominopelvic region (e.g., intra- or retroperitoneal bleeding, severe pancreatitis, and peritonitis) or secondary to extra-abdominal causes (e.g., extensive burns, severe sepsis, or massive fluid resuscitation). The WSACS released a classification, correlating different levels of IAP with different clinical scenarios: Grade I (IAP 12–15 mmHg), Grade II (IAP 16–20 mmHg), Grade III (IAP 21–25 mmHg), and Grade IV (IAP > 25 mmHg) with the recommendation that, while medical intervention is appropriate for any grade, surgical decompression should be always reserved for Grade IV or in patients refractory to other treatment options. A presumptive decompression should be considered at the moment of laparotomy in patients with multiple risk factor of IAH or ACS.

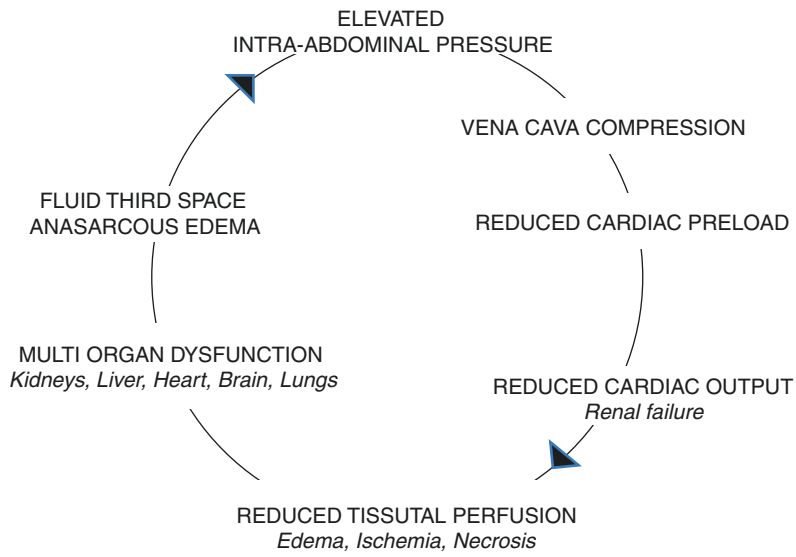

Fig. 63.3 Pathophysiological aspects in abdominal compartment syndrome

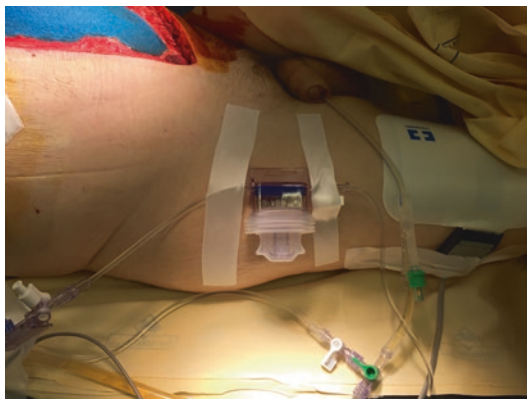

Fig. 63.4 Measurement of IAP (transducer zeroed at the level of the midaxillary line, on the thigh)

63.3 Clinical Strategy

The poor results in lifesaving treatments in severe traumatic injuries or complex abdominal diseases have driven us to overturn one of the basic principles of surgery, asserting now that the best practice in complex surgical emergencies isn't the execution of a single and definitive procedure but to carry out a multistage surgery. The first step, passing through a staged laparotomy, is aimed to control active bleeding and bacterial pollution sources to avoid a subsequent hypovolemic and septic shock. In the first case, bleeding will be controlled by vessel suture or packing, in case of a severe parenchymal lesion (e.g., liver injury). In the latter case, it will be necessary to perform a resection of the damaged bowel, often without anastomosis, but making an ostomy, placed laterally to allow maximal medial mobility of the wound edges, in view of an abdominal wall closure. At the end of the procedure, with a temporary abdominal closure (TAC), the patient will be transferred as soon as possible to an intensive care unit, where severe metabolic alterations will be adequately corrected. Within 24–48 h after ICU recovery, an exploration with extended debridement and washing of the abdominal cavity will be planned, searching for unidentified visceral damages. This procedure will be eventually repeated until addressing any issue. Only once the patient has been stabilized will be taken into account the restoration of anatomical and functional continuity of damaged organs as well as the abdominal wall, which has been deliberately left open not only to evaluate the clinical evolution but also in order to reduce the redoubtable risk of an abdominal compartment syndrome (Fig. 63.5).

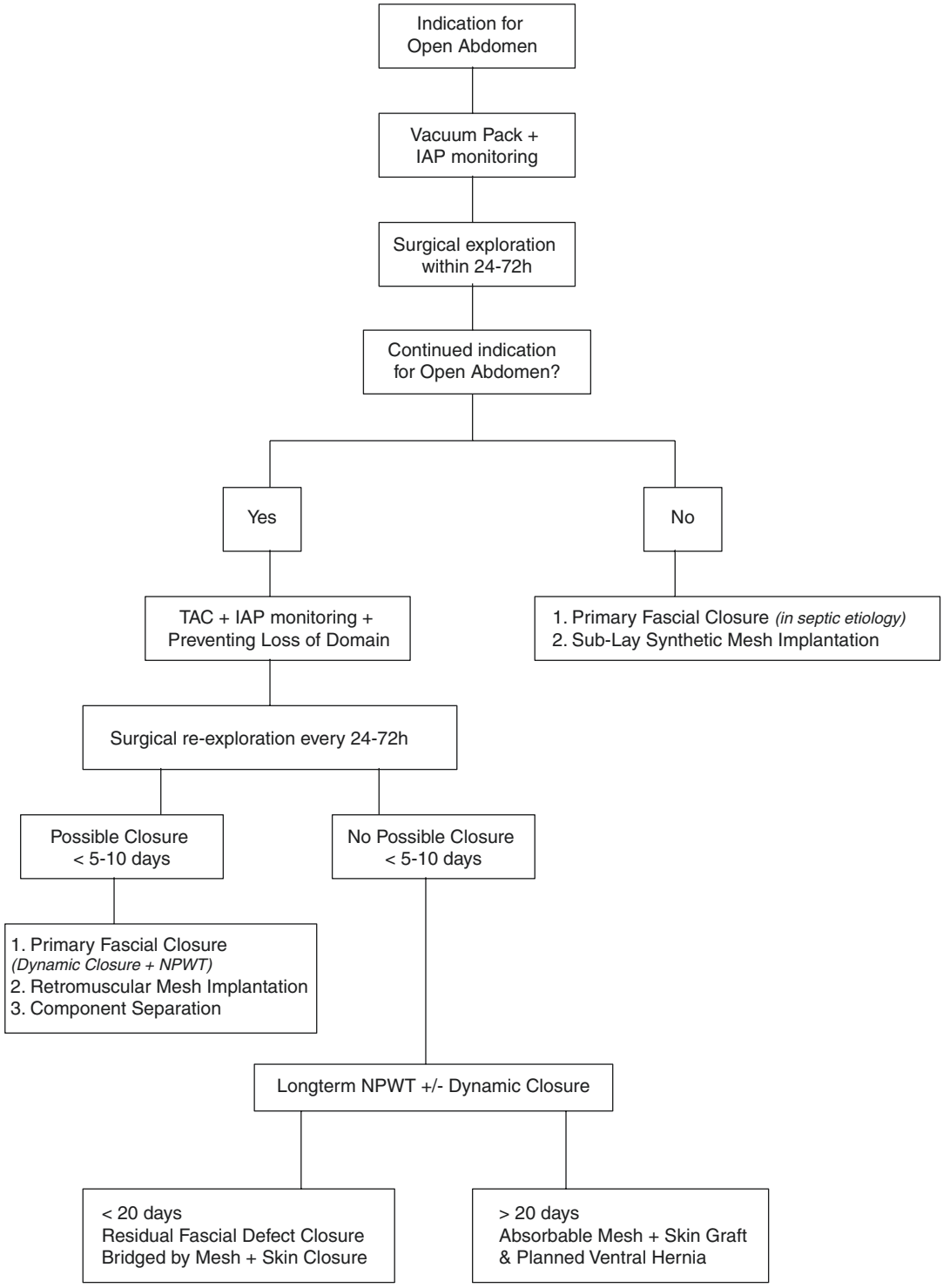

Fig. 63.5 Algorithm in open abdomen treatment

63.4 Clinical Scenario and Classification of Open Abdomen

Sometimes a full fascial closure is not feasible for extended loss of abdominal wall tissue (e.g., necrotizing fasciitis) or when a midline approximation is technically impossible, due to an excessive tension as a result of a pronounced bowel edema. The open abdomen is an obliged solution in abdominal compartment syndrome, while in damage control surgery, it may be considered as the first step in a planned multistage treatment.

In 2009, Björck, Bruhin, and Cheatham [20, 21] after a consensus group meeting, proposed a classification of the open abdomen, describing the clinical course and comparing the results in a heterogeneous patient population. They established the first guidelines, in order to improve its management.

They have identified four degrees:

Grade 1. Open abdomen without adherence between bowel and abdominal wall or fixity by lateralization of the abdominal wall, with a subgrade **A**, without contamination, and subgrade **B**, with contamination of the abdominal cavity.

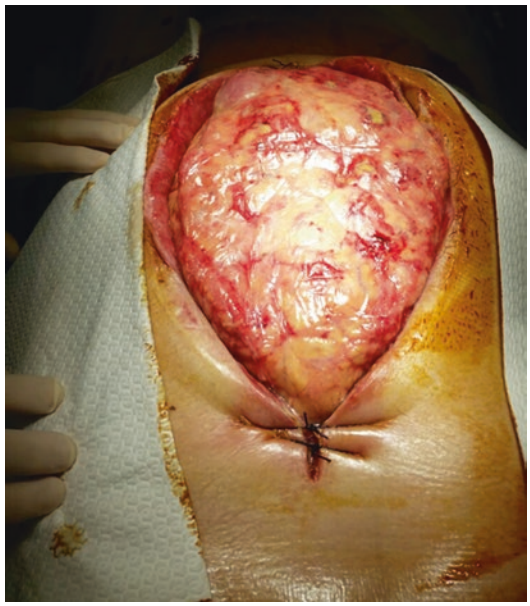

Fig. 63.6 Frozen abdomen

Grade 2. Open abdomen developing adherences and/or fixity of the abdominal wall, with a subgrade **A**, without contamination, and subgrade **B**, with contamination of the abdominal cavity.

Grade 3. Open abdomen complicated by enteric fistula.

Grade 4. Frozen abdomen with adherent or fixed bowel, unable to close surgically, with or without enteric fistula (Fig. 63.6).

63.5 Temporary Abdominal Closure (TAC)

Temporary abdominal closure (TAC) represents the best option following a staged laparotomy, in order to monitor eventual complications before abdominal wall closure. In this phase, the patient is maintained in a critical care setting, with acid-base balance, hypothermia, and coagulation abnormalities corrected. As primary task, it carries out a mechanical barrier against evisceration and contamination, but it also allows abdominal volume expansion without causing hypertension. Furthermore, it should ensure a complete evacuation of fluids, bacteria, and metabolic waste from abdominal cavity, in order to reduce the intra-abdominal edema, infection, or inflammation, thus reducing the risk of bowel damages and fistulization.

Several techniques have been performed, and each one has its own advantages and disadvantages. No prospective randomized clinical trials are yet available to compare effectiveness, even though retrospective studies demonstrate their proficiency in reducing mortality rate.

Towel clipping of the skin edges: one of the simplest, fastest, and cheapest forms for temporary abdominal closure in patients with unstable condition. Towel clips are placed 1 cm apart and 1 cm away from each side of the skin edge and covered by adhesive plastic drape (Fig. 63.2).

Open packing of the abdomen: one of the oldest techniques in open abdomen treatment and firstly used to control severe abdominal injury and bleeding. The abdominal wound and viscera were covered with a sterile plastic sheet, to

prevent adhesion, which in turn was covered with gauze dressings. Widely spaced retention-type sutures, encompassing all layers of the abdominal wall, were tied above the gauze packing. In the later stages, the gauze dressings were progressively removed, and retention sutures gradually tightened until the incision can be closed [22]. This approach was associated with severe bleeding during repacking, septic complications associated with misunderstood visceral lesions, or multiple organ failure (MOF) syndrome due to excessive intra-abdominal pressure [23]. Subsequently, to address these problems and get better outcomes, surgeons preferred, especially in septic patients, to leave the open abdomen without retention sutures, with the wound dressing changed and the abdominal cavity washed every day [23]. However, clinical data reported heavy complications, such as evisceration or enteric fistula, and survivors need complex abdominal wall reconstructive surgery; thus, open packing is not considered anymore an effective technique.

Bogota bag: named by Mattox while observing it for the first time in Bogota, Colombia, when an intravenous presterilized bag or bowel bag was shaped to cover the abdominal viscera and sutured to the skin edges of the wound. Sterile wet towels were placed over the plastic sheet which in turn was covered with an iodine-impregnated adhesive drape. The abdominal cavity will be easily explored and debrided with the dressing changed every day (Fig. 63.7). This TAC technique is easy to do even in unfavorable environmental conditions and is less expensive than other described techniques. But it shows a strong limitation to drain fluids and preventing the abdominal wall retraction, with a primary fascial closure rate lower than 40%.

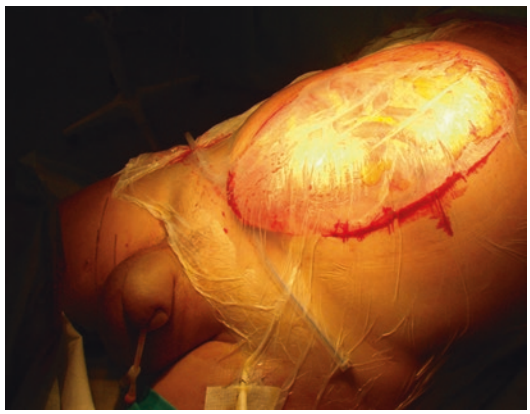

Fig. 63.7 Bogota bag

Mesh closure: absorbable or permanent synthetic materials have been used in TAC [38], implanted as bridge between the edges of the abdominal incision and improving primary closure rates, from 33% to 89%. The substantial difference is related to their mechanism of action. The permanent meshes play a role as strong mechanical barrier against lateralization of abdominal muscles and favor wound edge closure, by excising the central part and resuturing the mesh together when wound contraction occurs. The absorbable meshes work as scaffold to stimulate ingrowth of granulation tissue, with definitive wound healing by secondary intention. The macroporous meshes, due to the continuous irritating friction of the bowel on the prosthetic surface, elicit a bowel phlogistic reaction, with mesh or intestinal loop adhesions, which may lead to intestinal occlusions. The subsequent intraluminal hypertension, acting on a weakened and often dehydrated bowel, will lead to perforation and fistulization (7–15%). If the synthetic absorbable meshes seem to show better resistance to infections and adequate drainage of intra-abdominal fluids, they show bowel complications similar to the ones given by permanent meshes, not to mention a higher rate of incisional hernias.

Synthetic microporous materials, such as expanded polytetrafluoroethylene (ePTFE), even if offering an inadequate drainage of intra-abdominal fluids, are considered safer, with low risk of bowel adhesions but associated with an increased risk of infections due to the submicronic pore size structure, which allows bacteria colonization and protection from host immune cells; thus, it isn't recommended to implant one in a contaminated environment.

Zipper closure: was firstly described by Leguit, in 1982, and subsequently by other authors in post-pancreatitis abscess treatment [24, 25] (Fig. 63.8). The zipper is sewn directly to

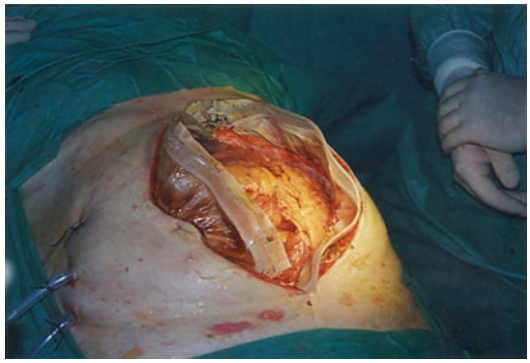

Fig. 63.8 Zipper closure in temporary abdominal closure

the abdominal wall, with a running suture in nylon and sometimes combined with a mesh in order to prevent an intra-abdominal hypertension, as described by Teichmann [26]. The skin is preferred to the fascia, as site to anchor the zip, thereby diminishing the incidence of postoperative dehiscence in abdominal wall closure. Planned relaparotomies must be performed every 48–72 h, associated with repeated lavages and debridement, as long as the abdomen is judged clean and infection subsided [27]. The mesh-zipper device, even if performing a very quick and easy access into the abdominal cavity and making it easier to close, is abandoned nowadays.

Wittmann Patch: firstly reported by Teichman and then by Wittmann [28]. This technique appears similar in concept to the zipper, providing a simple method to achieve a primary abdominal fascial closure, from 78% to 100% of patients, with rate of complications under 4%. It is a simple method, with two opposing pieces of Velcro fabric, anchored to the fascia. They are imbricated to cover the gap between the wound edges and progressively approached. A nonadherent barrier, to avoid adhesion, is inserted between the patch and the viscera. The Velcro is easy to open and shows an outstanding resistance to mechanical stress. It facilitates the exploration of the abdominal cavity and avoids intra-abdominal hypertension by adjusting the bridging with the abdominal girth changes, due to bowel edema or paralytic ileus. The limits of this technique are represented by incomplete abdominal cavity drainage, due to the Velcro fabric which seals the wound, and the high risk of post-incisional hernia, following prolonged fascial traction, with subsequent tissue ischemia.

Vacuum-assisted closure therapy: the name originated from Barker's group, who firstly reported the term "vacuum pack," describing an innovative technique in temporary abdominal closure, named Barker's vacuum pressure therapy (BVPT). The pack consists of four component layers. The first one, the deepest, is a perforated polyethylene sheet placed beneath the peritoneum of the abdominal wall, widely beyond the wound edges. Providing visceral protection, it prevents adhesions and decreases the risk of bowel occlusion and fistulization. The wide perforation, distributed all over the surface, through the negative pressure, allows a uniform suction of the peritoneal fluids. The second layer consists of soft draining material, such as sterile surgical towels, positioned over the perforated polyethylene sheet, between it and abdominal parietal peritoneum, widely within the margins, to prevent visceral protrusion. The third layer is represented by silicone drains, placed above sterile surgical towels, which transmit the negative pressure (−100/125 mmHg) to the dressing required to suck the outgoing fluids. The last sheet, superficial, is an adhesive drape set on the skin, above and beyond the wound edges, to seal all the system. The BVPT, in addition to its historic heritage, is still in use in rural communities and in difficult environment hospitals, being cheap and effective. However, it may also be used in high-level intensive care units during the first 48 h, switching to a prepackaged dressing when the critical moment is over. The prepackaged dressing represents an improvement due to the easier and quicker setting up. It usually consists of an inner perforated plastic-encased sponge placed close to the viscera, in order to prevent adhesion or fistula and at the same time to allow intraperitoneal fluid suction. A microporous sponge is placed over it, coming in contact with fascia and abdominal walls, and in turn wrapped with an adhesive dressing. At the top, after drilling a small 2 cm hole, a suction device is applied for fluid evacuation. Subsequent studies have shown that NPWT stimulates angiogenesis, which leads

to a fast ingrowth of granulation tissue and cells of the immune system. The suction exerted by NPWT, aspiring intra-abdominal fluids, reduces bowel edema and cleans the abdominal cavity from inflammatory catabolites and bacterial burden, decreasing drastically the risk of infection. Furthermore, it favors wound healing and skin graft survival, with progressive approach of the wound edges together. The intra-abdominal negative pressure should be applied continuously, with a value low as −80 mmHg, to prevent dangerous ischemic effects and dehydration on the bowel, and eventually carried out to −25 mmHg in patients with high risk of bleeding. An eventual intestinal suture, in order to avoid negative-pressure effects, should be hidden, positioning the bowel deep in abdominal cavity or protected by omentum. The whole system must be changed approximately within 48–72 h, to avoid any risk of bacterial contamination or draining system occlusion by debris. Many studies demonstrate that NPWT favors abdominal closure, with low complications, from 60% to 88% of cases [29–31]. Recently, new devices with substantial refinements as visceral protecting layer with a high-performing absorption surface, such as ABThera System® KCI (Fig. 63.9), are supplied by industry. This new system is designed to envelop all the viscera from subphrenic to pelvic area and laterally to paracolic gutters, by facilitating the removal of exudate through six arms of polyurethane foam (spider drape) (Fig. 63.10). Most recently, this system has been integrated with a programmable irrigation system (VeraFlo® System KCI) (Fig. 63.11) able to instill fluids, such as saline sterile solution, wound cleansers, and antimicrobial solutions (Prontosan® B. Braun). They will dwell in the abdominal cavity, coming in direct contact with viscera, before being removed by negative-pressure suction. In septic patients, dilution and solubilization of infectious materials should reduce significantly bacterial burden, debridement, and bowel dehydration, with low risk of adhesions and fistulization. Additionally, it has been proven that soaking the dressing with saline solution and controlled instillation of local anesthetics, such as lidocaine, 30 min prior to removal may provide a better comfort at dressing changes. The cost-effectiveness of NPWT has been related to positive clinical outcomes in a

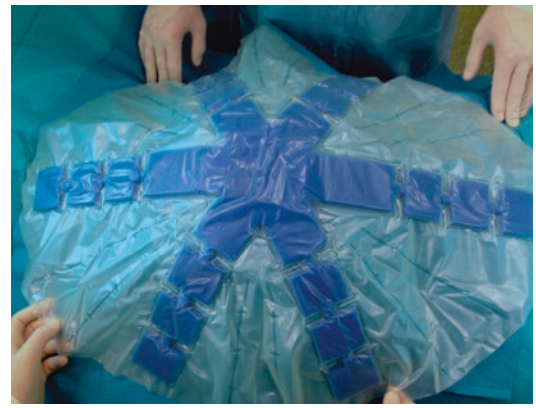

Fig. 63.10 Spider drape ABThera KCI-Acelity

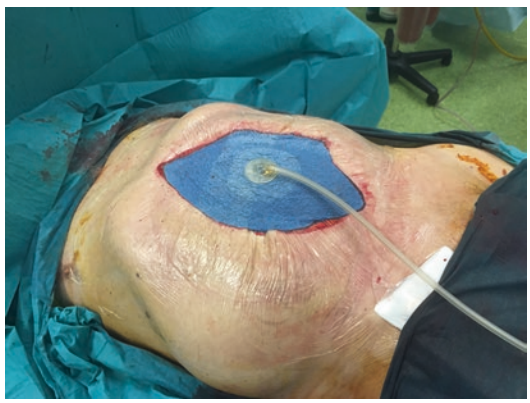

Fig. 63.9 ABThera KCI-Acelity

Fig. 63.11 VeraFlo System KCI-Acelity

variety of wound types and in TAC, with easier reconstructive and less time-consuming methods in wound closure, especially when carried out as soon as possible [32–35].

