Advances in Laparoscopy of the Abdominal Wall Hernia

Juan Manuel Suárez Grau
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This book is dedicated to all the people who make the daily work of a surgeon possible. In particular, I thank my colleagues in Riotinto Hospital and Sagrado Corazón Clinic in Seville: I can always count on your support for all the ventures upon which we have embarked and upon which we will embark in the future.
I am especially grateful to my professors, who awakened my interest, both in surgery and medical research.
I would also like to thank all the surgeons who have helped me train in laparoscopic surgery.
Most of all, I thank my family: Carolina, Claudia, and Sabina, who have had to endure the long hours of work that have made this book possible.
In my doctoral thesis, I cited this quote from Goethe, and I would like to do so again: "Whatever you can do or dream you can, begin it. Boldness has genius, power and magic in it."
I would like also thank you to Liz Corra and her incessant work and supervision regarding every detail of this book.

Preface

In the history of general surgery, there is a turning point, after the first cholecystectomy performed by P. Mouret in Lyon. This new approach Mouret employed helped avoid aggressive incisions that had long recoveries, and it improved aesthetic results. One of the most important factors is that, since then, this approach has become universally accepted by practitioners as well as the public.

Hernia surgery has been the perfect candidate for short-stay centers and has been treated as a surgery that fills the small time gaps in an operating theater schedule between longer surgeries, without any hope of advancing beyond polypropylene meshes. Fortunately, this field of surgery has grown in the wake of improvements in materials, meshes, and sutures and in the wake of surgeons who specialize in the abdominal wall.

PTFE was a breakthrough, addressing the problems of intra-abdominal adhesions of polypropylene mesh, allowing for the first incursions into the world of laparoscopic incisional hernia.

The double crown technique has been accepted, and the fixation of the mesh has advanced slowly toward a path increasingly atraumatic and physiological (absorbable tackers, glues, etc.).

Companies have experienced the possibility of expanding their products into the area of hernia surgery because of the large numbers of such surgeries. And today we can find multiple international, national, and regional associations specializing in the abdominal wall. Journals are now published that are specific to this pathology.

The quantum leap to laparoscopy is more obvious every day, above all in incisional hernias in the midline abdominal wall.

Inguinal hernia surgery is the current challenge. This type of surgery is in greater demand, and the number of surgeons who are interested in this technique is growing daily. Advances in trocars, mesh, and clips are accompanied by the training in laparoscopic surgery of residents and young surgeons. Surgical training is increasingly directed toward minimally invasive surgery and clearly contemplates the hernia pathology within the techniques to be developed in the future. Robotics surgery and single port laparoscopfic surgery are clear examples of this significant development.

In this book, we have attempted to cover the techniques already established as well as the new advances in laparoscopic surgery of the abdominal wall. We intend herewith to create a useful guide for those surgeons who face hernias on a daily basis and who intend to further train themselves in this field.

Seville, Spain Juan Manuel Suárez Grau, MD, PhD

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Chapter 1
A Brief Historical Review of Surgical Treatment of Hernia

Jose J. Diaz Jr.

Abstract History of surgical treatment of hernias of the abdominal wall includes the first treatments with cautery and golden stitch, the first anatomical reparation of Purman and von Czerny, and the modern era of the herniorrhaphies with Bassini that represented a new approach in the treatment of inguinal hernias. Anatomical surgeons such as Halsted, McVay, and Shouldice described reparations of inguinal hernia. At the same time, with regard to ventral hernia, Grynfelt, Petit, Stoppa, Rives, and other surgeons have described famous techniques used even today. A new era for reparations of abdominal hernias started with the introduction of meshes. Usher used a polypropylene mesh for inguinal hernia. Other materials have been used. PTFE-e is a mesh which allows direct contact with intra-abdominal viscera and is used in the laparoscopic approach to hernias. The laparoscopic approach started with surgeons such as Toy and LeBlank, who used PTFE-e meshes. Ventral hernia laparoscopic repair is a reality used globally. Inguinal hernia laparoscopic treatment has extended to all centers with experience in hernia repair because of its advantages and its results. New devices and technologies are on the horizon (single port, robotic, new material, fixation, and others).

Keywords Hernia • Abdominal wall • History • Hernioplasty • Herniorrhaphy • Laparoscopy • Mesh

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Introduction

Hernias of all types continue to be a very common problem in surgical practice today. They come in all forms, from congenital to acquired. The first recorded mention of inguinal hernias was by Celsus in the first century AD. It was not until the sixteenth century that surgical repair could be undertaken based on modern anatomy. This was done by cauterizing the hernia sac or instilling an acidic chemical. The hernia sac was tied at the external ring with a golden thread – the so-called golden stitch [1, 2].

Inguinal Hernia and Tissue Repairs

The German surgeon Matthaus Gottfried Purman (1649–1711), a distinguished bather surgeon of his time, treated inguinal hernias using conservative management with adjusted hernia supports [3]. Surgery was indicated only for marked extended hernias. Purman did not perform operative reinforcement of the anterior wall of the inguinal canal. The German surgeon Vinzenz von Czerny (1877) performed the first operation to narrow the hernia opening of the inguinal canal [3, 4].

Eduardo Bassini from Padua in 1889 published a short text in Italian about "a new operation method to treat inguinal hernias." In this paper, Bassini described a three-layered repair involving the internal oblique muscle, the transverse abdominal muscle, and the transversalis fascia [5]. A separate suture to the posterior edge of the inguinal band was used to narrow the internal ring. William S. Halsted (1852–1922) reported independently on a similar operation [6]. In 1942, Chester B. McVay described the modification of this repair to include a suture to the accurate ligament (Cooper's ligament or ligamentum pubicum superius) to close the femoral canal in the presence of a femoral hernia [7]. Edward Earle Shouldice (1890–1965) pointed out the importance of the transversalis fascia for repair of the posterior wall of the inguinal canal [8].