A prolonged NPWT over 3 weeks may lead to a "frozen abdomen" often associated with an entero-atmospheric fistula, which impacts seriously on patient morbidity and mortality, representing a hard therapeutic challenge. In this case, the patient needs to undergo a prolonged conservative treatment with adequate nutrition, hydration, and systemic sepsis treatment, associated with circulatory, respiratory, and renal system support. NPWT plays a favorable role in perilesional healing, helping to divert the enteral content and transform the entero-atmospheric fistula into enterocutaneous fistula, easier to treat. Later, once the patient has recovered, a planned surgery is going to be executed to restore bowel continuity through resection or direct suture, in small-sized fistula.

Dynamic retention sutures: firstly described by Reimer [28], this technique uses button anchors and elastomers, placed transfascially across the wound, to gradually pull the rims together and close the wound in a dynamic manner (Figs. 63.12 and 63.13). When associated with negative-pressure wound therapy (NPWT), it achieves fascial reapproximation in more than the 80% of the cases, with an overall wound reduction in 95%, associated with minimal complication and low incisional hernia rate ranging around 13% [29].

Vacuum-assisted wound closure and mesh-mediated fascial traction (VAWCM): vacuum pack therapy associated with continuous medial fascial traction leads to a light higher incidence of abdominal wall closure in TAC, ranging from 78% to 89%, if compared to NPWT alone, with no increased risk of any major complication [36, 37]. The medial traction is obtained through a polypropylene mesh sutured to the edges of the fascia and progressively reduced in size, by excision and

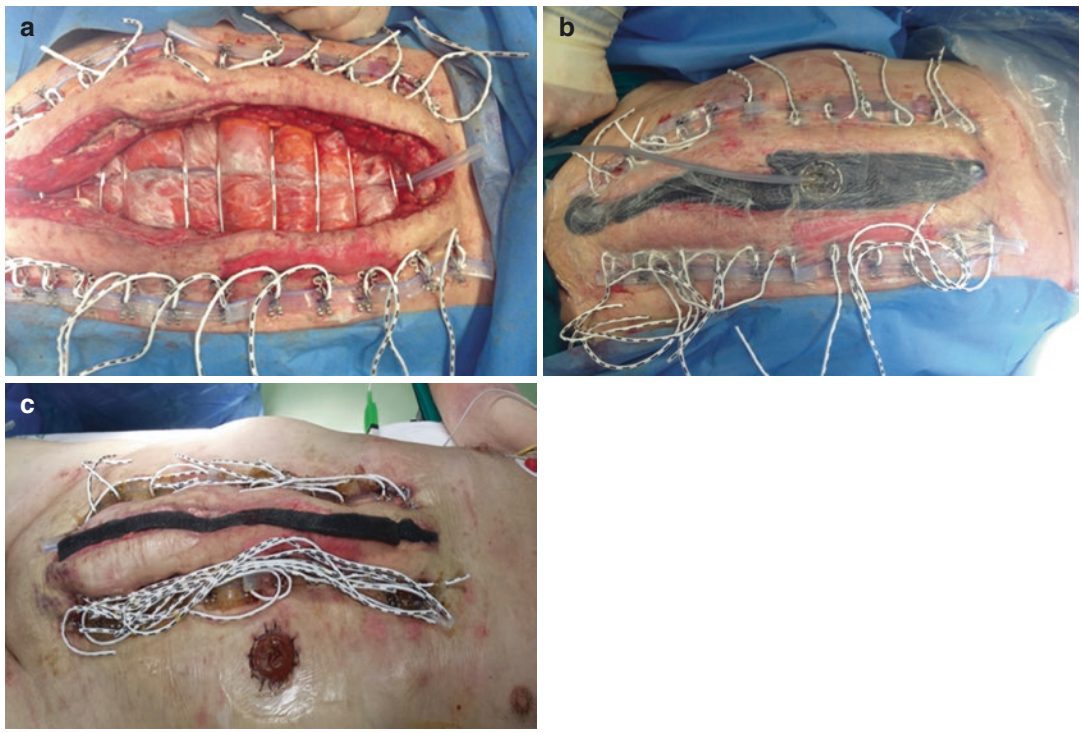

Fig. 63.12 (**a**–**c**) System ABRA Canica (Courtesy of Prof. Francesco Gossetti, Rome, Italy)

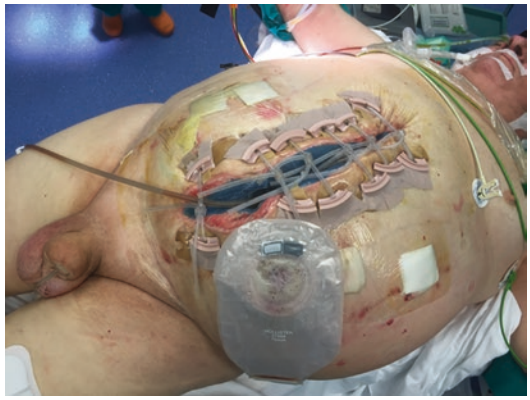

Fig. 63.13 Poor men retention suture

resuture in its middle part, with final fascial closure executed under very low tension. The incidence of incisional hernias, in patients undergoing a **VAWCM** for a delayed primary fascial closure, has been recently investigated. After 1 year of follow-up [38], the survivors developed a clinically detectable hernia in 36% of cases, and other 30% of them had asymptomatic small hernia detected only by CT scan or after laparotomy, but offering a substantially different scenario if compared with giant planned hernia observed after other different techniques.

63.6 Definitive Abdominal Closure

Once the emergency is over and the patient is stabilized, a new surgical challenge has to be faced: the abdominal wall closure.

It should be attempted as soon as clinically feasible, on average (and when possible) within 7–10 days after the staged laparotomy. After this time frame, loss of abdominal domain, lateralization of the recti, and chronic phlogistic contraction tend to be maximal, and abdominal wall closure will be more and more difficult. In this occurrence, we have to manage carefully a delayed wound closure, with skin graft, and the subsequent planned hernia repair will be scheduled at least 1 year after the first laparotomy.

Before executing a definitive abdominal wall reconstruction, we need to take into account some aspects which shouldn't be underestimated. If the reapproximation of the wound edges is performed under excessive tension, it may lead to an intra-abdominal hypertension, often associated with an abdominal compartment syndrome or fascial dehiscence. Furthermore, handling the aponeurotic fascia recurrently or exposing it to a tension, such as during a temporary abdominal closure, can result in ischemic tissue damage, able to decrease its tensile strength and elastic capacity and inducing a higher incidence of incisional hernia.

In the light of the above arguments, a primary abdominal wall closure should be pursued, whenever possible, by direct suture or prosthetic repair, eventually associated with component separation techniques. The direct suture of the fascia is the cheapest and quickest to perform but shows a high rate of incisional hernia, due to tension and fascial weakness. Substantial differences between single stitches and running suture or nonabsorbable and slow-absorbable materials are not reported [39, 40].

Better result, in terms of incisional hernia, may be achieved by prosthetic repair, when materials and techniques are wisely chosen. Permanent synthetic meshes, such as polypropylene, polytetrafluoroethylene, and polyester, have been used in the past, bridging the fascial gap but associated with long-term complications, as previously mentioned. Thus, these synthetic meshes, as inlay repair, have been abandoned [41] and reserved only in abdominal wall reconstruction with a retromuscular position (sub-lay) in clean-contaminated surgical fields, Grade II of Ventral Hernia Working Group (VHWG) [42] classification (e.g., in intra- or retroperitoneal massive bleeding due to rupture of abdominal aortic aneurysm).

To address the shortcomings of permanent synthetic meshes, the biologic grafts may be taken into consideration, even if a strong scientific evidence is not proven yet, due to a limited and inhomogeneous experience and their high costs. The raw materials are derived from different donors (human, supine or bovine) and site of harvest (intestinal submucosa, pericardium, liver, or, more frequently, dermis) and marketed in

different sizes and thickness, to satisfy every demand. Subsequently, they are chemically and physically processed, with different proprietary procedures, to remove every cellular component, antigens, viruses, or prions but preserving the extracellular matrix (ECM) and basement membrane components. The elimination of the antigens is strategic in order to avoid activation of lymphocyte Th1 cytotoxic phenotype, by cytokines (IL-2), interferon (IFN-y), and tumor necrosis factor (TNF-β), associated with both allogenic and xenogeneic transplant rejection [43]. At the end of the processing cycle, all materials show excellent physical properties, such as tensile strength and flexibility, which make them suitable to support adequately any mechanical stress which undergoes the abdominal wall in the first 6–12 months, before being replaced by host tissue [44]. Once implanted, the host immune system recognizes the prosthetic material as biologic tissue, avoiding a chronic foreign body reaction such as synthetic meshes and promoting a physiologic neoangiogenesis, which exerts a fast cellular colonization by monocytes, fibroblasts, and stem cells. The interaction between host and graft, passing through a remodeling process, should lead to a native original tissue. Furthermore, an excellent vascularization enhances local resistances to infections, ancillary to the high number of immune cells present inside the scaffold.

To grant a better structural stability, resistance to infection, and long-lasting permanence in implantation's site, some industries increase the collagen cross-linking. But too much of it may modify so deeply the tissue structure, which can exert a heavy impact on the extracellular matrix deposition and scaffold degradation, with a foreign body reaction like synthetics, as demonstrated in experimental model [45, 46]. In this manner, the surgeon will be faced with a crucial doubt, deciding between optimal tissue integration (low or no cross-linking process) and mesh strength and durability (high cross-linking process). The suggested solution could be "in media stat virtus."

The use of biologic meshes has been often associated with some issues such as the high cost of the device, due to the complexity of production and difficult to reduce, or the high rate of recurrences, ancillary to the implanted materials and repair techniques. Human acellular dermal matrix was one of the most commonly used products and was applied in the largest overall number of patients in the published studies, but it is prone to bulging and recurrences [47], due to high amount of elastin, which provides low mechanical resistance. But the aspect which impacts mostly on recurrences is probably the site of graft implantation. This argument has been recently discussed on scientific papers, comparing outcomes in homogeneous group of patients, who underwent complex abdominal reconstruction with cross-linked grafts by two different groups of skilled surgeons in complex abdominal wall repair. Both have similar short-time complications such as infection, seroma, and wound dehiscence, but one team experienced a 66% of recurrences, while the other only 14%, similar to synthetics. The reported data shows a substantial different prosthetic locations: the American team has a larger number of "bridging" repair (56% against 14%) (Fig. 63.14) compared to the Italian team,

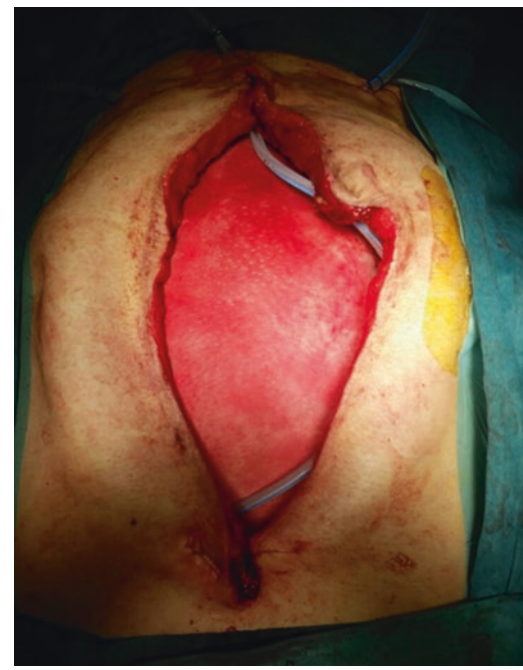

Fig. 63.14 Fascial closure with biologic patch (Permacol Medtronic) as bridge repair

which performed an abdominal wall reinforcement with sub-lay prosthesis and midline reconstruction (86% against 44%) [48, 49].

To obtain good clinical results and avoid waste of money with biologics, the correct clinical indication related to the surgical site contamination should be emphasized. An American survey mailed to practicing surgeons revealed that almost 50% of inquired surgeons agreed to use biologic grafts in dirty environment [50]. This results in contradiction with the Ventral Hernia Working Group [42] recommendations, which suggests a proper indication in potentially contaminated or contaminated surgical field, as in case of gastrointestinal tract violation, the presence of a stoma or after the removal of an infected mesh. In active infection, a downgrading of surgical site infection must be obtained by NPWT and targeted antibiotic therapy, before an abdominal wall reconstruction with a biologic mesh will be performed.

A strength abdominal wall reconstruction without tension, especially after a TAC, is very often associated with a component separation, to ensure a stable midline approximation. The first technique has been reported by a plastic surgeon, Oscar Ramirez [51], (Fig. 63.15) who through a midline incision and after undermining the soft tissue from anterior recti fascia suggested to reconnect the rectus from the external oblique muscle bilaterally, cutting all along the linea semilunaris and dissecting the avascular space between external and internal oblique muscle, toward the rachis. This brilliant solution has been widely used even by general surgeons for a long time, but it came out to be associated with some issues, such as skin and soft tissue ischemic sufferance with necrosis (Fig. 63.16a, b), due to periumbilical vascular transection during surgical procedure, or unaesthetic lumbar bulging (Fig. 63.17). In recent times, even if carried out by endoscopic approach with any vascular complications, this procedure has been progressively replaced in complex abdominal wall repair by posterior component separation, which allows a better medialization of the rectus muscles. It is performed through a midline incision, preparing the anatomical space between the rectus muscle and its posterior fascial sheet, as in the first step in Rives-Stoppa procedure. Subsequently, will be

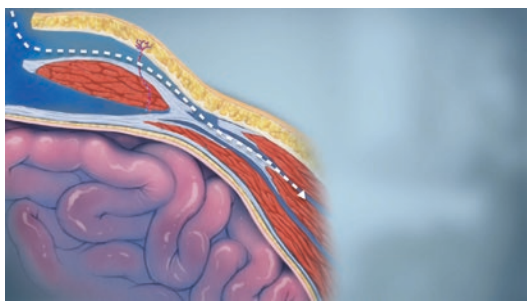

Fig. 63.15 Lateral component separation (sec. O. Ramirez)

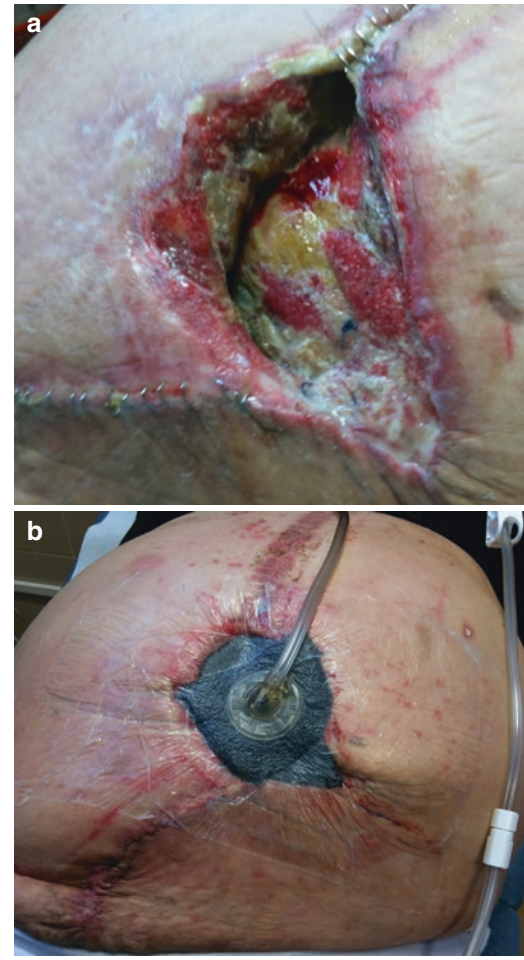

Fig. 63.16 (**a**) Ischemic soft tissue lesion, (**b**) the same lesion with VAC therapy KCI-Acelity

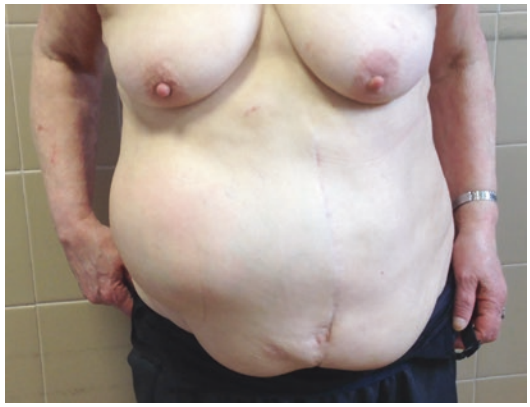

Fig. 63.17 Lumbar bulging after lateral component separation

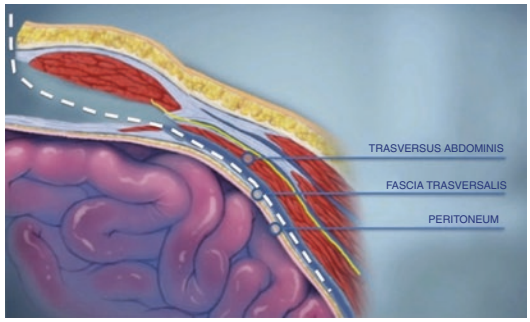

Fig. 63.18 Posterior component separation (sec. Novitsky and Rosen)

executed an incision on the posterior sheet of the rectus muscle, 5 mm medially to the neuro-vascular bundles, from epigastric to hypogastric region. Transecting the medial edge of the abdominal transverse muscle you will gain access to an avascular space, between its muscular fibers above and the transversalis fascia and peritoneum below, and freeing up this avascular space toward the para-vertebral space [52] (Fig. 63.18). An alternative solution, with synthetic mesh implantation, is to follow the space between transversus and internal oblique muscle, transecting all the neurovascular bundles and the posterior fascia just behind it [53], to avoid the mesh directly positioned on the peritoneum, associated with high risk of adhesions, but with the functional consequences of muscular denervation (Fig. 63.19).

The open abdomen represents an undeniable resource as lifesaving solution in management of major surgical emergencies. Much has been done, but still much needs to be done in the next future in order to obtain better outcomes in terms of survival and quality of life. Despite the complexity of the clinical frameworks, we expect further improvement in the abdominal wall reconstruction, thanks to innovative materials and new surgical procedures that will help to solve most of the issues encountered so far.

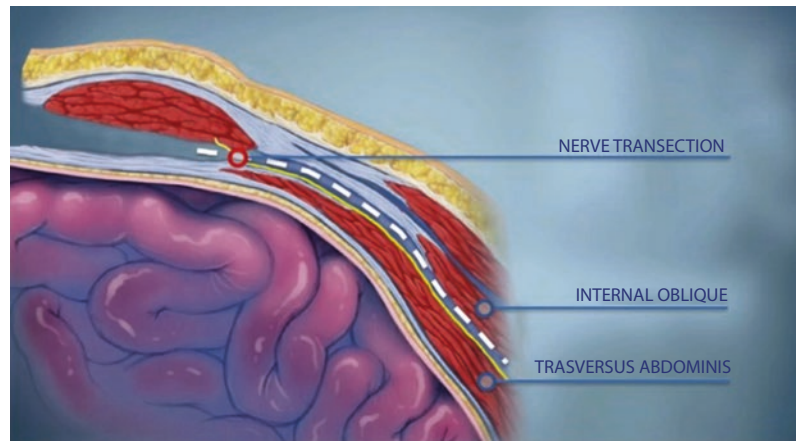

Fig. 63.19 Posterior component separation (sec. Alfredo Carbonell)

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Results and Complications of Incisional Hernia Surgery

64

René H. Fortelny, Anna Hofmann, and Ferdinand Köckerling

64.1 Introduction

Even though the laparoscopic approach to general surgery started in the early 1990s to minimize trauma to the abdominal wall and pain, we have to consider that actually today a high percentage of surgery is still done in an open approach. The risk of development of incisional hernia, especially after midline laparotomies, is found to be up to 44% in the literature. Though new techniques for closure of the midline like the "small bite technique" seem very promising [1, 2], the percentage of incisional hernias after 1-year follow-up with 21% are quite high. After 2 years of surgery, the rate of incisional hernia is only about 50% and 75% within 3 years. Not surprisingly, the increase of the hernia incidence from 1 year to 3 years of follow-up is about 60% [3].

The complications associated with incisional hernias are most likely chronic pain and discomfort but can lead also to incarceration and life-threatening strangulation.

Whereas all laparoscopic incisional hernia repairs are performed with the use of a mesh mostly in a bridging technique, predominantly the mesh provides a reinforcement of the direct closure of the defect in open repair. Mesh-associated complication like infections, shrinkage, and pain as well as complications due to mesh fixation and finally the recurrence rate have to be analyzed and compared to the different techniques of open and laparoscopic approach especially in terms of the long-term results.

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64.2 Material

To address the current issues of complications in open and laparoscopic incisional hernia repair, two meta-analyses [4, 5] focusing the comparison of the outcome in both techniques based on RCTs and data of the Herniamed registry were analyzed in this chapter. The aim of merging the analysis of clinical studies and the daily practice was to represent the genuine rate of complication rates in open and laparoscopic incisional hernia repair. The analysis of the different variables of outcome mainly focused on the intra- and postoperative complications, as well as chronic pain and recurrence.

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64.3 Results

In the meta-analysis of Awaiz et al. [4], six RCTs comparing laparoscopic versus open mesh repair for elective incisional hernia were included [6–11].

The overall complication rate in the laparoscopic group (LG) was 38.9% compared to 41.53% in the open group (OG) without any significant difference (OR 1.07, 95% CI 0.33, 3.42, $p = 0.91$). Concerning the bowel complication, a significant less percentage was found in OG with 2.11% compared to 5.89% in the LG (OR 2.56, 95% CI 1.15, 5.72, $p = 0.02$). The infection rate of 2.41% detected in the LG a significant lower percentage compared to 12.16% in the OG (OR 0.21, 95% CI 0.07, 0.64, $p = 0.01$), which was corrected after a comment by Jensen et al. [12] in the final analysis of Awaiz et al. [13].

The incidence of wound hematoma or seroma with 15.28% in the LG versus 12.69% in the OG (OR 1.54, 95% CI 0.58, 4.09, $p = 0.38$), as well as the reoperation rate with 0.48% in the LG versus 3.41% in the OG (OR 0.32, 95% CI 0.07, 1.43, $p = 0.14$), was analyzed without any significant difference (Table 64.1). Regarding the variables of length of hospital stay (SMD −0.83, 95% CI −2.22, 0.56, $p = 0.24$) and time back to work (SMD −3.14, 95% CI −8.92, 2.64, $p = 0.29$), also no significant differences were found (Table 64.2). The analysis of postoperative pain obtained no significant difference between both groups (OR 1.41, 95% CI 0.81, 2.46, $p = 0.23$). Finally also rate of recurrence in the LG with 8.74% compared to 6.92% of OG was without any significance (OR 1.41, 95% CI 0.81, 2.46, $p = 0.23$) (Table 64.1).

Table 64.1 Results of the review of Awaiz et al. [4, 13] concerning distribution of laparoscopic and open repair in incisional hernia and number and percentage of complications (bowel injuries, wound infection, hematoma/seroma, reoperation, and recurrence)

	Laparoscopic	%	Open	%
Patients	373		378	
Bowel complications	22	5.9	8	2.1
Complications	145	38.9	157	41.5
Wound infection	8	2.1	46	12.2
Hematoma/seroma	57	15.3	48	12.7
Reoperation	1 (206)	0.5	7 (205)	3.4
Recurrence	32 (366)	8.7	24 (374)	6.4

Table 64.2 Comparison of laparoscopic and open repair regarding hernia size, OP time, oral intake of painkiller, and hospital stay of the Herniamed registry

Mean (SD)	Laparoscopic	Open
Hernia size (cm^2)	31.6 (42)	20.9 (27.8)
Op time (min)	87.3 (28.8)	99.1 (24.5)
Oral intake	39.2 (13.7)	49.2 (13.8)
Hospital stay (d)	3.5 (1.4)	5.4 (1.8)

In summary, the results of the analysis of both techniques seem to be comparable in terms of complication rates except wound infection, which was in favor of the laparoscopic repair.

Albeit the results of this review seem to reflect the evidence, some basic limitation has to be taken into account. For most of the outcomes in the included studies except for bowel complications, recurrence rate, reoperation, and neuralgia, a high degree of heterogeneity has to be considered.

Another meta-analysis published by Al Chalabi et al. [14] included four RCTs comparing open versus laparoscopic repair of incisional hernias [8–11] and one RCT [5] with ventral hernias. A total number of 611 patients, 306 patients in the laparoscopic group and 305 patients in the open repair group, were enrolled in the final analysis. The range of follow-up in the studies was from 2 months to 35 months. The recurrence rate was similar ($p = 0.30$), wound infection was higher in the open repair group ($p < 0.001$), length of hospital stay was not statistically different ($p = 0.92$), and finally the operation time was longer in the laparoscopic group but did not reach statistical significance. The drawback of this systematic review may be the inclusion of one study in ventral hernias (Pring et al.; [5]), which could bias the results of the meta-analysis due to the fact of crucial difference in the results of repair in primary and incisional hernias.

Table 64.3 Distribution of the different OP methods (number and percentage) and results: OP time, hospital stay, intraop and post-op complication, and reoperation of the Herniamed registry

OP method	Open IPOM	Sublay	Onlay	Sutures	Component separation	Laparoscopic IPOM
Patients	5989 (13.7%)	14,584 (33.4%)	2282 (5.2%)	4598 (10.5%)	913 (2.1%)	13.058 (29.9%)
Operative time (min)	84	99	80	49	143	78
Hospital stay (d)	8	8	8	6	12	6
Complications intraop	2.40%	1.60%	1.50%	2.20%	2.80%	2.70%
Complications post-op	9.50%	11.40%	9.30%	4.80%	23.40%	4.30%
Reoperation	4.30%	5.30%	4.40%	2%	13.30%	2%

In the Herniamed registry, which was founded in 2009 by Köckerling [15], 47,580 data of incisional hernia repairs out of 417,147 hernia cases enrolled between 01 September 2009 and 24 April 2017 were analyzed concerning the different methods of repair as well as associated complications.

The distribution of the different repair techniques is shown in Table 64.3. The highest percentage of operation method was found in the sublay mesh repair with 10.5% followed by laparoscopic IPOM (29.9%), open IPOM (13.7%), suture repair (10.5%), and component separation (2.1%). Regarding the operation time, the suture repair was the fastest (49 min) and the component separation the longest (143 min). The median time for the laparoscopic IPOM with 78 min was nearly the same as for the onlay repair (80 min) and the open IPOM (84 min) compared to the sublay mesh repair lasting 99 min. The median hospital stay for open IPOM, sublay, and onlay was 8 days whereas 21 days for the component separation.

The intraoperative complication rate ranged between 1% and 3% (onlay 1.5%, sublay 1.6%, suture 2.2%, open IPOM 2.4%, laparoscopic IPOM 2.7%, CS 2.8%).

The postoperative rate of complication on the contrary differed significantly between the different procedures. The lowest rates were found after suture repair and laparoscopic IPOM with 4.8% and 4.3%, respectively, whereas 9.8% and 11.4% after onlay and sublay were detected. After component separation, the highest rate of 23.4% was described.

Similar distribution of the reoperation rates due to complications was seen: 2% in the group after suture repair and laparoscopic IPOM followed by open IPOM (4.3%), onlay (4.4%), and sublay (5.3%). Again the component separation was found to be associated with the highest reoperation rate (13.3%).

Following the reviews of Awaiz [4] and Al Chalabi [14], the comparison of open sublay versus laparoscopic IPOM was also analyzed for the data of Herniamed registry.

Looking at the size of defect (W1, W2, and W3, EHS classification) comparing laparoscopic IPOM and open sublay, the distribution is quite different, 38%, 49%, and 13% versus 25%,54%, and 21%, respectively (Table 64.4). The interpretation of these analyses detects the tailored approach concerning the chosen procedure in association with the defect size. Therefore, the results have to be seen very carefully and can be valued only in case of multivariable analysis or after propensity score matching.

The rate of wound infection in laparoscopic IPOM with 1.9% was significantly lower in comparison to the sublay with 4.7%. These results confirm the analysis of the reviews [4, 14]. Chronic pain and pain at rest or during exercise after 1 year of follow-up are without any difference between laparoscopic IPOM and sublay. The recurrence rate after laparoscopic IPOM after 1 year was 7.2% and after sublay 7.8% (Table 64.4).

Table 64.4 Distribution of defect size (EHS classification) and OP method (sublay versus laparoscopic IPOM) and rate of complications, reoperation, and recurrence, as well as pain at rest or during exercise and chronic pain after 1 year of the Herniamed registry

	Sublay (%)	Laparoscopic IPOM (%)
W1 (<4 cm)[a]	25	38
W2 (4–10 cm)[a]	54	49
W3 (>10 cm)[a]	21	13
Wound infection	4.7	1.9
Complications post-op	11.4	4.3
Reoperation	5.3	2
1a follow-up		
Recurrences	4.4	5.8
Pain at rest	11	10
Pain during exercise	20	20
Chronic pain	7.8	7.2

[a]Defect size (EHS-classification)

64.4 Conclusions

In summary, the analysis of Herniamed registry data confirms the results of the reviews of Awaiz [4, 13] and Al Chalabi [14] in terms of the higher risk of wound complications in open repair of incisional hernias compared to the laparoscopic technique. Furthermore, the analysis of the registry data detected lower rates of overall complications and reoperations in favor of the laparoscopic method. Since the tailoring of the surgical method in association with the size of the defect in the registry data could be seen, obviously, the members of the Herniamed registry are following the guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias of the International Endoscopic Hernia Society (IEHS) [16–18] in terms of limitation for laparoscopic repair up to a defect size of 8–10 cm. With respect to the defect size, the laparoscopic IPOM repair seems to obtain excellent results.

64.5 Discussion

The laparoscopic technique of repair of ventral and incisional hernia first described by Le Blanc developed not only in terms of technical equipment but also in mesh technologies. The everlasting discussion of the size of mesh overlap started with the first recommendation of Le Blanc in 2003 [19] and leads to the recent published review by Le Blanc [20]. In this review, an analysis was performed to determine the relationship between hernia recurrence rate and area of mesh overlap in open and laparoscopic repair including 45 prospective studies and 50 retrospective studies, enrolling 8864 patients in total. In laparoscopic procedures, the pooled estimation of risk for each group based on the extent of mesh overlap obtained incidence rates of 8.6%, 4.6%, and 1.4% for <3, 3–5, and >5 cm mesh overlap, respectively, whereas in open repair, no trend between hernia recurrence rate and mesh overlap could be seen (6.5%, 7.0%, and 6.0% for <3, 3–5, and >5 cm mesh overlap). These results reflect the importance of mesh overlap in laparoscopic repair especially in respect of the bridging technique.

According to the recommendation of the IEHS guidelines, "the mesh used for laparoscopic repair of a ventral hernia should overlap the hernia defect by at least 3 to 4 cm in all directions" (Grade B—Level of Evidence) and "a large overlap of the defect by mesh is necessary, with a minimum of 5 cm if the mesh is fixed without transfascial sutures. A larger overlap is recommended for larger hernias than the overlap used for small hernias" (Grade C). Another main issue of recurrence in the repair of incisional hernia is the relationship between mesh and fixation. In the guidelines of the IEHS [16], the recommendations are stated: "Suture fixation alone or a combination with tacks should be performed" (Grade B) and "The tacks-only fixation can be considered the technique of choice, taking into account the increased risk of postoperative pain due to the number of devices and the need for an additional overlap of mesh (at least 5 cm) to prevent recurrence caused by shrinkage" (Grade C). All these recommendations are predominantly based on the studies of Le Blanc [19] and could be extended to the results of the experimental studies of Kallinowsky et al. [21, 22], which revealed a direct association of mesh-type, overlap, and fixation according to the defect size.

Berler et al. [23] published an overview of new technologies of fixation models like push-pins, screws, or barbs associated with different mechanisms of fixation aiming the prevention of mesh migration and at the end a potential recurrence. The trend of minimizing the trauma of fixation, as already seen in the laparo−/endoscopic repair in inguinal hernias, seems to follow the use of glue and self-adhering meshes to achieve less chronic pain and better long-term outcome.

Another discussion is arising by the implementation of new laparo−/endoscopic techniques with the purpose to place the mesh in a retromuscular position to prevent any kind of complication associated with mesh or fixation. The mini/less open sublay (MILOS) and endoscopic MILOS (eMILOS) technique developed by Reinpold and Bittner et al. [24], endoscopic-assisted linea alba reconstruction (ELAR) by Köckerling [25, 26], stapled Rives-Stoppa by Costa et al. and Moore et al. [27, 28], and finally robotic approaches by Carbonell et al. [29] provide the advantages of minimally invasive approach in combination with the safest place of mesh implantation.

The reports of these brand-new hybrid techniques are very promising, but have to be proved in the long-term results.

Including all the developments and progress in incisional hernia repair, the old two main opposing techniques of open and laparoscopic repair will be replaced by tailoring each incisional hernia case with the best available technique including all new operation methods.

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Incisional Hernia: The Robotic Approach

65

Conrad Ballecer, Lucas R. Beffa, Jeremy A. Warren, and Alfredo M. Carbonell

65.1 Introduction

The optimal management of ventral abdominal wall hernias has undergone significant transformation over the last several decades. Despite this change, modern ventral hernia repair techniques remain founded on the principles and techniques used by Rives and Stoppa [1]. Their concept of placing synthetic mesh in the retrorectus position revolutionized the field of hernia surgery. Furthermore, the component separation techniques (CST) first described by Ramirez [2] in 1990 provided an additional tool for closure of large, complex ventral hernias. Adding to these techniques, Novitsky introduced the transversus abdominis release (TAR) as a retromuscular repair, essentially extending the Rives-Stoppa dissection laterally via a posterior component separation [3]. This created a large retromuscular myofascial release and a well-vascularized compartment which is protected from the abdominal viscera. This space allows significant overlap of the defect with synthetic mesh for reinforcement of the repair.

As the field of hernia surgery continues to evolve via technological advancements along with increasing use of evidence-based decisions, so will the techniques and platforms that surgeons utilize routinely. Since the introduction of robotic surgery, robotic ventral hernia repair has gained popularity. Surgeons have adapted this approach in a wide array of specialties ranging from cardiac and thoracic surgery to gynecology and urology. This platform was first used to perform a retrorectus Rives-Stoppa hernia repair by Abdalla [4]. Since then, it has become apparent that many of the open techniques can be converted to a minimally invasive approach with robotic assistance. This makes robotic ventral hernia repair a perfect union between the advantages of conventional open surgery melded with the benefits of minimal access to the abdominal cavity.

Currently, there remains diminutive evidence to support the use of robotics in ventral hernia repair; however, evidence is beginning to emerge with encouraging results. Gonzalez et al. [5] described a comparative retrospective analysis of 134 patients undergoing laparoscopic ventral hernia repair to robotic ventral hernia repair. In both groups, intraperitoneal mesh was placed, and they reported decreased hernia recurrence rates, increased ability to close the hernia defect, shorter length of stay, and decreased postoperative complication rate in the robotic group compared to those undergoing standard laparoscopic ventral hernia repair. Warren et al. [6, 7] reported similar results with increased ability to close the hernia defect and shorter length of stay with

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robotic hernia retromuscular repair compared to laparoscopic intraperitoneal repair, with no difference in surgical site infections between the two approaches. Looking to the future, our Open versus Robotic Retromuscular Ventral Hernia Repair (ORREO) trial (NCT03007758) will provide prospective, randomized data on which approach is superior.

There are several advantages a robotic platform can provide which are not amendable to an open or laparoscopic approach. Robotic surgery makes it possible to perform the same dissection as conventional open hernia repair through minimal incisions that would otherwise be near impossible with standard laparoscopy. This affords several benefits including the ability to restore abdominal wall anatomy through a minimally invasive approach, limiting the wound burden to the patient, creating a well-vascularized space in which to place mesh with significant overlap of the defect, improved ergonomics, excellent visualization, and avoiding the placement of intraperitoneal mesh. Disadvantages include cost, time, and training staff specifically for robotic surgery.

In this chapter, we aim to discuss patient selection, a step-by-step guide to our operative approach for robotic CST (or robotic TAR) and lastly postoperative management. While we recognize that our approach may differ from others, we aim to provide a broad foundation to which alterations and adjustments can be made to the procedure with ease, should the need arise, given a specific clinical scenario.

65.2 Preoperative Considerations

Patient selection is of paramount importance in ensuring hernia repair success. Patients with risk factors for increased wound morbidity, smoking, diabetes, and obesity appear to be well suited for robotic hernia repair. A robotic approach is ideal because the exact same steps for an open repair are performed but with the benefits of decreased wound complications that are seen with laparoscopic surgery. As with any laparoscopic surgery, the patient must also be able to tolerate pneumoperitoneum, thus making end-stage pulmonary and heart failure comorbidities a relative contraindication.

Large midline defects, up to 20 cm in width, have been closed robotically; however, defects between 6 and 10 cm in widest dimension seem to be best suited for robotic repair with good cosmetic results. Midline defects are ideal, but subcostal, iliac, and flank hernias can also be repaired using the same basic techniques of a robotic retromuscular dissection. Lastly, patients who have thin abdominal wall musculature tend to have more elasticity and compliance to their abdominal wall. This lends itself to defect closure under less tension and better visualization of the layers of the abdominal wall. Additionally, epigastric and suprapubic defects are amendable to robotic repair utilizing a single-dock Rives-Stoppa technique. Both techniques for double-dock robotic TAR and single-dock Rives-Stoppa will be described in this chapter.

All patients are enrolled in an enhanced recovery after surgery protocol. This includes drinking 8 oz of carbohydrate-rich sports drink within 4 h of surgery and preoperative doses of celecoxib and pregabalin. The goal of this program is to avoid the use of narcotics intraoperatively as well as limit postoperative narcotic use as much as possible. Patients receive 5000 units of subcutaneous heparin preoperatively, in addition to mechanical sequential compression devices on the lower extremities for venous thromboembolic prevention.

65.3 Double-Dock Robotic TAR Technique

65.3.1 Patient Positioning and Theater Setup

The patient is positioned supine with the arms at 90°. The patient's arms are not tucked since this would interfere with the ability to place the ports lateral and also impair movement of the robotic arms. The bed is flexed so the angle between the patient's costal margin and iliac crest is widened (Fig. 65.1). This step allows for a wider area in the lateral abdomen for horizontal port placement.

The room is set up for docking of the robot on the patient's left side and the side cart of the robot perpendicular to the bed. The center column is aligned over the patient's anterior superior iliac spine (Figs. 65.2 and 65.3). This allows working room for the assistant at the bedside between the sidecart and the patient's right arm.

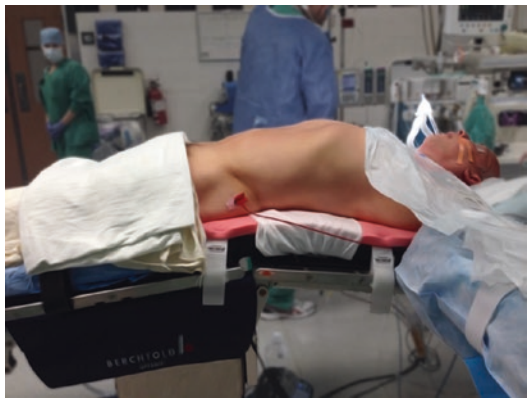

Fig. 65.1 Patient positioning

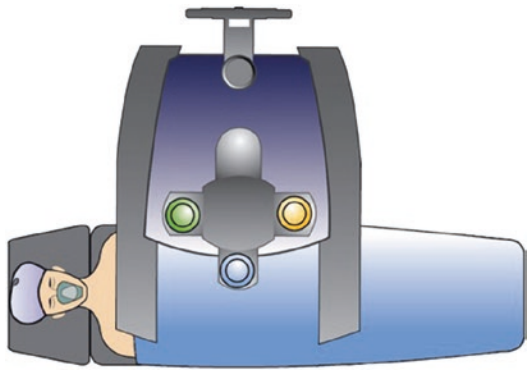

Fig. 65.2 Schematic of robotic docking

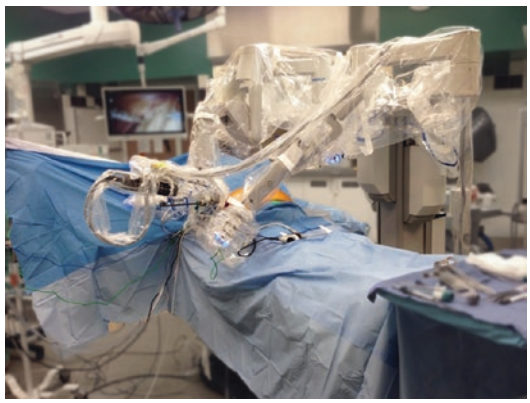

Fig. 65.3 Picture of robot docking

65.3.2 Incision and Access

Intraperitoneal access is obtained using a 5 mm optical view trocar at the right subcostal margin along the inferior border of the 11th rib. Once pneumoperitoneum is established, a 12 × 150 mm balloon tip trocar and 8 mm bariatric length robotic trocar are placed on the right side, laterally along the midaxillary line. The initial 5 mm entry trocar is switched to a similar 8 mm bariatric length robotic trocar (Fig. 65.4).

65.3.3 Operative Steps

Lysis of adhesions is first performed, either laparoscopically or robotically depending on the patient and clinical scenario. Once the robotic ports are free of adhesions, the robot is docked to the right-sided ports and any additional adhesiolysis is completed. Once the abdominal wall is clear of all adhesions, the abdomen is surveyed (Fig. 65.5).

The next step is to develop the retrorectus plane. This is similar to the open approach where the posterior rectus sheath is incised vertically, immediately lateral to the hernia edge or linea alba. The dissection is extended at least 5–7 cm above and below the hernia to allow for sufficient

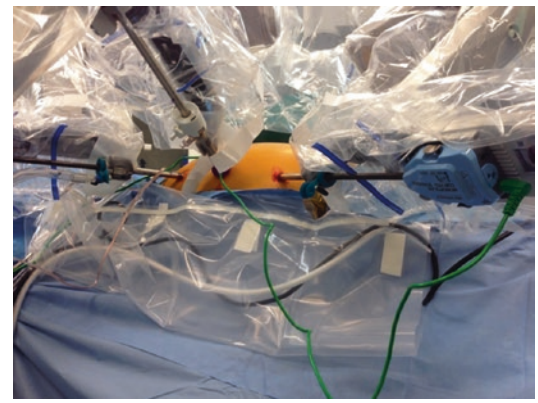

Fig. 65.4 Port placement with robot docked

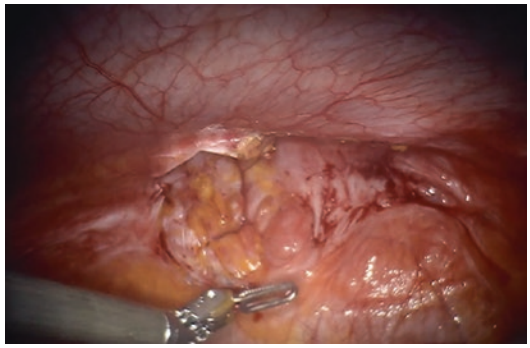

Fig. 65.5 Hernia defect after adhesiolysis

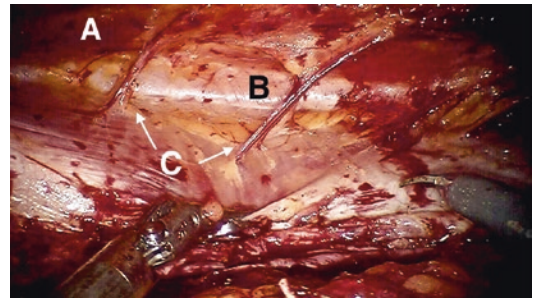

Fig. 65.7 Lateral border of retrorectus dissection (**a**) Rectus muscle. (**b**) Semilunar line. (**c**) Neurovascular perforators

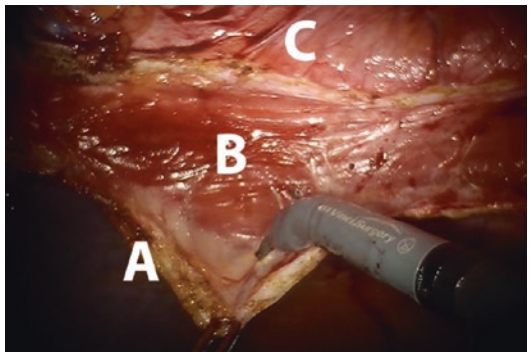

Fig. 65.6 Rectrorectus dissection (**a**) Cut edge of posterior sheath. (**b**) Rectus muscle. (**c**) Hernia defect

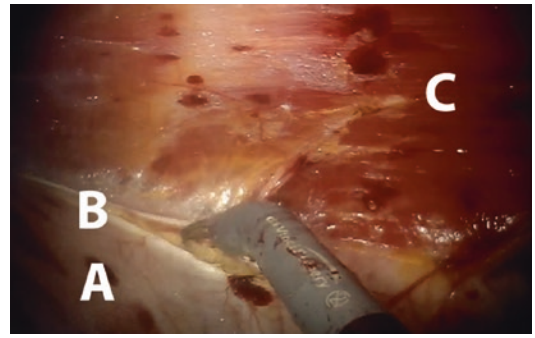

Fig. 65.8 Beginning the TAR with incision of the posterior sheath (**a**) Posterior sheath. (**b**) Incision along posterior sheath. (**c**) Rectus muscle anteriorly

mesh overlap. The retrorectus dissection commences by peeling the posterior rectus sheath away from the posterior aspect of the rectus muscle (Fig. 65.6). This dissection is then carried laterally until the lateral perforating neurovascular bundles are encountered. Once these perforators are reached, this serves as the landmark for the most lateral extent of retrorectus dissection.

Once the lateral edge of the rectus sheath is reached (again as identified by the perforating vessels and nerves), then the transversus abdominis muscle is exposed by incising the posterior rectus sheath about 1 cm medial to the perforating vessels (Fig. 65.7). This incision is directed posteriorly. Once the posterior sheath is incised, the transversus abdominis muscle is identified and divided down to the transversalis fascia, thus releasing the muscle from its attachments to the posterior sheath. The TAR most easily begun in the upper abdomen, near the costal margin where the transversus abdominis muscle is more robust; however, the TAR can also be initiated in the lower abdomen. The division of the muscle is then extended inferiorly along the length of the entire dissection where it becomes less muscular and more aponeurotic. Again, it is critical to note that the line of division of the transversus abdominis muscle is medial to the neurovascular perforators (Fig. 65.8).

Once the muscle is divided, the transversalis fascia will be exposed; deep to that layer lays the peritoneum (Fig. 65.9). Lateral dissection can continue in either of the pre-transversalis fascia or pre-peritoneal planes. The pre-peritoneal plane usually separates more easily, but the peritoneum can be extremely thin. The pre-transversalis plane is more difficult to develop but may be necessary if the peritoneum is too thin. Blunt dissection is performed from medial to lateral, peeling the peritoneum or transversalis fascia away from

the posterior aspect of the cut transversus abdominis muscle.

This space is dissected, lateral, until the peritoneal flap, with the attached posterior sheath, rests without tension, upon the visceral contents below. This will create an extensive medialization of the posterior rectus sheath with peritoneum attached, laterally, for visceral sac closure later in the procedure. Small tears in the peritoneum during this dissection may be repaired with absorbable suture.

At this point, a similar configuration of trocars is placed on the contralateral side. Sizing of the retromuscular pocket and thus the proposed mesh size is now performed. The entire vertical dimension of the pocket is measured intracorporeally with a metric ruler. This will be the exact vertical dimension of the mesh. The horizontal measurement is made from the lateral most extent of the dissection to the lateral edge of the hernia defect or rectus muscle. The resulting measurement must then be doubled to reflect the similar dissection, which will be performed on the contralateral side.

A large-pore, mid-weight uncoated polypropylene mesh is cut to the measured size. The mesh is rolled along its vertical axis, leaving a 2 cm portion of mesh unrolled. An absorbable suture is placed into the mesh roll to prevent unrolling of the mesh during positioning. The mesh roll is now introduced into the dissected space through the contralateral 12 mm cannula on the left (Fig. 65.10). The mesh is positioned so that the unrolled edge lies under the contralateral cannulae. The edge is secured to the lateral abdominal wall with absorbable suture.

The robot is then undocked from the right-sided trocars, the patient bed is pivoted 180 degrees, and the robot is re-docked with the left-sided trocars. The rectrorectus and TAR dissection is carried out, identically, on the contralateral side. As this opposite dissection is carried out, the initial trocars which were placed intraperitoneal will need to be pulled back and repositioned pre-peritoneal, as dissection of the peritoneal flap continues lateral to them. The resulting peritoneal defects from these ports are closed with absorbable sutures.

The posterior rectus sheaths are now suture-approximated in the midline, utilizing a 2-0, absorbable, self-fixating, barbed suture (Fig. 65.11). The posterior sheath and peritoneal flap are inspected a final time to identify any holes that were created or missed during dissec-

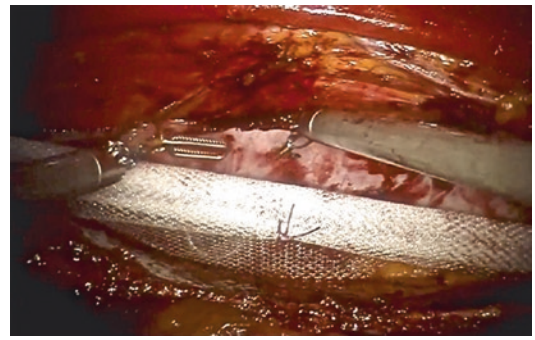

Fig. 65.10 Mesh positioning

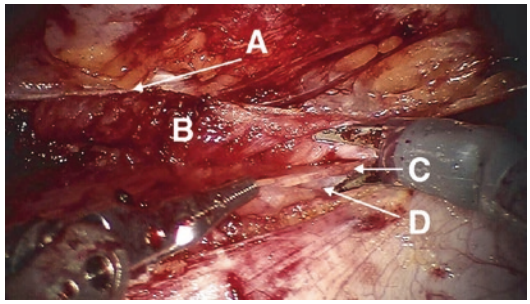

Fig. 65.9 Developing the TAR (**a**) Cut edge of transversus abdominis fascia. (**b**) Cut edge of transversus abdominis muscle. (**c**) Transversalis fascia. (**d**) Pre-peritoneal plane

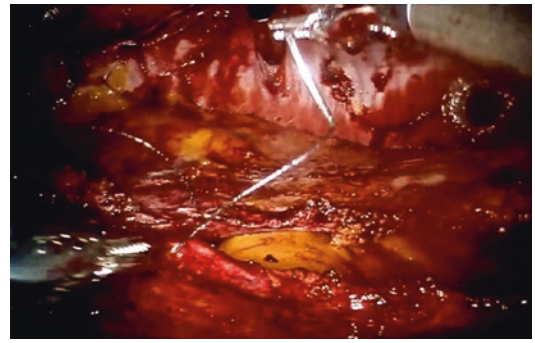

Fig. 65.11 Closing of posterior sheaths and thus the visceral sac

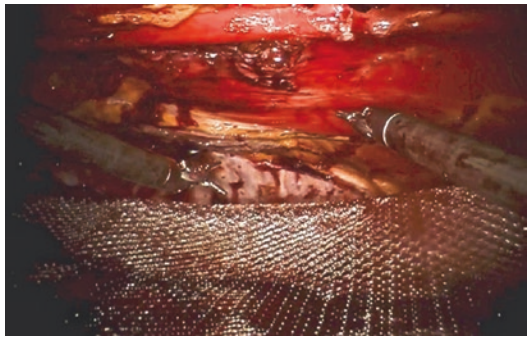

Fig. 65.12 Deployment of mesh

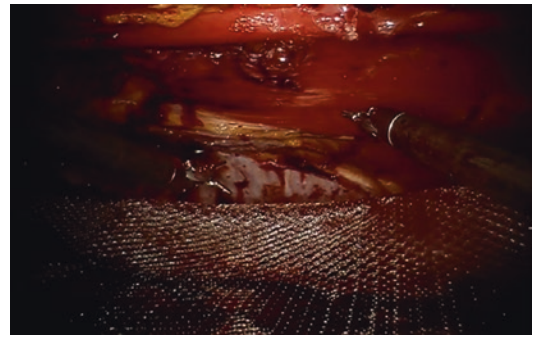

Fig. 65.13 Final mesh position

tion and closed with absorbable suture. At this juncture, the visceral sac is completely closed.

The suture holding the mesh roll is cut and the mesh is unrolled toward the patient's right side (Fig. 65.12). The mesh should lie flat against the closed posterior sheath and occupy the entire retromuscular dissected space. Similar to the left side, the right edge of the mesh is secured to the lateral abdominal wall with absorbable suture. Additional superior and inferior fixation of the mesh is performed, as needed.

65.3.4 Closure

The anterior rectus sheath and hernia defect are now suture-approximated with a #1, absorbable, self-fixating, barbed suture. Every third bite of the fascia should incorporate a bite of the hernia sac to help obliterate the dead space and reduce the size of the resulting seroma. Decreasing the intra-abdominal pressure to 8–10 mmHg will help to facilitate fascial closure. Should there be excessive tension, the bedside assistant may place two to three figure-of-eight sutures with a suture passer device to bring the defect together, facilitating the running suture closure.

Once the fascial defect is closed, the robot is undocked, and the laparoscope is inserted to inspect and ensure the mesh is lying flat. The trocars are then removed and the procedure ended. The trocar sites do not require fascial closure, since the mesh extends beyond the fascial incisions in the retromuscular plane (Fig. 65.13). The skin is reapproximated with absorbable sutures and skin glue.

65.4 Single-Dock Rives-Stoppa Retromuscular Technique for Epigastric and Suprapubic Hernias

65.4.1 Patient Positioning and Theater Setup

This approach can be used for epigastric or suprapubic defects, which are amenable to a robotic approach. The patient is positioned supine with the arms at 90°. The patient bed is flexed to allow the angle between the rib cage and pelvis to widen. This maneuver will increase the angle between the robotic arms and the patient's body which prevents the robotic arms from colliding with the patient's chest when performing suprapubic hernia repair. For subxiphoid defects, the patient is placed in a split leg position and also flexed to prevent robotic arm collisions with the legs. The robot is then positioned parallel to the bed and the arms are swung over the patient to dock to the ports.

65.4.2 Initial Access and Port Placement

For suprapubic defects, the initial port is placed in the right upper quadrant along the costal margin to gain entry into the abdominal cavity. This port is upsized to a 12 mm assistant port. Next, three ports are then placed in a straight line across the upper abdomen: one in the right upper quad-

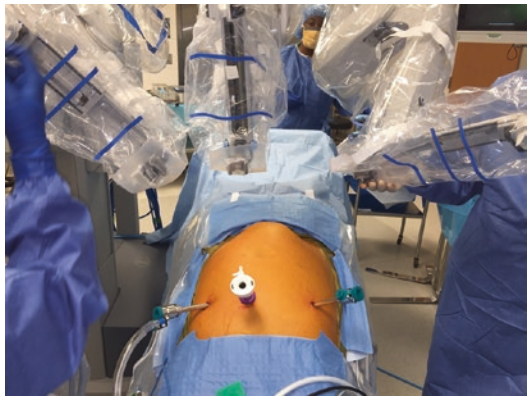

Fig. 65.14 Suprapubic hernia port placement

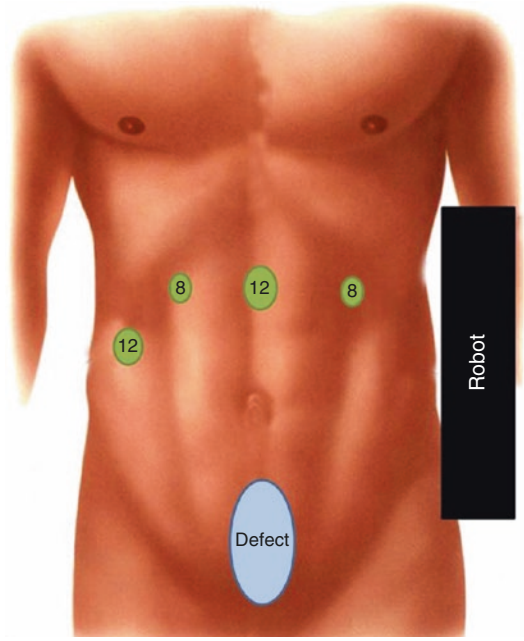

Fig. 65.15 Schematic of port placement and robotic docking for suprapubic defect

rant (8 mm robotic port), one immediately off-midline (12 mm), and one in the left upper quadrant (8 mm robotic port). The 12 mm trocar for the camera is placed off-midline, directly through the rectus muscle, thus avoiding the linea alba, which is the thinnest portion of the abdominal wall (Figs. 65.14 and 65.15). For epigastric defects, the ports are essentially mirrored to go across the lower abdomen except for the assistant port, which is placed in the lower abdomen on the

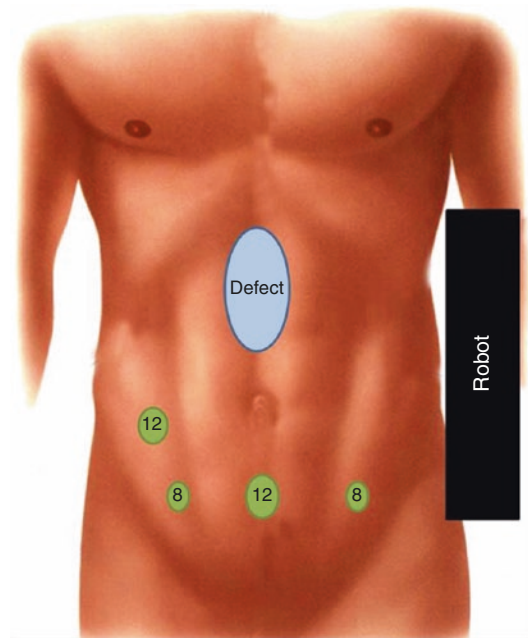

Fig. 65.16 Schematic of port placement and robotic docking for epigastric defect

opposite side of the robot (Fig. 65.16). The robot is docked parallel to the patient, and arms are maneuvered to the ports.

65.4.3 Operative Steps

After adhesiolysis is complete, and the abdomen surveyed, dissection starts with a transverse incision of the posterior rectus sheath from semilunar line to semilunar line using monopolar scissors. The transverse incision must be made at least 5 cm from the edge of the defect as to allow for adequate mesh overlap. This dissection is carried medially toward the linea alba, and once the linea alba is encountered, the posterior sheath is incised. Dissection then continues within the preperitoneal plane. When the contralateral side is reached, the posterior sheath is incised on the contralateral side, and the retrorectus dissection continues toward the lateral border of the rectus (Fig. 65.17). It is important to preserve the linea alba when crossing from the underside of one rectus muscle to the next. The dissection is then carried toward and around the hernia defect.

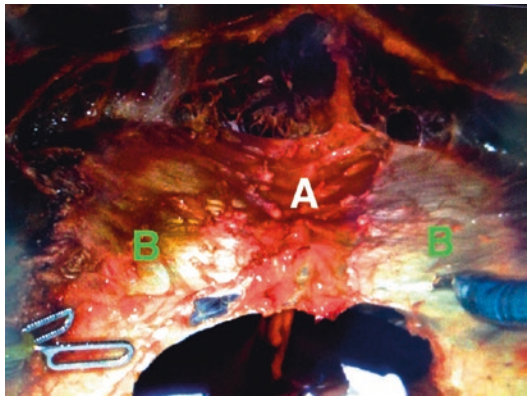

Fig. 65.17 Dissection of both sides of posterior rectus sheath and pre-peritoneal plane (**a**) Pre-peritoneal plane. (**b**) Both sides of posterior rectus sheath mobilized off the rectus muscle

Once the hernia defect is encountered, dissection around the hernia sac begins by pulling the sac down from the abdominal wall and continuing dissection more anteriorly. If dissection becomes too difficult here, the hernia sac can be transected; however, enough redundant hernia sac must be left behind for closure of the posterior sheath later.

After developing the entire retrorectus plane on both sides to the costal margin for epigastric defects or Cooper's ligaments for suprapubic defects, the hernia defect of the anterior abdominal wall is closed in a fashion similar to the double-dock technique. The large retromuscular space is then measured intracorporeally. Any defect in the posterior sheath or bridging peritoneum is closed with absorbable suture. The measurement of the dissected space allows tailoring of the mesh to exact dimensions for maximal mesh overlap. The mesh is brought into the field through the 12 mm assistant port and deployed against the anterior abdominal wall, and fixated at its four corners with absorbable suture. Finally, the initial, horizontal flap created by incising both posterior rectus sheaths is closed utilizing a 23 cm, 2-0, absorbable, self-fixating, barbed suture on a GS-22 needle (V-Loc™ 180, Covidien, Minneapolis, Minnesota, USA).

Once this is complete, the robot is undocked and the 12 mm port sites are closed with an absorbable suture utilizing a suture passer device. The skin is reapproximated with absorbable suture and skin glue.

65.4.4 Postoperative Management

All patients who undergo ventral hernia repairs receive the enhanced recovery after surgery protocol. This is a collaborative effort between surgeons, anesthesiologists, nurses, and therapists with the overall goal being to eliminate intraoperative administration of narcotics and significantly limit postoperative narcotic use. Urinary catheters are removed in the operating room. A postoperative, intravenous, low-dose ketamine infusion is utilized, in addition to intravenous acetaminophen and ketorolac. The ketamine infusion is discontinued on postoperative day 1 depending on the patient's level of pain control, and oral analgesics begun.

The patients and floor nursing staff are instructed to ambulate the patient as soon as possible following surgery, typically within a couple hours of arriving to the surgical ward. Diet is advanced as tolerated. Both mechanical and chemical venous thromboembolic prophylaxes are continued through the hospital stay. Most patients achieve adequate oral pain control on either postoperative day 1 or 2, resulting in an average length of stay between 1 and 2 days.

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Parastomal Hernia Prevention and Treatment

66

Cesare Stabilini and Ezio Gianetta

66.1 Introduction

66.1.1 Definition and Incidence

Parastomal hernia (PH) is the most frequent complication associated with the presence of a colostomy [1]. According to EHS [2], a PH can be defined as an abnormal protrusion of the contents of the abdominal cavity through the abdominal wall defect created during placement of a colostomy, ileostomy, or ileal conduit stoma. The incidence of the disease is variably depicted in current literature biased by the retrospective nature of most of the studies. In recent years thanks to well-conducted RCTs, a clearer picture of the problem has been defined. Considering control arms of RCTs on mesh prophylaxis, the true overall incidence of PH has been estimated to be 55%, with a follow-up ranging from 10 to 80 months [3]. When analyzing time pattern of development, mainly in retrospective studies, it has been showed [4] that the risk of hernia development remains nearly constant over time, confirming the degenerative and iatrogenic nature of the condition. No direct study has ever compared directly techniques of construction, so there's some form of uncertainty with respect to hernia rates among different type of ostomy. An overview of the literature suggests that end colostomy is associated with the highest incidence of parastomal hernia. Loop ileostomy was associated with a parastomal hernia incidence of 16% at 4 months in a RCT, where diagnosis was done during surgery for continuity restoration [5]. A similar incidence was reported in a case series with a clinical diagnosis of parastomal hernia at a mean follow-up of 9 years [6].

The figures of PH repair are not satisfying, in latest meta-analyses [7], depending on technique of repair. It ranges between 46.2% and 80.6% after suture repair, 0% and 28.6% for mesh repair, and 2.1% and 41.7% for laparoscopic repair.

66.1.2 Predisposing Factors and Pathogenesis

Several conditions have been individuated as possible factors associated with the development of this complication, such as advanced age (>75 years), neoplastic processes with dissemination, obesity (BMI > 25 kg/m^2), diabetes, increased intra-abdominal pressure (chronic cough, constipation, enlargement of the prostate), and postoperative infection around the stoma [8].

According to its pathogenesis, the main causative factor of a PH is that the simple opening of the trephine creates a defect, under the traction forces exerted by the lateral muscles of the abdomen, and by the raises of intra-abdominal pressure, this defect enlarges becoming quite invariably a true hernia.

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According to traditional literature, various techniques have been claimed to reduce the occurrence of PH if adopted during stoma construction, for example, the extraperitoneal route of the stoma, its transrectal position, or the rule of keeping the trephine no more than 3.5 cm wide. After a careful examination of the data available and their quality [9–11], none of the aforementioned precautions could be recommended with a high level of evidence, except for the advice to keep the size of the trephine as narrow as possible.

66.1.3 Prevention

Considering the high prevalence of the disease and the relatively scarce results of the repair of PH, surgeons have been forced to look for different solutions to lower the occurrence of hernia.

In 1986 Bayer [12] was the first to introduce a Marlex mesh for the surgical prevention of parastomal hernias with good results (no recurrence among 43 patients operated with a 4-year follow-up). Since then a multitude of papers have been published addressing this type of procedure firstly in form of case series and currently in well-conducted RCTs. From meta-analysis [7] of 412 patients recruited in these trials, there's a clear evidence that placing a mesh during stoma construction at the index procedure significantly lowers the risk of PH occurrence in comparison to no mesh placement (OR 0.24; 95% CI 0.10–0.58; $p = 0.034$; $I^2 = 53.8\%$). Moreover, the presence of a mesh does not predispose to stoma complications as showed by the similar frequency of stoma site infection among the groups with and without the device (OR of 0.88; 95% CI 0.28–2.73; $p = 0.9901$; $I^2 = 0\%$).

Accordingly, it is currently strongly recommended from European Hernia Society guidelines to place a mesh during the construction of the stoma as prophylaxis of PH.

66.2 EHS Classification

Four classifications [13–16] can be found in medical literature published from 1994 with the aim to guide treatment and prognostic stratification of the patients with a PH. They rely mainly on radiological and intraoperative findings related to the type of hernia and its content. Their main weaknesses could be showed by the fact that they are not adopted in any surgical study after the first publication. They have not gained popularity since they are unable to determine the clinical behavior or the best type of treatment or the highest risk of recurrence for each of the different groups individuated.

Table 66.1

EHS parastomal hernia classification		Small (≤5 cm)	Large (>5 cm)
Concomitant incisional hernia?	No	I	III
	Yes	II	IV
		Primary	Recurrent

To effectively compare results among operated patients, it's mandatory to adopt a classification that should be simple, appropriate, practicable, and universally accepted. On this assumption, in 2014 on behalf of EHS, experts were gathered to create a new classification of PH that could be well accepted by the scientific community [2]. The resulting classification has only two variables chosen from literature on PH treatment [16, 17] represented by defect diameter evaluated intraoperatively and categorized in more or less than 5 cm and the coexistence of a midline defect. The PHs are also categorized according to their primary or recurrent nature (see Table 66.1).

The new EHS classification is very appealing for its simplicity, immediacy, and the fact that it is able to define patients at higher risk for acute complications (mainly those with PH diameter <5 cm), local complications, and stoma dysfunction (those with diameter >5 cm) and those requiring different surgical approaches (those with a concomitant midline incisional hernia).

66.3 Prophylactic Mesh Placement During Stoma Construction

Our preferred position for mesh placement at the time of stoma construction is the retromuscular plane with a keyhole configuration. We do it dur-

ing open and laparoscopic colorectal resections requiring a stoma without modifying the technique and with minimal time consumption. In our division laparoscopy is the first approach for the treatment of colorectal malignancies; in case of palliative colic resection, the specimen is exteriorized from the same site of the future stoma; in case of curative abdominoperineal resection, the specimen is exteriorized from the perineum, stapled, and then reinserted in the peritoneal cavity.

The transected colon is extracted from an abdominal incision preoperatively marked after inspection of the abdominal wall in the standing and sitting positions. A traditional circular incision with skin excision is performed and the subcutaneous tissue minimally dissected; a 6 cm incision is made on the anterior rectal aponeurosis. The rectus muscle is retracted, and before entering the peritoneal cavity, a blunt dissection of the retromuscular plane is performed to achieve a retromuscular/preperitoneal space at least 7–8 cm wide.

A large pore lightweight 10 × 10 cm polypropylene mesh is placed in the retromuscular or preperitoneal position trimmed to fit the space. Two perpendicular incisions are made in the mesh to allow passage of the colon. The mesh is then secured with two absorbable stitches to the underlying aponeurotic tissue.

The subsequent stoma construction respects principles of traditional surgery. No drains are left in place.

66.4 Indications to Parastomal Hernia Repair

Complicated PHs need immediate correction because they represent a life-threatening condition; out of this situation, in our practice, the presence of a parastomal hernia per se is not an indication to repair. No data concerning watchful waiting can be found in literature, so the risk and benefit of the procedure must be carefully weighted before judging suitability for surgery. Our current indication for surgery falls on patients affected by PH with or without concomitant midline defects showing symptoms of impaired quality of life (pain, recurrent obstruction, inability to keep in place stoma bags). PH patients often are excluded from surgery because of advanced age, comorbid conditions, and low life expectancy; consequently the rate of cases submitted to repair remains low.

66.5 Techniques of Parastomal Hernia Repair

66.5.1 General Considerations

According to EHS classification, we usually adapt our technique to the type of hernia and the presence of concomitant midline defect: in cases of types I and III PH, we prefer a laparoscopic approach; in cases with associated incisional hernia (II–IV), we do advise the adoption of an open reconstructive approach.

The choice of Sugarbaker among the technique of PH repair comes from experience and several considerations.

Non-mesh techniques and stoma relocation are not considered valuable option for their poor result in terms of recurrence [18]. Open mesh techniques are not inferior to laparoscopy but suffer from a higher risk of infection, require extensive dissection (in particular for onlay repair), and carry a theoretical risk to cause an incisional hernia at the midline when such an access is used. Laparoscopy, on the other side, offers the potential to lower surgical site occurrences, quickens recovery, and solves the problem of postoperative incisional hernia even if the risk of port-site hernia still remains. Among laparoscopic techniques, we have abandoned keyhole in favor of modified Sugarbaker technique for the better results in terms of recurrence provided by this latter approach [17, 18].

On the opposite hand, when repairing PH with concomitant incisional hernia, several factors must be taken into account:

1. As stated by EHS classification on incisional hernias [19], when dealing with multiple abdominal wall defects, the final size of the defect to be treated corresponds to an area of abdominal wall comprehending all the defects (see definition in detail). Accordingly, the area

to be protected by the mesh is quite wide, the dissection is extensive, and very often an anatomic reconstruction must be privileged for correction of abdominal deformity.
2. The use of intraperitoneal meshes has shown issues related to materials, foreign body reaction, and prosthesis manufacturing [20, 21]: when dealing with large defects, the need for large amount of implanted material must be addressed. The larger the mesh, the higher the risk of developing unexpected complications.
3. The intraperitoneal laparoscopic manipulation and adequate fixation of large prosthesis are possible but represent a challenge even in experienced hands.

According to these concepts, our current strategy is to treat these types of defects by an open approach and use a composite or traditional simple mesh in the retromuscular position.

66.5.1.1 Patient Preparation

The presence of PH on clinical examination is not sufficient as preoperative workup; usually the patients are submitted to a dynamic CT scan to better define the characteristics of the hernia sac and content but more importantly to identify the concomitant presence of an incisional hernia.

Linear ultrasound has currently no role in workup strategy.

The technique described by Janes [22] with the patient in the prone position lying on an inflatable plastic ring is used only in doubtful cases and in obese patients.

For the procedure no bowel preparation is prescribed since the eventual spillage of liquid stools during the procedure is less likely.

66.5.2 EHS Types I–III: Modified Laparoscopic Sugarbaker Technique

66.5.2.1 Positioning of the Patient

The commonest position of the stoma is in the left aspect of the abdominal wall in the form of an end colostomy; the subsequent description will thus refer to a standard left terminal PH repair.

The patient under general anesthesia lies in the supine position with the leg adducted. A venous access is placed with the left arm abducted. A urinary catheter is placed to monitor urine output and reduce the risk of inadvertent injury during dissection. Stomach decompression is not routinely requested. If used, the nasogastric tube is removed soon after the end of the surgical procedure.

The antibiotic prophylaxis is given according to local infective politics and usually covers aerobic and anaerobic flora.

After complete disinfection, a gauze is placed in the stoma to avoid fecal spillage, and a Steri-Drape is used to cover all the abdominal wall. This is done in order to keep the mesh far from the stoma during the procedure and reduce the risk of contamination. The surgical field, as in laparoscopic incisional hernia repair, is kept broad to expose all the aspects of the anterolateral abdominal wall.

The surgeon stands on the right side of the patient, the camera assistant on surgeon's left; the scrub nurse is on the right. The monitor and video equipment is on the side of the stoma.

66.5.2.2 Induction of Pneumoperitoneum and Trocar Disposition

Parastomal hernias should be regarded as incisional hernias; thus most of the general surgical techniques adopted for incisional hernia can be generalized to them. According to current evidences and recommendations, a safer technique to establish pneumoperitoneum does not exist [23]. However, in our division, whenever possible, we prefer the Veress needle placed in right or left subcostal position on the middle clavicular line. Midline placement is always avoided for the frequent presence of a laparotomy, and some caution is taken in case of known previous spleen flexure mobilization for the risk of underlying adhesions.

In case of failed attempts to establish pneumoperitoneum with Veress needle or previous history of diffuse peritonitis or extended adhesions, an open trocar insertion technique might be preferred even if charged by a higher risk of trocar-site incisional hernia.

After induction, the capnoperitoneum is maintained at 12 mmHg during the initial phase of the procedure.

On principle we do not use sharp cutting trocars for the associated risk of severe injury to the parietal (epigastric) vessels and chose instead reusable dilating trocars which are considered more safe [24].

The first 10 mm optical trocar is placed in the right flank halfway between the costal margin and the iliac crest on the anterior axillary line. This optic trocar is then used to place two additional operative ports, usually 5 and 10 mm lateral to the first to have a correct triangulation. The trocars are placed far from the PH taking into account the required mesh overlap and the possible individuation of a midline defect.

66.5.2.3 Dissection

After placing the trocars, a complete liberation of the front abdominal wall is achieved, as recommended by guidelines, with the use of sharp dissection [24]. The use of energy sources is limited to reduce at maximum the risk of bowel injury. It is already commonly acknowledged that this step of the procedure is crucial: an unidentified bowel injury can start an acute peritonitis and multiorgan failure possibly fatal to the patient. Thus, great attention is given to achieve a safe adhesiolysis by traction and countertraction of the involved viscera pursuing the avascular plane between them and the aponeurotical sheath possibly sacrificing little portions of the latter in difficult cases of tight adhesions.

After the laparotomy is freed from visceral adhesions and inspected for additional incisional hernias, the area of the ostomy is treated to prepare the "landing zone" for the mesh; the bowel content of the hernia sac is carefully reduced; the adhesions in a circular area of least 5 cm are taken down; the umbilical ligament is released if necessary, but more frequently the Retzius space is partially or totally taken down to reach the pubic bony region (especially in case of PH type III). The final step is the full circular mobilization of the stomal bowel and its mesentery as far as it can be parietalized without tension. At the end of this maneuver, we always check for the absence of deep visceral adhesions between the stomal bowel and other loops to reduce the risk of postoperative obstruction.

We usually keep the peritoneal sac in place without removing it, and we stretch downward the colon to reduce a stomal prolapse if present.

On a routine base, we close the defect with transfascial USP 0 polypropylene passed with a Bercy clamp and tie the knots to the anterior abdominal wall; this maneuver in our opinion reduces the occurrence of postoperative seroma and helps in stabilizing the mesh and reconstructing the anterior abdominal shape.

Once this step is completed, the colon is usually fixed with serofascial absorbable suture to the deep anterior abdominal wall in a lateral position.

66.5.2.4 The Mesh

For this type of repair, the mesh should be suitable for intraperitoneal use; accordingly polypropylene meshes are excluded for their intense foreign body reaction and the subsequent risk of adhesions and fistula formation.

In our practice the ideal mesh should be resistant, transparent to avoid inadvertent bowel injury during fixation, and have a barrier to prevent adhesions. Several meshes have been proposed so far and can be used to repair a PH; none of them has showed clear superiority over the others, and the available studies are mainly retrospective, so a definitive conclusion cannot be made.

According to Coda's classification [25]:

Simple material meshes: The only mesh of this type suitable for intraperitoneal use is ePTFE. It was the first material adopted for the laparoscopic repair of incisional hernias [26] and has allowed laparoscopy to become a widespread technique. It is a good option since it offers a permanent stable repair, and in the last years, the features of the mesh have been greatly improved with reduction in material and better handling, but it still suffers from a certain weakness toward infection, and it forms a visual barrier during mesh fixation.

Composite meshes also known as barrier lightweight meshes: These highly ingegnerized

devices are our first choice to repair a PH; they are designed for intraperitoneal use, contain reduced prosthetic material, induce less inflammatory reaction, and can be seen through. Their main weakness is the presence of a barrier only on one side living open the possibility of bowel erosion on the unprotected surface.

PVDF: It's the latest material introduced in hernia surgery and one of the most appealing. Its elasticity and high porosity and the reduced risk of adhesion could make it a good solution in this field [27, 28].

Biologic meshes: We do not recommend their use in intraperitoneal position for the higher rate of resorption caused by the enzymatic hydrolysis. Their use is currently not supported by meta-analysis [29, 30] because at higher costs they provide a repair not superior to traditional synthetic meshes in terms of recurrence or surgical site infections. Nonetheless they represent an option when placed extraperitoneally for the advantage in SSI.

The mesh is adapted to the measure of the defect to obtain an overlap of at least 5 cm of the original gap.

The mesh is marked for orientation; six stay sutures are passed; it is then folded and entered through a trocar without touching the surgical field.

66.5.2.5 Fixation

Once the mesh is unfolded and oriented, sutures are passed with needle passer transfascially and suspended. At this point an absorbable tacker is used to fix the mesh. During fixation the pneumoperitoneum is lowered at 7 mmHg. A modified double-crown technique is adopted, and two rows of tacks are placed under vision around the parietalized bowel at 2 cm intervals.

Usually the transfascial sutures are tied on the aponeurosis at the end of the procedure with pneumoperitoneum at 0 mmHg.

66.5.2.6 End of Procedure

After careful hemostasis, usually no drains or nasogastric tube is left in place. The trocars are extracted under vision and the port entry infiltrated with long-acting local anesthetic agents.

Before waking up the patients, the stoma is checked for patency.

66.5.3 EHS Types II–IV: Modified Retromuscular Mesh Repair

Before the publication of the posterior component separation technique with transversus abdominis release [31] by Novitsky, the treatment of this clinical scenario was really challenging with frequent recurrences and unsatisfactory results.

Currently this technique has proven valuable in our hands and represents our first choice in case of double abdominal wall defect.

66.5.3.1 Patient Position

Except for absence of video equipment and first assistant lying on the left side, the patient position does not differ from the one described for the laparoscopic repair.

66.5.3.2 Dissection

The abdomen is opened with excision of the previous scar if necessary. The peritoneal cavity is immediately entered and inspected for recurrent disease. A complete adhesiolysis of the anterolateral wall is performed, the herniated bowel is taken down, and the margin of the defect as well as the bowel is fully mobilized.

As for the Rives-Stoppa technique, the rectal sheath is opened longitudinally starting on its deep aspect laterally to the midline 0.5–1 cm. The retromuscular plane is completely dissected in a cranio-caudal fashion from the costal margin to the pubic region. Care is taken to completely free and preserve from injury the stoma bowel and outline the intercostal nerve emergence. The next step is the transection of the transversus abdominis: as in the original technique, we prefer to start the release at the cranial end of the muscle at the level of the costal margin where the structure is readily recognized and more represented. This step can be very challenging in PH treatment in case of recurrent hernias because of peritoneal scar fusion and at the level of the stoma where adhesions to the bowel can raise serious difficulties.

After release of the muscle, dissection is taken further in the avascular preperitoneal plane as far as requested to obtain a tension-free closure.

Usually we follow the same steps on the right side extending the dissection only to the lateral margin of the right rectus muscle as described in Rives-Stoppa technique. We perform TAR on the right side in type IV midline defects requiring abdominal reconstruction.

According to the original technique, the subxiphoid fat pad is dissected completely to allow cranial fixation; the pubic region and the inguinal region are also exposed.

On principle we reduce the parastomal defect by narrowing the fascial edges with slowly absorbable interrupted suture; the hernia sac is excised in very few cases.

Stoma relocation is not routinely adopted except for those patients with concomitant stricture or stoma prolapse; in those cases the bowel is transected and moved on the opposite side.

66.5.3.3 Reconstruction

The deep aponeurotic layer is closed with a running slowly absorbable USP 0 suture. Peritoneal tears wherever done during dissection are closed with absorbable sutures. A wide mesh trimmed on the defect usually at least 30 × 30 cm with a 5 cm overlap is inserted in the dissection plane developed with TAR and fixed to the subxiphoid area and the pubic region and with transfascial nonabsorbable sutures to the posterolateral abdominal wall. The mesh is split from a lateral end creating a slit to allow passage of the bowel. The two tails are solidarized with a running USP 0 polypropylene suture behind the bowel to reconstruct mesh integrity and then fixed to the abdominal wall.

66.5.3.4 The Mesh

Thanks to the extraperitoneal position, this technique offers the possibility of using several types of meshes and prevents, even with interindividual variability, from erosions, adhesions, and fistula formation with the underlying visceral content.

Lightweight polypropylene or polyester meshes have a good handling, large pores resulting in less foreign body reaction, better tissue incorporation, and less long-term chronic pain [32]. Moreover the high tensile strength decreases the recurrence risk of the hernia [29]. Adding these properties with the low cost of the materials and the possibility to have them shaped in large sheaths results in these meshes being our first choice for the reconstruction of such cases.

Another option can be represented by *composite meshes* especially in cases with a fragile deep layer, in which the possible exposure of the mesh is an actual risk and the barrier layer offers further protection from contact with viscera.

The use of *biologics* is appealing since the sublay position is optimal for tissue ingrowth, mechanical stability, and the potentially contaminated nature of the surgical field. However, the results in our practice and those published in literature are not superior to simple material meshes [29]. If we consider also the difficulties in providing large meshes and the high cost of these devices, it seems very unlikely their widespread adoption.

66.5.3.5 End of Procedure

After careful hemostasis, usually two drains are placed on the mesh. Nasogastric tube is not used. The anterior aponeurosis is sutured with a running slowly absorbable suture. The wound is usually infiltrated with long-acting local anesthetic agents. The skin is closed with traditional technique.

Before waking up the patients, the stoma is checked for patency.

66.6 Postoperative Care

All operated subjects are mobilized the same day and allowed clear liquids the night of the procedure. On the first postoperative day, the patient is given light laxatives to fasten bowel movements. Routinely we don't use abdominal binder in the postoperative period. The patient is encouraged to resume normal activity and usual stoma management. Discharge in uneventful cases is usually on the third or fourth postoperative day.

The first postoperative visit is planned 10 days after surgery to remove sutures and check the surgical field.

Follow-up is scheduled at 1–6–12 months postoperatively.

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Scarless Surgery for Ventral and Incisional Hernias

67

Hanh Minh Tran and Mai Dieu Tran

67.1 Introduction

Laparoscopic surgery has become widely adopted for many abdominal operations beginning with the first laparoscopic cholecystectomy by Mühe in 1987 [1]. For the next 30 years, many operations have become standardised in an attempt to improve the safety and efficacy and to decrease morbidity and mortality. Central to conventional multiport laparoscopic surgery is the use of multiple (smaller) abdominal incisions to improve triangulation of instruments. While parietal trauma is vastly decreased, compared to previous bigger and more morbid muscle-cutting incisions, there are the inevitable risks of trocar-related bowel or vascular injuries as well as potential port-site hernias [2, 3]. Visible scars, though smaller, are unavoidable.

Natural orifice transluminal endoscopic surgery (NOTES) became a reality in 2007 when, for the first time, it was possible to perform laparoscopic surgery via alternative sites such as the vagina, where truly scarless surgery could be achieved [4, 5]. The true test of a new procedure is whether it remains experimental or becomes part of the surgical repertoire of experienced laparoscopists. To date, NOTES has remained largely experimental. Indeed, in the field of hernia surgery, where the use of mesh prosthetics is inevitable, there have only been a handful of hernia repairs by NOTES to date owing largely to the uncertainty of sterility of the introduced mesh via a natural orifice [6–8].

Single-incision laparoscopic surgery (SILS), an offshoot of NOTES, has become much more widely practised and, in some specialised centres, has become their technique of choice for hernia surgery [9, 10]. Given the relatively high incidence of inguinal hernias, adoption of SIL inguinal herniorrhaphy provides a natural platform to learn SILS which can then be applied to the repair of more complex hernias including ventral/incisional and parastomal hernias [11, 12]. The small incision created by SILS can be hidden in natural scars such as the umbilicus or positioned in the suprapubic area well below the bikini line so that it is virtually invisible for all intents and purpose [13]. The principal author has performed over 2000 SIL hernia repairs including inguinal, ventral, incisional, lumbar and parastomal hernias since 2009, and SILS has become his standard of care for all patients with hernias who are fit for general anaesthesia. This chapter provides a step-by-step guide to the use of some commonly used single-port devices together with tips and tricks for successful adoption of SIL hernia surgery with the aim of improving patient care by minimising parietal trauma and hence visible scarring.

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67.2 Suggested Instrumentation for Successful Adoption of Single-Incision Laparoscopic (SIL) Ventral and Incisional Herniorrhaphy

- S-shaped retractors (Fig. 67.1)
- A pair of "dolphin" and "Merrylands" grasping forceps with diathermy pins under the handles (Fig. 67.1)
- A pair of extralong (52 cm) blunt graspers
- 30° angled, 5 mm and 52 cm laparoscope (Karl Storz, Tuttlingen, Germany) (Fig. 67.1)

Single-port devices:

- Triport+ (Olympus, Winter & Ibe GmbH, Hamburg, Germany) (Fig. 67.1)
- SILS port (Covidien, Norwalk, Connecticut, USA) (Fig. 67.2)
- GelPOINT mini port (Applied Medical, Rancho Santa Margarita, CA) (Fig. 67.3)

The type of single-port device used depends on the availability, cost, surgeon's preference and applicability for a particular patient with a particular hernia to maximise success. It is suggested that surgeons should familiarise themselves with as many of the available devices as possible even though they would only use one or two predominantly.

The incision site for the single-port device is dictated by the type of hernia being repaired as

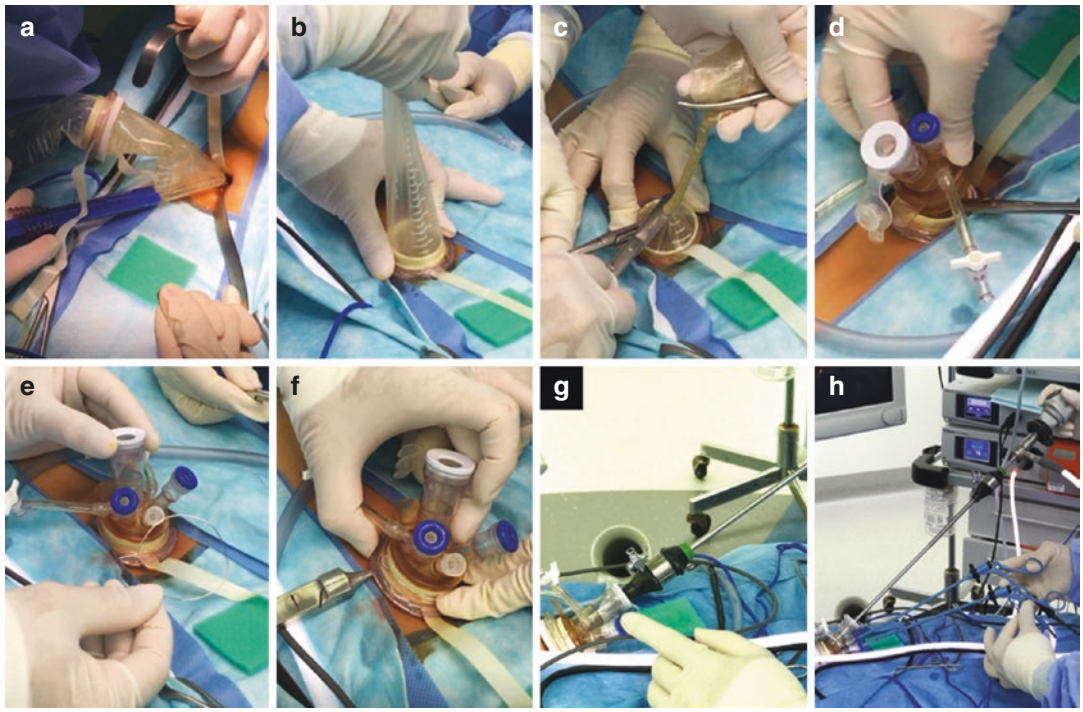

Fig. 67.1 Insertion of Triport: (**a**) shows retraction with S-shaped retractors for introduction of inner ring of Triport posterior to rectus muscle, (**b**) outer ring of Triport is pushed down as excess sheath is pulled up, (**c**) excess plastic sheath is removed, (**d**) top platform of Triport is placed into outer ring, (**e** and **f**) a wire loop placed around outer ring, (**g**) a non-disposable 5.5 mm port is placed into extraperitoneal space through which 5.5 mm laparoscope is placed, and (**h**) 5.5 mm non-disposable port is pulled back along the scope during dissection with standard straight dissecting instruments with diathermy pins under the handles

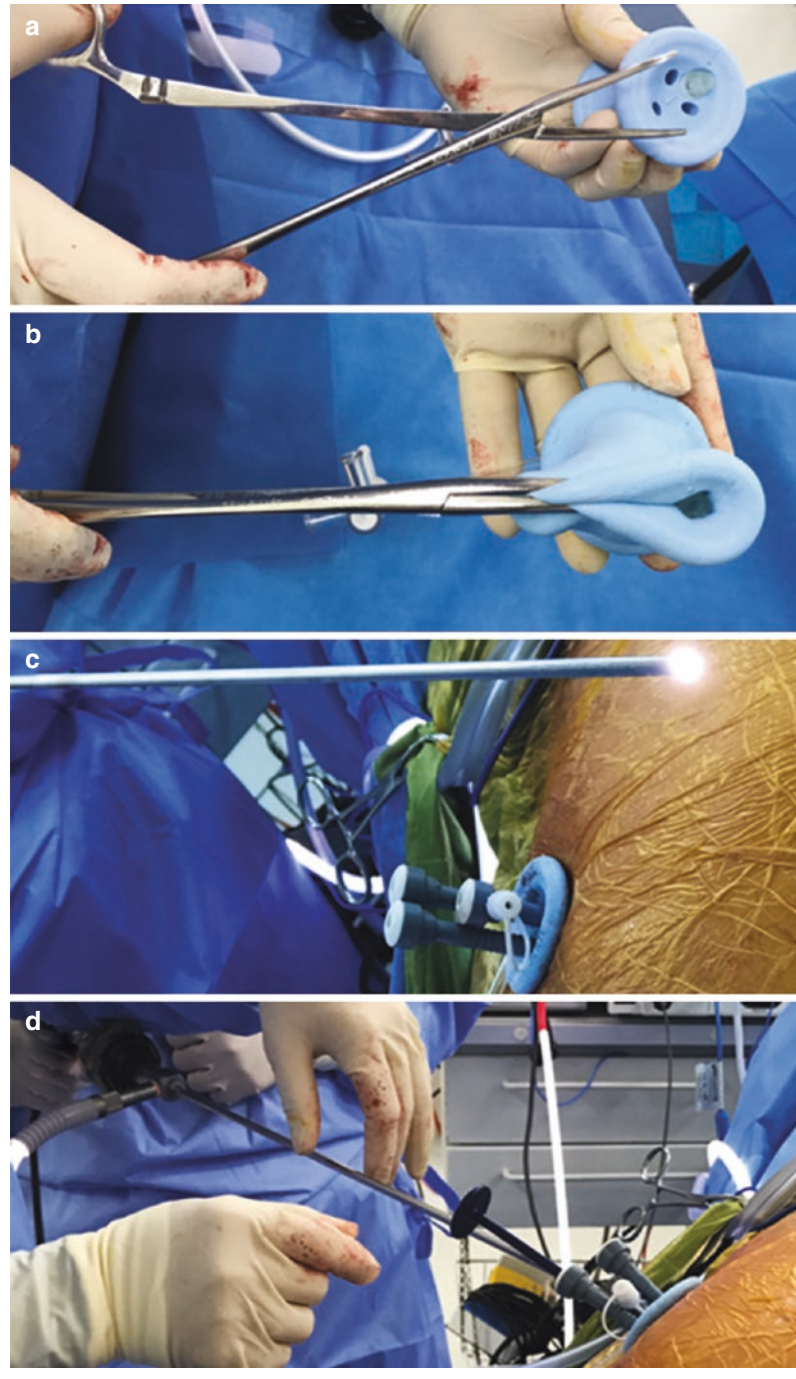

Fig. 67.2 Insertion of the SILS port: (**a** and **b**) show foamy port grasped with a pair of Roberts forceps, with the insufflation hose beyond it, is inserted either into peritoneal or extraperitoneal space, (**c**) 5 mm ports are placed before the scope is inserted into anteriorly placed port to ascertain desired space has been entered into, and (**d**) other two 5 mm ports are then positioned into correct space with blunt introducer

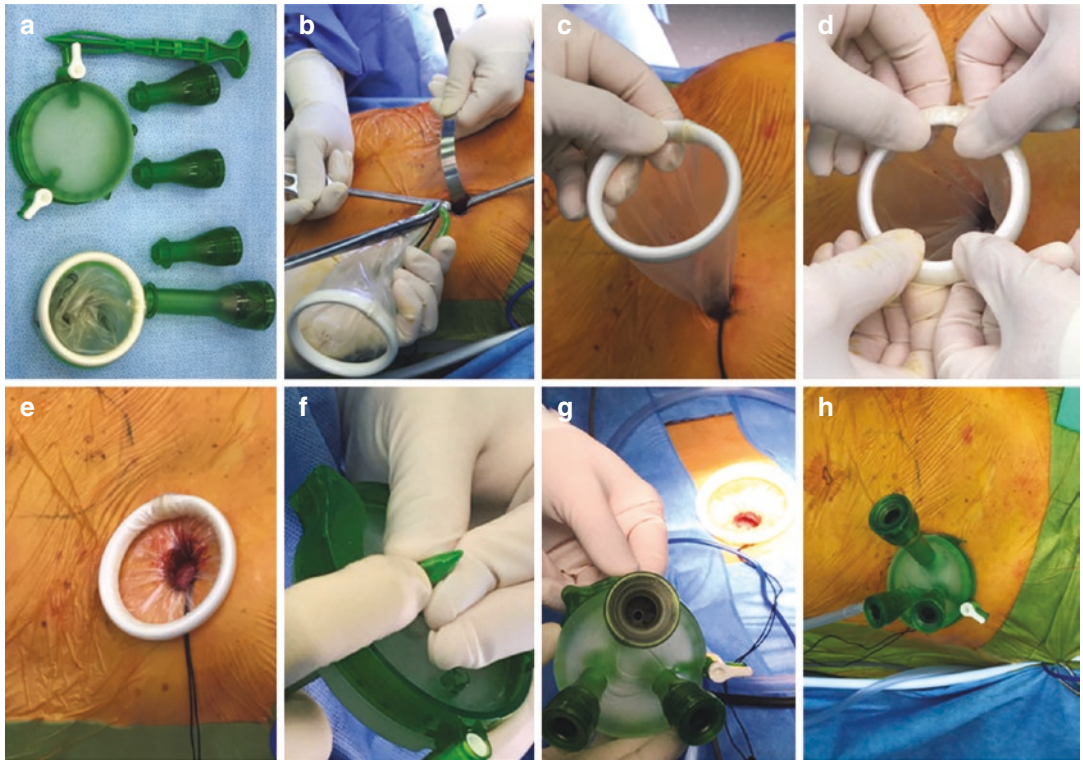

Fig. 67.3 GelPoint Mini Port insertion: (**a**) shows components of the GelPoint Mini Access System, (**b**) the inner ring is grasped with a pair of Roberts forceps for placement into the peritoneal cavity (or extraperitoneal space), (**c**) outer ring is pulled firmly out, (**d**) surgeon and assistant work in unison to roll the outer ring inward to remove excess plastic sheath until (**e**) outer ring sits snuggly against the skin, (**f**) top platform is prepared with insertion of ports into gel membrane, (**g** and **h**) top platform is applied over the outer ring and locked in position

well as patient preference for a minimal or invisible scar. Three commonest sites are infraumbilical, upper outer quadrant and suprapubic positions. While all three single-port devices can be used at any of the incision sites, subtleties exist in dictating the most appropriate device to be used.

67.3 Infraumbilical Incision and Closure

After infiltration with 20 ml of 0.5% bupivacaine with 1:200,000 ephedrine, a 1.5 cm crescentic infraumbilical incision is made, and the incision is initially stretched with a pair of Metzenbaum scissors before the dissection is made with electrocautery down to the anterior rectus sheath. The anterior rectus sheath is then incised to no more than 1.5 cm (but this can be enlarged if SILS or GelPOINT mini port is used), and then the rectus muscle belly is retracted laterally with an S-shaped retractor (Fig. 67.1). It is important to avoid the intersection of the rectus muscle, as this may cause bleeding and entry into the peritoneal space, so if encountered the rectus sheath incision should be moved 1 cm either inferiorly or superiorly. For an intraperitoneal approach, the posterior rectus sheath is again incised transversely, and then the peritoneum before the single-port device is deployed intraperitoneally. For extraperitoneal approach, the S-shaped retractors are used to bluntly dissect the extraperitoneal space superiorly sufficient for the introduced single-port device to sit snuggly behind the incision. This incision is particularly applicable for lower abdominal incisional hernias, such as after

Pfannenstiel incision, recurrent inguinal hernias after failed anterior and laparoscopic repair (using modified laparoscopic intraperitoneal onlay mesh repair [14]) or lumbar hernia repair either intraperitoneal or preferably extraperitoneal approach (see later). Wound closure is effected with slowly absorbable 0 monofilament sutures continuously in layers. The inferior skin edge (and sometimes the upper edge too) is usually traumatised, and a 1 mm sleeve of this is excised before the skin wound is closed with absorbable 4.0 monofilament. The skin wound is then dressed with tapes and adhesive waterproof dressings.

67.4 Upper Outer Quadrant Incision

While this is the most visible of all SILS incisions, it offers the most access to the entire abdominal cavity where large and complex hernias including parastomal hernias can be repaired. These repairs can be performed with a mere 2 cm incision which, when placed in the line of skin crease, can offer a highly cosmetically pleasing scar. Here, the incision is made just inferior to the tip of the ninth rib, and the incision is dissected down to the muscle layers which are sequentially split (akin to the Gridiron incision for appendectomy) before the peritoneum is entered. The single-port device is then placed intraperitoneally. As a precaution, a nasogastric tube is always placed preoperatively to ensure the stomach is empty especially when the left upper outer quadrant is chosen. Furthermore, as a modification for patients with midline hernias combined with significant diastasis of the recti and significant excess abdominal skin, the abdominal flap can be created (by the plastic surgeon), and the upper outer quadrant incision is made directly into the muscle layers which, when closed, will offer no visible scar apart from that for the well-concealed abdominoplasty scar [15]. The muscle layers are closed in layers with slowly absorbable 0 monofilament sutures, absorbable 2.0 sutures subcutaneously and absorbable 4.0 monofilament suture subcuticularly.

67.5 Suprapubic Incision

Preoperatively, patients are requested to wear their usual bikini bottom or briefs, and the incision is marked at least 1 cm below this line so that it become "invisible". A 2 cm transverse incision is made, and as the wound is dissected with electrocautery, the linea alba is encountered. Due to its position close to the pubic symphysis, the muscle bellies of the recti tend to be well developed and even overlapping. Therefore, care is taken to identify the midline before the muscle bellies are retracted and incised longitudinally. Before the peritoneum is entered, the patient is placed in the reversed Trendelenburg position so that the underlying bowel loops fall superiorly to minimise the risks of accidental enterotomy. This incision is particularly important for young patients, such as models, in whom any visible scar is unacceptable. This incision can be used to repair upper abdominal hernias with or without diastasis of the recti. The wound is closed with slowly absorbable 0 monofilament sutures to the rectus muscle, absorbable 2.0 sutures subcutaneously and absorbable 4.0 monofilament sutures subcuticularly.

67.6 Insertion of the Single-Port Device

67.6.1 Triport

At the umbilicus: The inner ring of the device is placed inside the introducer (Fig. 67.1) before its tip is placed at the entry of the rectus sheath defect before the inner ring is deployed. Usually only half of the inner ring is placed posterior to the rectus muscle, and then the remainder can be grasped and pushed in with a pair of broad and blunt tissue forceps. The inner ring is digitally manoeuvred so that the inner ring lies centrically behind the rectus sheath defect. While the relatively thin and soft inner ring of the device allows for the smallest possible skin and fascial incisions (no more than 1.5 cm), it also means that it is susceptible to dislodgement if the fascial incision is bigger than 1.5 cm either due to inadver-

tent large incision, excessive retraction by the assistant with the S-shaped retractors or due to thinning of the anterior rectus sheath at the umbilicus in certain individuals especially elderly and multiparous female patients. In this case, a figure-of-eight suture needs to be placed at the lateral edge (and sometimes the medial edge too) of the rectus sheath incision to narrow the rectus sheath defect to minimise the risks of dislodgement of the inner ring. The excess plastic sheath is then pulled up by pushing down the outer ring until it lies snuggly against the skin. A pair of Kocher's forceps is then applied to the lower part of the plastic sheath, and they are then twisted until no excess sheath is visible. The latter is excised before the top platform of the Triport device is placed inside the outer ring with the assistant opening the Kocher's forceps and wriggling them out. Although the manufacturer claimed that this snug fit would prevent slippage of the plastic sheath through the top platform, we found that this occurred during prolonged procedures, and hence we routinely apply a wire loop around the outer ring which is then twisted tightly around both it and the plastic sleeve (Fig. 67.1). This prevents slippage of the plastic sheath which will create a redundant pocket of plastic sheath above the skin which will make it harder to insert instruments and mesh.

At suprapubic or upper outer quadrant sites: Sutures on either side of the muscle defects are routinely placed to prevent dislodgement of the inner ring. Furthermore, these sutures (slowly absorbable 0 monofilament) can then be used to close the defects once the inner ring is removed.

67.6.2 SILS Port

Due to the relatively inflexible foamy port, the skin and fascial/muscle incision needs to be between 2 and 2.5 cm. The foamy port is grasped with a pair of Roberts forceps with the insufflation hose distal to it (Fig. 67.2), and the device is inserted with one firm but swift motion before the forceps and retractors are removed. Correct placement of the SILS port will be obvious when the device appears to be "sucked" down against the skin. Failure of correct port placement usually means the skin and/or fascial/muscle incision is too small. The SILS port is then rotated with two pairs of Kocher's forceps applied to the foam opposite each other so that the insufflation hose now lies posteriorly (Fig. 67.2). While three 5 mm ports are inserted into the foamy port and insufflation is then commenced to insufflate either extraperitoneal or intraperitoneal space, the anterior 5 mm port is placed fully inside this space for insertion of the 5 mm scope to ensure that the correct space has been entered. The other two 5 mm ports are then fully inserted using the introducer. Once adequate dissection has been achieved for mesh placement, the anteriorly placed 5 mm port can then be removed and replaced with a 12 mm port. Its placement is greatly assisted by partially pulling out one of the other 5 mm port so that it lies outside of the skin with care taken to prevent its accidental dislodgement and dropping on the floor.

67.6.3 GelPOINT Mini Port

The inner ring of the port is grasped firmly with a pair of Kocher's forceps, and with one swift motion, the inner ring is placed inside the desired space (either extraperitoneal or intraperitoneal). The inner ring is then pulled snuggly up by traction on the outer ring which is then sequentially turned inward with both the surgeon and the assistant operating in unison due to its relative stiffness until it lies snuggly against the skin. A prepared top platform with the ports already inserted into the gel membrane (by the assistant) is then placed on top of the outer ring, and it is then locked in place (Fig. 67.3). During insufflation, the gel membrane bellows out further separating the ports which will further minimise the risks of clashing of both the ports, the dissecting instruments and the laparoscope.

67.7 Overcoming the Relative Lack of Triangulation During SILS

With relatively little practice, some 25 cases, it is possible to overcome the relative loss of triangulation during SILS [16]. This is first and foremost assisted by the use of the extralong and 5.5 mm laparoscope as the side arm of the scope is now well away from the handles of the conventional (30 cm long) dissecting instruments. Modified dissection techniques are necessary to overcome the clashing of instruments with each other and with the scope:

Chopsticks dissection: The dissecting instruments move (vertically or horizontally) on the opposite side of the scope (Fig. 67.4).

Inline dissection: The dissecting instruments move inline in the opposite direction to each other, hence preventing clashing with each other and with the scope (Fig. 67.4).

In practice, a combination of chopsticks and inline dissection in varying degrees are employed to effect seamless dissection (Fig. 67.4). With practice, we have shown that SIL (inguinal) hernia repair is as efficacious as multiport repair and that identical operating times can be achieved with the added benefits of reduced post-op pain, analgesic requirements and faster return to physical activities [17].

Urinary catheterisation: This is necessary for almost all ventral hernia repairs to prevent accidental damage especially for very prolonged procedures where the urinary bladder is likely to fill up and extends superiorly toward the umbilicus. Furthermore, it is a prerequisite when performing a suprapubic incision or for suprapubic hernias. The catheter can usually be removed at the end of the procedure unless it is anticipated that precise fluid balance monitoring is necessary such as when a prolonged ileus is anticipated after significant manipulation and/or division of bowel adhesions.

Specific hernia operations are now described in detail bearing in mind the main goal of the operation is to achieve the best possible success rate, while minimising scarring is a secondary consideration.

67.8 Hernias in the Suprapubic Space

These commonly occur after Pfannenstiel or lower midline incisions (Fig. 67.5). Due to close proximity to the pubic ramus, most anterior procedures will usually fail since the mesh cannot be sutured to the bone inferiorly. It is important to determine preoperatively that the mesh can placed with at least a 5 cm clearance superiorly, i.e. below the single-port device. On occasions, it is possible to place the incision superiorly to the umbilicus as this will afford an extra 1–2 cm clearance below the umbilicus while achieving the same excellent cosmetic result.

Once laparoscopic visualisation and inspection of the entire abdominal cavity have been done, the division of adhesions begins using sharp dissection while minimising electrocautery. The dissection will be assisted by placing the patient in the reversed Trendelenburg position and/or rotated sideway. Once the herniated contents have been reduced, the peritoneum is incised transversely 1 cm superior to the pubic symphysis and continued laterally and inferiorly posterior to the pubic bone. The extent of the lateral dissection is akin to that during the transabdominal preperitoneal inguinal hernia repair but without dissection of the superior flap. The extent of the lateral dissection depends on the size of the hernia to achieve adequate mesh coverage of the defect. For defects measuring 6 cm or less, closure can be affected with interrupted transfascial sutures (Fig. 67.5).

Once the mesh size has been estimated to provide adequate coverage of the defect, sutures are placed superiorly and laterally on the mesh before its insertion into the peritoneal cavity so that they can be used as transfascial sutures. Once introduced, the superiorly placed transfascial

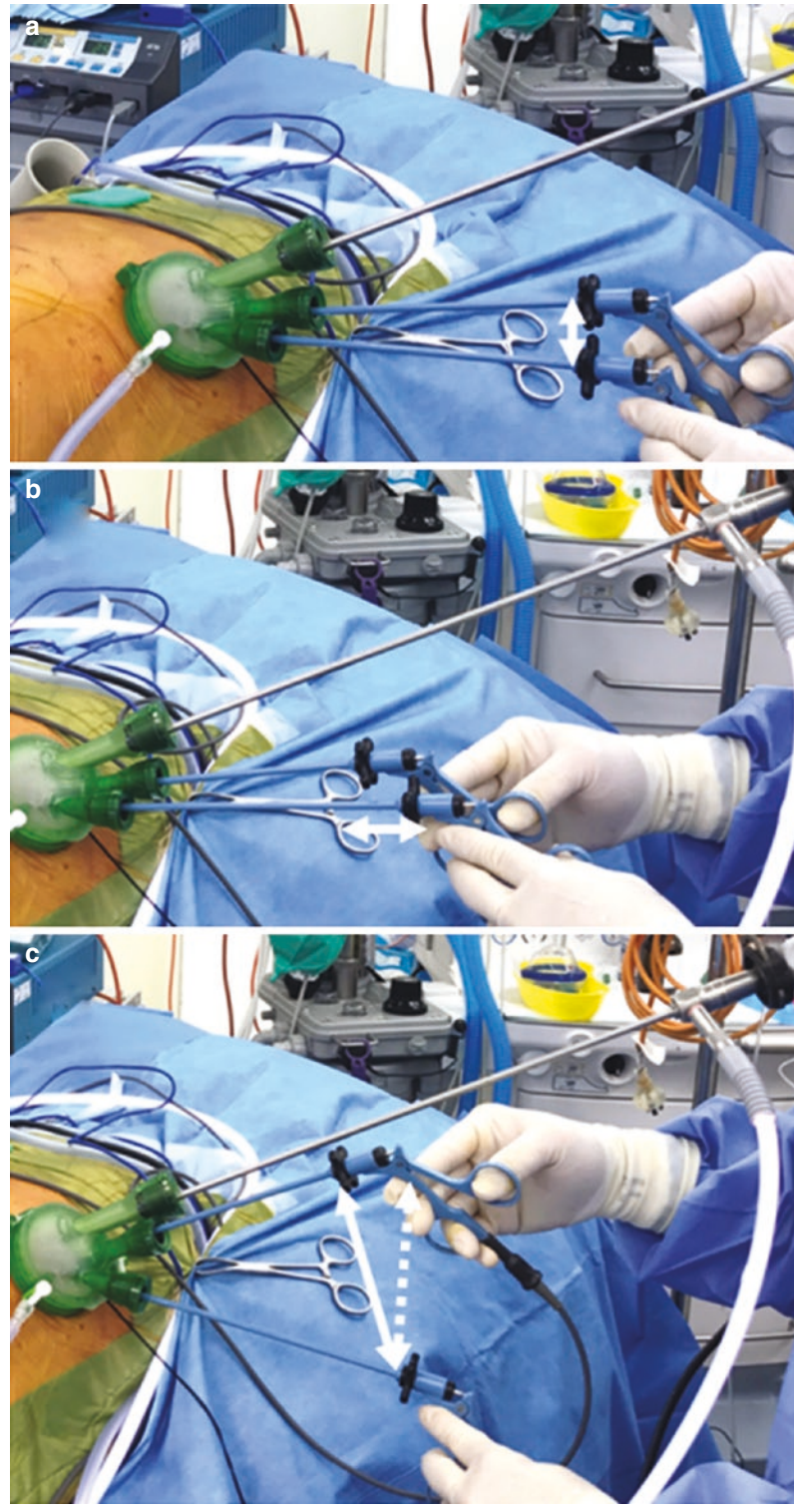

Fig. 67.4 Modified dissection techniques for single incision laparoscopic surgery: (**a**) shows neutral position of extralong scope and standard straight dissecting instruments, (**b**) "inline" dissection technique with dissecting instruments moving in opposite and parallel to each other (note side arm of extralong scope offers unhindered movements of the handles of the dissecting instruments), and (**c**) broken arrow shows "chopticks" dissection technique with instruments moving either vertically or horizontally on either side of the scope while solid arrow shows combination of "inline" and "chopticks" dissection techniques during most of the operation

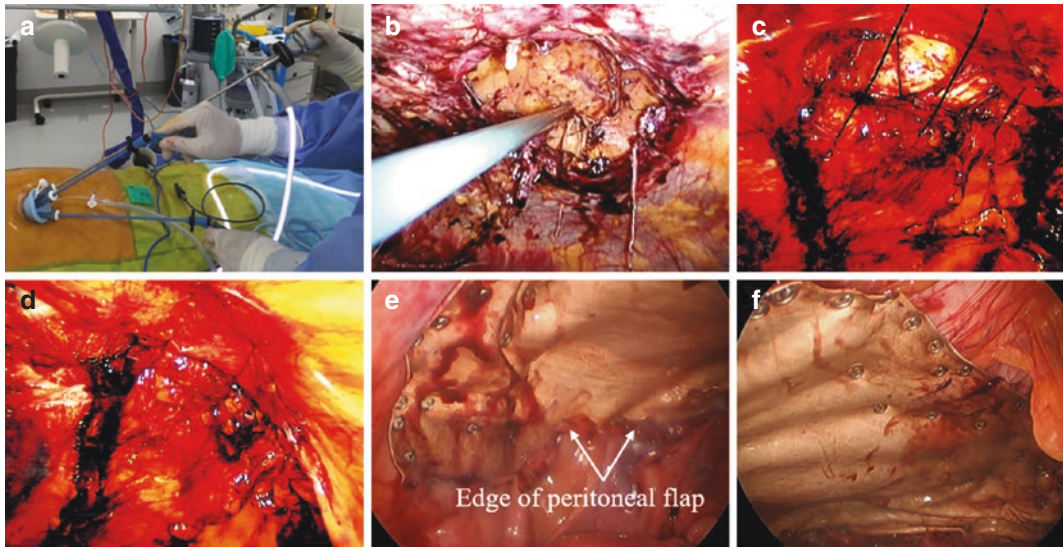

Fig. 67.5 SIL suprapubic incisional hernia after caesarian section: (**a**) shows setup with infra-umbilical SILS port, (**b**) dissection of large suprapubic incisional hernia, (**c** and **d**) defect closure with interrupted transfascial sutures, (**e**) inferior peritoneal flap is tacked lightly onto mesh covering its inferior edge and fibrin sealant sprayed along mesh-peritoneal interface, and (**f**) superior edge of the mesh tacked in place with "double crown" technique

suture is then placed first in order to aid with positioning of the mesh intraperitoneally. The inferior aspect of the mesh is then tacked onto the pubic rami and continued laterally just medial to the deep inguinal ring, and no tacks are then used until the area of the laterally placed transfascial sutures in order not to accidentally entrap the groin nerves including the ilio-inguinal, ilio-hypogastric and lateral cutaneous nerve of the thigh. The inferior aspect of the mesh especially over the area which has not been tacked is then sprayed with fibrin sealant, and then the inferior peritoneal flap is then reflected over the mesh and lightly tacked onto it (Fig. 67.5). Care is taken to ensure there are no significant gaps in between the tacks to prevent bowel herniation which could potentially cause bowel obstruction.

Other types of hernias which can be treated in the similar way include recurrent inguinal hernias after failed anterior and laparoscopic repair [14] and hernias arising from harvest site of the rectus flap used by the plastic surgeon such as in breast reconstruction.

67.9 Spigelian and Lateral/ Lumbar Hernias

Spigelian hernia: Although these hernias are said to be relatively rare, one study showed that it can be associated in up to 10% of all direct inguinal hernias [18]. This is not too surprising given that the same weakness lateral to the rectus muscle inferiorly contributes to the direct inguinal hernia defect. This can extend more proximally causing either low-lying or high-lying Spigelian hernia especially in the so-called "Spigelian hernia belt" area roughly 6 cm infero-lateral to the umbilicus. Due to the fact that most Spigelian hernias still have the overlying external oblique muscle, i.e. have herniated through the transversalis and internal oblique muscles, this makes it clinically more difficult to diagnose, and most are either diagnosed by ultrasonography or computed tomography. The minimally invasive technique involves either the standard laparoscopic ventral hernia repair either multiport or single-port. Alternatively, it can be treated as a SIL TEP

repair where the dissection starts in the same way as for a TEP inguinal hernia repair. However, as the dissection starts from the umbilicus inferiorly and laterally, the Spigelian hernia can be reduced. The advantage here is that any concomitant direct inguinal hernia can be repaired at the same time. The extraperitoneal dissection needs to be continued laterally and superiorly in order to clear the space to some 5 cm proximal to the Spigelian defect. There are often sizeable blood vessels entering the rectus, and these may need to be clipped and divided rather than by electrocautery. A standard polypropylene-based mesh can be used since it is in the extraperitoneal space (Fig. 67.6). For a coexisting direct inguinal hernia, the Spigelian hernia is repaired first with a mesh allowing the inferior aspect of the mesh to be unfixed, and then the direct inguinal hernia can be fixed in the usual manner according to surgeon's preference. It is recommended that the mesh be fixed for large direct defects, to prevent eventration into the direct defect causing a recurrence (Fig. 67.6) [19]. It is the author's preference to use the Triport device in these cases due to its relative mobility and the smaller inner ring, and this will permit better proximal coverage of the Spigelian defect.

67.10 Lateral and Lumbar Hernias

While lateral abdominal hernias, such as those arising from an appendicectomy scar, can be repaired laparoscopically with a laparoscopic IPOM approach either by conventional multiport or SILS, lumbar hernias either incisional (after nephrectomy or spinal surgery from a lumbar incision) or traumatic such as a seatbelt injury may be better repaired via an extraperitoneal approach with SILS from the umbilical single-port. The extraperitoneal approach enables the incision to be closer to the hernia, compared to the upper outer quadrant incision, as well as permits the use of a much large piece of polypropylene-based mesh which can be more securely tacked onto the pubic ramus inferiorly and the iliac crest antero-anteriorly.

67.11 Traumatic Lumbar Hernia from Seatbelt Injury

This particular patient was involved in a head-on collision and sustained multiple fractures. A CT scan performed on admission showed herniation of small bowel due to avulsion of the abdominal muscles from the iliac crest (Fig. 67.7). She presented to the principal author some 12 months after the original accident with a large lateral/lumbar hernia with very significant lateral abdominal muscle retraction/atrophy to just below the rib margin. A decision was made to repair this hernia via SIL TEP repair with an infraumbilical incision.

Two sandbags were placed under the patient's right buttock and lower ribs. The patient was widely prepped with iodine solution and draped to expose from midthigh to above the xiphisternum and draped with an iodine-impregnated adhesive drape. After placement of the Triport into the extraperitoneal space, the initial dissection was similar to that for a TEP inguinal hernia repair. However, the dissection then extends laterally over the iliac crest. As the dissection proceeded, the patient was rotated toward the surgeon standing on the left side of the patient as this allowed the abdominal contents to fall away from the operative site. The dissection then continued posterior to the ascending colon and extending proximally toward the inferior margin of the ribs. Extreme care was taken to prevent accidental perforation of the peritoneum which would have made the operation more difficult. Fortunately, the chronicity of the hernia resulted in thickened herniated peritoneum. The mesh size was then estimated so that it was big enough to extend from pubic symphysis to the rib margin (cranio-caudal direction) as well as antero-posteriorly.

While the dissection was performed with the Triport, insertion of the very large piece of polypropylene mesh (26–40 cm) was not possible via the 10 mm port of the Triport, and so the single-port device was replaced with a SILS port where the mesh could be inserted into the extraperitoneal space with a disposable 15 mm port

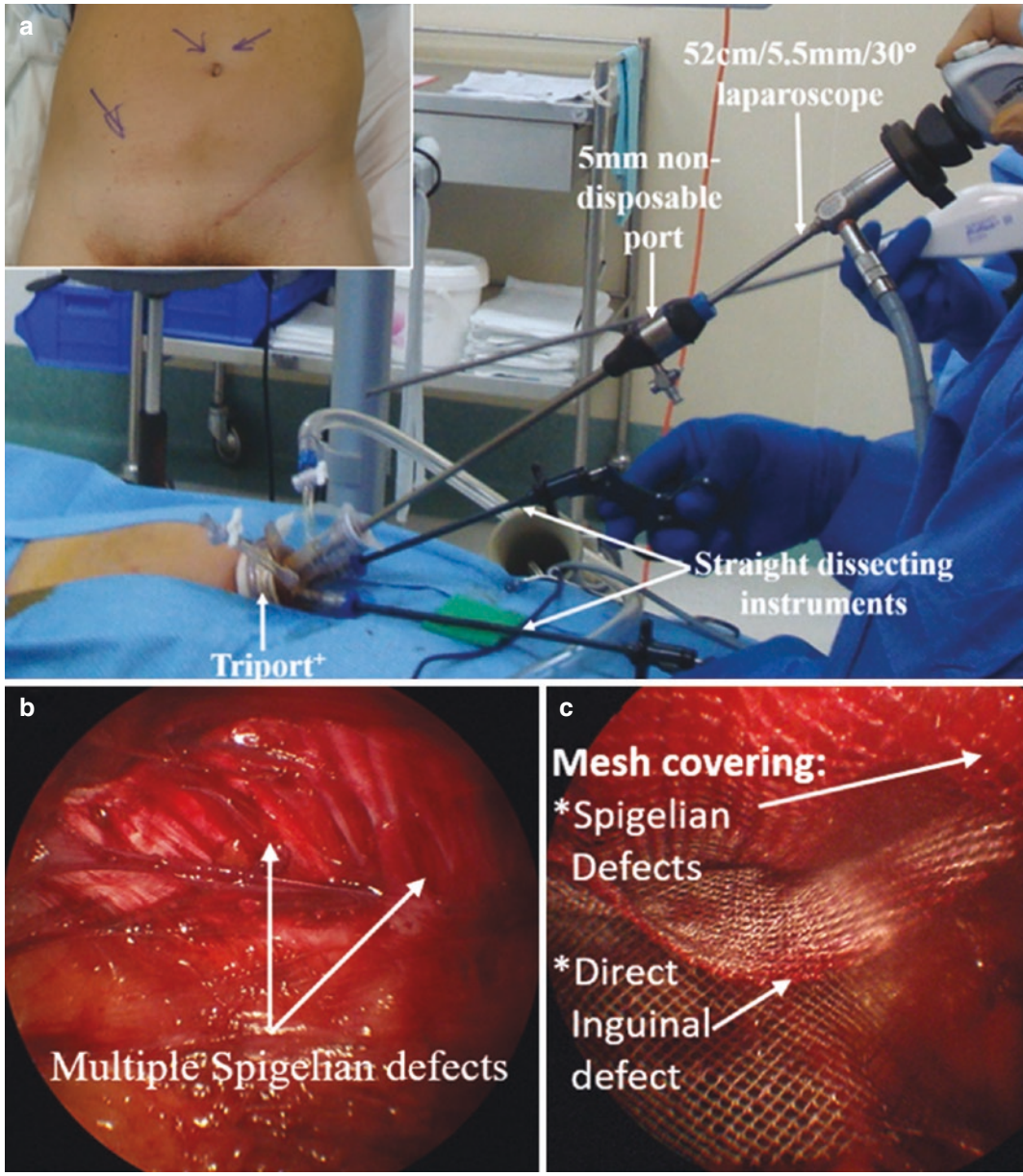

Fig. 67.6 Single incision laparoscopic repair of a right sided Spigelian hernia: (**a**) shows setup with Triport placed in extraperitoneal space via an infra-umbilical incision; extralong scope and straight dissecting instruments are used while inset shows external marking of the Spigelian hernia as well as concomitant umbilical hernia, (**b**) multiple Spigelian defects identified, (**c**) mesh is placed over the Spigelian defects which is fixed proximally with tacks while it lies free inferiorly while another piece of mesh is placed posterior to it to cover the concomitant direct inguinal hernia defect

(Fig. 67.7). Despite the entire dissection being extraperitoneal, there was sufficient space for unrolling and manoeuvring into the correct position before the mesh was fixed with non-absorbable tacks into the pubic ramus and iliac crest. Care was taken to avoid damage to the lateral cutaneous nerve of the thigh and then anteriorly. Fibrin sealant was then sprayed along the poste-

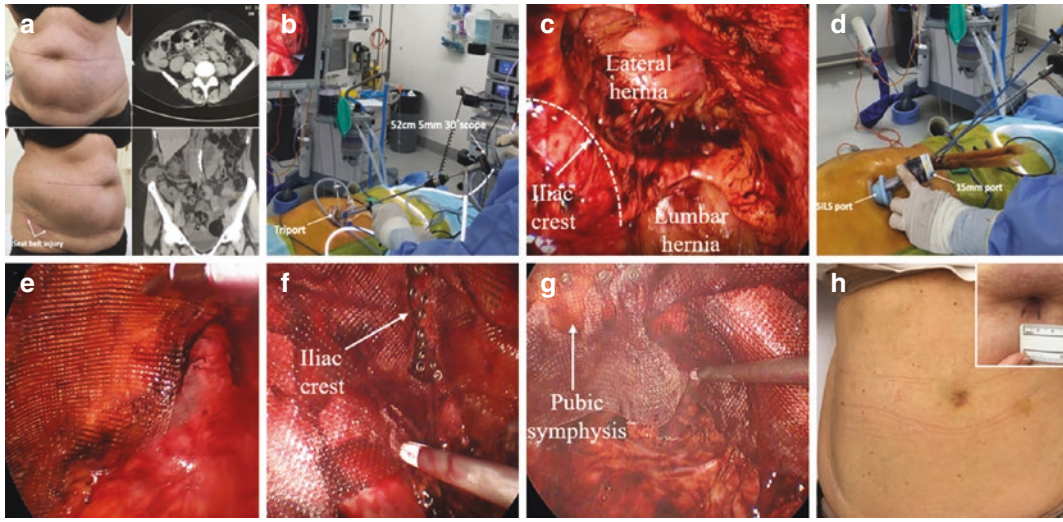

Fig. 67.7 Single incision laparoscopic repair of lateral and lumbar hernias via totally extraperitoneal approach: (**a**) shows patient with traumatic seatbelt injury causing lateral and lumbar hernias, (**b**) patient setup with Triport placed extraperitoneally via an infra-umbilical incision, (**c**) dissection of lateral and lumbar hernias just superior to iliac crest (broken line), (**d**) due to the large size of the mesh used (30–40 cm Polypropylene mesh), the Triport was replaced with a SILS port with a 15 cm disposable port for ease of placement of mesh into extraperitoneal space, (**e**) superior aspect of mesh well above lumbar hernia and just inferior to costal margin, (**f**) fixation the mesh into iliac crest with non-absorbable tacks (avoiding lateral cutaneous nerve of the thigh), (**g**) fixation of mesh inferomedially into pubic ramus while fibrin sealant is sprayed along inferior aspect of mesh, and (**h**) successful repair 14 months postop with a virtually scarless incision within the umbilicus

rior and superior aspects of the mesh just inferior to the rib margin (Fig. 67.7).

Closure of the wound was performed in the usual manner with the patient requiring hospital admission for just 2 days. The patient was advised to wear an abdominal binder for 3 months, and she returned to normal physical activities after 4 weeks. Her abdominal/lumbar bulge continued to decrease in size, and by 6 months, her abdomen looked normal with no evidence of recurrence after a follow-up of 14 months with virtually no visible scar at the infraumbilical incision site (Fig. 67.7).

67.12 SIL Ventral and Incisional Hernia Repair

With experience, any abdominal hernia, which can be repaired with multiport laparoscopic surgery, can be repaired with single-port with the exception for the very morbidly obese patients (body mass index greater than 40 kg/m^2) where the single-port device, such as the SILS port, would disappear into the subcutaneous layer although the GelPOINT mini port may be more suitable for such patients.

After placement of the single-port device in the upper outer quadrant, the steps of the operation are the same: firstly, safe division of adhesions by sharp dissection, avoiding electrocautery if at all possible, and augmented by saline jet dissection for severe bowel adhesions as this better delineates bowel wall; secondly, complete dissection of the entire midline from the previous laparotomy wound to ensure all incisional hernias are identified and reduced, taking down the ligamentum teres sufficiently for mesh placement; thirdly, closure of significant defects, less than 6 cm, with interrupted transfascial sutures (Fig. 67.8) as this will minimise the risks of seroma formation while increasing the mesh overlapping; and fourthly, adequate mesh overlapping of the defect by 5–7 cm is necessary as is

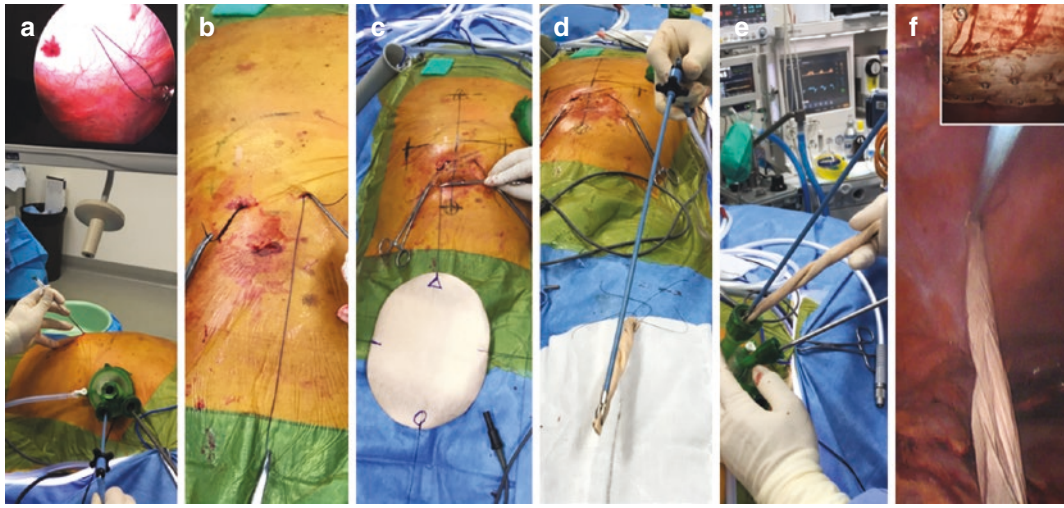

Fig. 67.8 Single incision laparoscopic ventral incisional hernia repair with GelPoint Mini Access System: (**a**) shows the GelPoint port placed in the left upper outer quadrant via a transverse 2 cm incision with the abdomen covered with iodine-impregnated adhesive drape, (**b**) the defect is closed with transfascial sutures, (**c**) the mesh is marked and sutures are placed in four quadrants, (**d** and **e**) show placement of the mesh via the 12 mm port under direct vision with the scope placed in one of the 10 mm ports, and (**f**) the mesh placed intraperitoneally with insert shows its fixation with "double crown" technique

a combination of transfascial suturing in at least four quadrants (and more if a very large piece of mesh is used). Tacks should be placed 1 cm apart and in a double-crown technique. The side of the mesh closest to the port is more difficult, and this should be tacked first, usually as close to the single-port device as possible, while the contralateral side is tacked last as this will allow further stretching out of the mesh and, if necessary, repositioning of the transfascial suture(s).

67.13 SIL Ventral Hernia with Suprapubic Incision

For a subgroup of patients who are often young and scar conscious, having any visible scar for the treatment of their hernia(s) is unacceptable to them. Often these are young men who are physically active and who have umbilical, epigastric and diastasis of the recti. Conventional treatment would involve two separate scars, one for the umbilical and one for the epigastric hernia, while the laparoscopic treatment would normally involve three separate incisions on the side of the abdomen while SILS is usually performed with an upper outer quadrant incision. SILS with an incision in the suprapubic area, below the "bikini" line, would offer virtually scarless incision.

Preoperatively, the hernias and the incision site are marked. The patient is then catheterized, placed in stirrups and the abdomen covered with iodine-impregnated adhesive drape (Fig. 67.9). A 2 cm suprapubic incision is made, and this is dissected down to the linea alba, which, in this location, tends to have overlapping muscle bellies of the rectus muscle. The linea alba is incised, and, with the patient in the Trendelenburg position, the peritoneum is entered for placement of the single-port device. These young patients often have small hernias, and usually only the ligamentum teres needs to be taken down superiorly for placement of the mesh (Fig. 67.9). The mesh is fixed in a standard fashion (Fig. 67.9).

Since 2010, it has also been our routine practice to treat patients with parastomal hernias with single-incision laparoscopic parastomal hernia repair with modified Sugarbaker technique (Fig. 67.10). Due to previous major bowel resection, extensive bowel and/or omental adhesions are usually encountered, and the key to success is

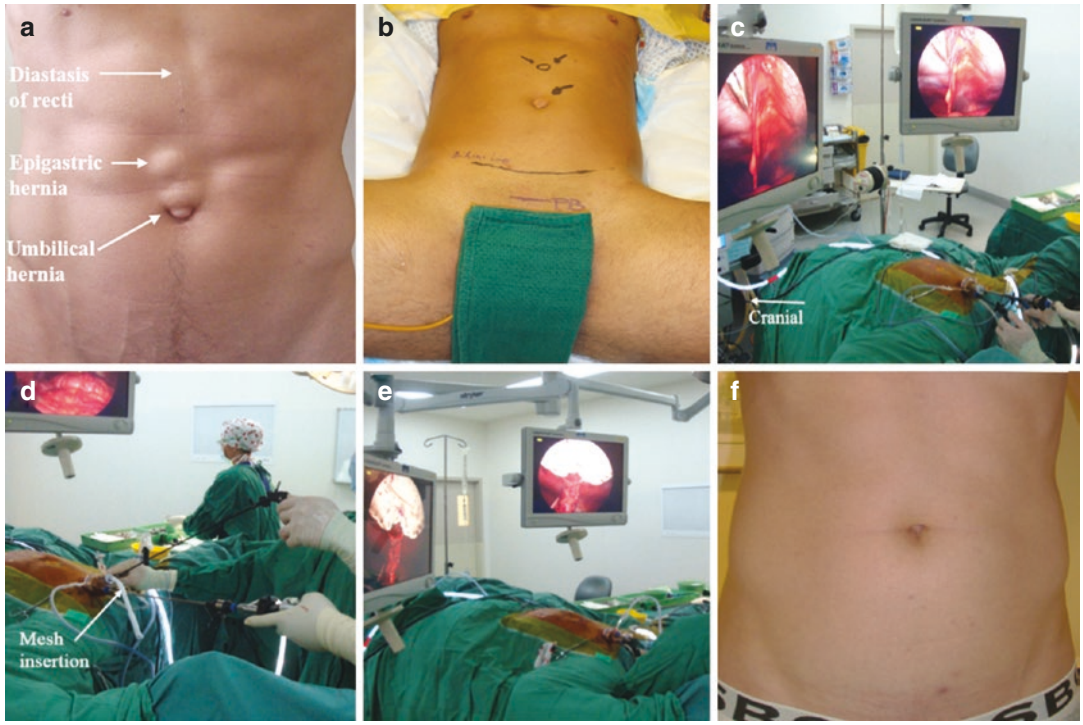

Fig. 67.9 Single incision laparoscopic ventral hernia repair with suprapubic incision to achieve "scarless" surgery: (**a**) shows a young patient with peri-umbilical and epigastric hernias associated with diastasis of recti, (**b**) patient is catheterized, placed in stirrups with preoperative marking of suprapubic incision site below the "bikini" line, (**c**) surgeon and assistant standing between the patient's legs with the single-port device placed in the suprapubic area, (**d**) mesh is inserted via the 10 mm port under direct visualization of the extralong scope placed in one of the 5 mm ports, (**e**) the screen shows the mesh fixed in midline position to cover the defects and (**f**) postop patients shows no visible abdominal scar wearing his usual briefs

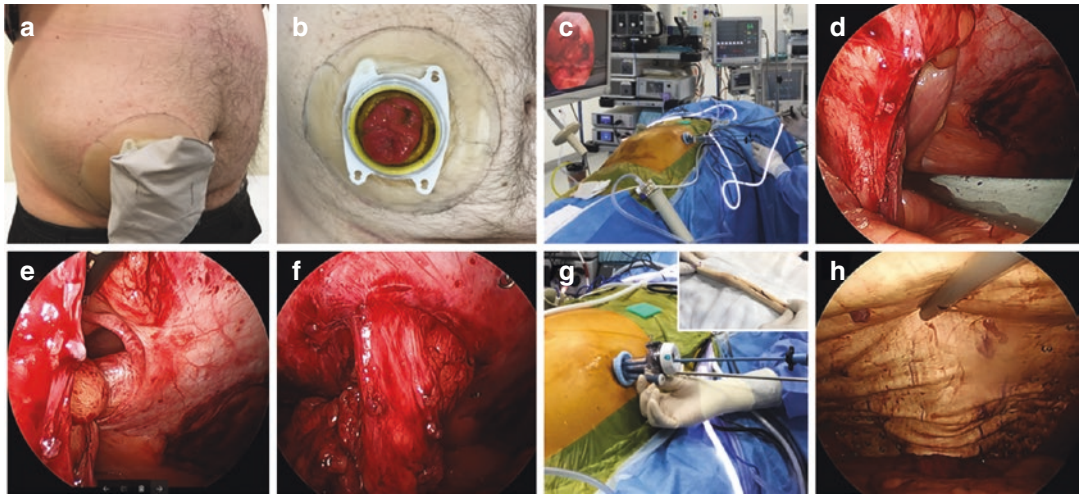

Fig. 67.10 SIL parastomal hernia repair with modified Sugarbaker technique: (**a** and **b**) show a patient with large parastomal hernia after pan-proctocolectomy for ulcerative colitis 10 years prior, (**c**) setup with SILS port placement in the left upper outer quadrant, (**d**) significant amount of herniated small bowel reduced, (**e**) the parastomal defect is exposed, (**f**) the skeletonized ileostomy limb, (**g**) placement of 18–26 cm mesh via a disposable 15 mm port under direct vision of the scope placed in one of the 5 mm port while the other one is partially pulled out to increase the space within the foamy port and (**h**) mesh covering the ileostomy limb in a tunnel

the safe division of adhesions and therefore meticulous millimetre by millimetre division of adhesions can be safely accomplished by SILS where the 5.5 mm scope is usually placed very close to the operative site. The herniated contents, often containing bowel loops, need to be fully reduced, while the ostomy limb needs to be skeletonised for lateralisation within a tunnel covered by the mesh (Fig. 67.10). Care is taken not to place tacks into the ostomy limb, while transfascial non-absorbable sutures are placed on either side of the ostomy limb to minimise the risks of the mesh being lifted off the lateral abdominal wall. Therefore, with experience, even highly complex hernias can be treated with SILS.

67.14 Discussion

The promise of truly scarless surgery with NOTES has not been realised some 10 years after its introduction predominantly because of the need to perforate an abdominal organ with the vagina being the most commonly used conduit [4, 5]. This effectively excludes half the population. Furthermore, mesh prosthetic use is virtually universal and recommended for all but very small abdominal hernias [20], and this precludes the use of NOTES in abdominal hernia repair although a few cases have been attempted [6–8]. In addition, the need for specialised instrumentation and its developmental lag, coupled with the need for a gynaecologist being present, means that it will remain in the domain of experimental surgery for quite sometimes to come.

SILS, on the other hand, has been much more widely adopted owing to the use of conventional dissecting instruments, while refinements of single-port devices continue to improve such that SIL (inguinal) hernia repair is not only safe but efficacious. Indeed, our prospective comparative study, comparing conventional multiport laparoscopic with balloon dissection of the extraperitoneal space and single-port TEP repair with telescopic extraperitoneal dissection, showed that the latter is highly cost effective [21]. Its safety has been confirmed in several meta-analyses drawing data from three RCTs each with 100 or more patients in addition to multiple other prospective studies [10, 17, 22–24]. There are currently no RCTs comparing multiport and single-port ventral hernia repair although a large number of non-randomised studies have demonstrated SILS's safety in ventral hernia repair [11, 25, 26].

There are obvious advantages to SILS in reduced parietal trauma, and since there are no sharp trocars involved, the risks of trocar-induced bowel and vascular injury are virtually negated. Additionally, the inline insertion of the dissecting instruments along the scope further reduces the risks of visceral injury especially when the assistant is trained to automatically pull the scope back to observe the entry of the instruments. Of course, this is absolutely essential every time a pair of laparoscopic scissors is introduced whether it is for single- or multiport surgery. Because the scope is still fixated on the operative field, there is less time wasted in finding the area the surgeon was operating again. The perceived relative loss of triangulation can easily be overcome by the use of the smaller and longer laparoscope as well as by modifying the dissection techniques, namely, "chopsticks" and "inline" dissection [9, 17, 21].

Utilising a natural scar such as the umbilicus or placing the incision in the suprapubic area will afford the patients the best cosmetic results while ensuring similar success to conventional multiport repair. On occasions where an upper abdominal skin crease incision is necessary, SIL VHR can provide the best possible cosmetic result while further reducing parietal trauma of additional ports and their potential for port site-related complications.

Although there is evidence that an umbilical incision via the linea alba can increase the risks of incisional hernias [27], our mode of single-port device placement does not involve entry via the linea alba at the umbilicus but rather the rectus is retracted laterally and the anterior and posterior rectus sheaths are incised and then closed after the procedure. To date, we have not experienced any incisional hernia arising from the umbilical incision. While the suprapubic incision involves incising the linea alba the bulky rectus muscle bellies and its overlapping at this site means that incisional hernia should be rare and indeed we have not experienced any incisional hernia arising from the suprapubic incision.

Conclusion

This chapter illustrates the step-by-step guide to SIL ventral/incisional hernia repair for any novice with tips and tricks learned from over 2000 cases. It will also be useful for experienced laparoscopists who may wish to expand their surgical repertoire which may be called upon for very difficult or unexpectedly difficult laparoscopic cases. While conventional laparoscopic abdominal hernia repair is widely practised, elevating any surgeon's skill set will further advance surgery and encourage the quest for improved patient care. Reducing parietal trauma with reduced incisions or placing such incisions in inconspicuous places, such as the umbilicus or the suprapubic area, will allow the surgeons to satisfy a more diverse range of patients whose individual wishes need to be taken into account. We have demonstrated that it is possible to perform any abdominal hernia repair with single-port surgery irrespective of size and complexity and the only limitation is the surgeon's imagination.

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