Ventral Hernia, Tissue, and Prosthesis Repairs

Joseph Grynfeltt (1840–1913) described the superior lumbar triangle hernia through the Grynfeltt-Lesshaft triangle. The French surgeon Jean Louis Petit (1674–1750) described the inferior lumbar triangle which bears his name. The German surgeon August Gottlieb Richter (1742–1812) described a hernia involving only one side of the bowel which can result in bowel strangulation leading to perforation due to ischemia without causing a bowel obstruction or many of the common warning signs [9, 10].

The incisional or ventral hernia became a surgical entity after the development of safe laparotomy in the late 1880s and 1890s. Most of these were repaired primarily [11]. Other surgeons used rotational flaps or curtis grafts. In the mid-1940s, C.R. Lam and T. D. Throckmorton, both from the USA, described a ventral hernia repair using tantalum mesh [12]. In 1948, Koontz presented his initial series of ventral hernia repairs with this mesh [13]. Cumberland in 1953 reported on the use of prefabricated nylon weave mesh in the repair of ventral hernia [14]. Yu Heien described using silk taffeta in the repair of abdominal wall defects [15]. It was Usher in 1963 who described the use of knitted polypropylene mesh to repair ventral defects [16].

Bauer [17] first described the use of expanded polytetrafluoroethylene (PTFE) for repair of large ventral hernia. Luijendijk was the first to describe in a randomized control trial that tension-free repair was superior to primary repair [18]. Cater [19] was the first to describe the laparoscopic diagnosis and repair of spigelian hernia. Finally, anatomic reparations techniques, such as early one-stage closure of patients with abdominal compartment syndrome using fascial replacement with human acellular dermis and bipedicle flaps, were performed at my institution in 2003 [20].

Modern Era of Hernia: Mesh Repairs and Laparoscopy

In the mid-1980s, M. E. Lichtenstein described the use of a prosthetic mesh to repair the inguinal defect. R. E. Stoppa, during the same time period, described the use of a large polyester mesh interposed in the preperitoneal space between the peritoneum and the transversals fascia. L. Schultz in 1990 reported on a clinical trial of a series of 20 laser laparoscopic herniorrhaphies. The following year (1991), L.W. Popp and J.D. Corbitt independently described a series of laparoscopic vs. conventional herniorrhaphies demonstrating proof of concept [10–12].

Ralph Ger in the early 1990s described one case of laparoscopic inguinal hernia repair with metallic lips only. His approach was applicable to hernia sacs with defects less than 1.25 cm. The first total extraperitoneal approach (TEP) to inguinal hernia repair was first described by McKernon and Laws in 1993. As with the transabdominal approach (TAPP), the principles touted by Rives and Stoppa for open preperitoneal repair of a large mesh providing coverage over all defects were primary principles of the laparoscopic approach to inguinal hernia repair [18–20].

The first laparoscopic ventral hernia repair was published in 1993 by LeBlanc.

Toy in 1996 modified preferences, since, instead of using either polypropylene or PTFE, he started using only PTFE to prevent the formation of adhesions. Subsequently, Park, Heniford, Chari, Holzman, Panton, and Carbajo, among others, working with a large series of over a hundred cases, have highlighted the benefits of this technique [21, 22].

O'Dwyer and Krähenbühl preferred general anesthesia to achieve adequate muscle relaxation and the possibility to work with higher inflation pressures.

Generally, any adult patient who can undergo general anesthesia and does not have uncontrolled coagulopathy may be eligible for an abdominal wall reconstruction laparoscopically. The best candidates, according to authors such as Frankum and Memon, seem to be patients with recurrent ventral hernias and those who are to be operated laparoscopically for other reasons [21–23].

Today, inguinal and ventral hernia repair via laparoscopy is a reality with enormous advantages in the postoperative period. It has a large learning curve and is more complicated than other common laparoscopic procedures, requiring more than 50–100 hernias in order to qualify as an assistant or primary surgeon.

These advanced laparoscopic procedures have begun to be included in short-stay centers and outpatient surgery centers with very favorable results in expert hands.

Future Directions

Today, both open and laparoscopic inguinal and ventral hernia repairs are performed with prosthetic mesh and biologic mesh. The incidence of hernia recurrence and complications continues to be a significant problem. The field of prosthetic materials continues to expand with new synthetics and biological mesh. In additional, sutureless surgical techniques are now part of the surgeon's armamentarium. Laparoscopic inguinal and ventral repair has brought new interest in and insight into this very difficult problem. Most recently, robotic laparoscopic repair was described by Ballantyne in 2003 [21]. The future of hernia repair will likely result in better prosthetics, less surgical trauma, and improved cosmetics.

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Chapter 2
Anatomy of the Abdominal Wall

Cristina Méndez García, Salud García Ruiz, and Carmen Cepeda Franco

Abstract The anatomy of the abdominal wall in the study of hernias consists of the description of the anterior, posterior, and inguinal areas of the abdomen. Knowledge of the muscles, nerves, arteries, and veins in each area is important in order to perform a preperitoneal or transabdominal laparoscopy to repair a hernia. Knowledge of the dangerous areas and structures is very useful in order to avoid complications of the surgery.

Keywords Anatomy • Hernia • Surgery • Abdominal wall • Muscle • Nerves • Inguinal • Laparoscopy

Anatomy of the Anterior Abdominal Wall

The abdominal wall is composed of muscles and fascia which cover the anterolateral area between the xiphoid process (following the costochondral ridge until the transverse process of the twelfth dorsal vertebra) and a line that passes through the iliac crests, femoral arches, and pubis.

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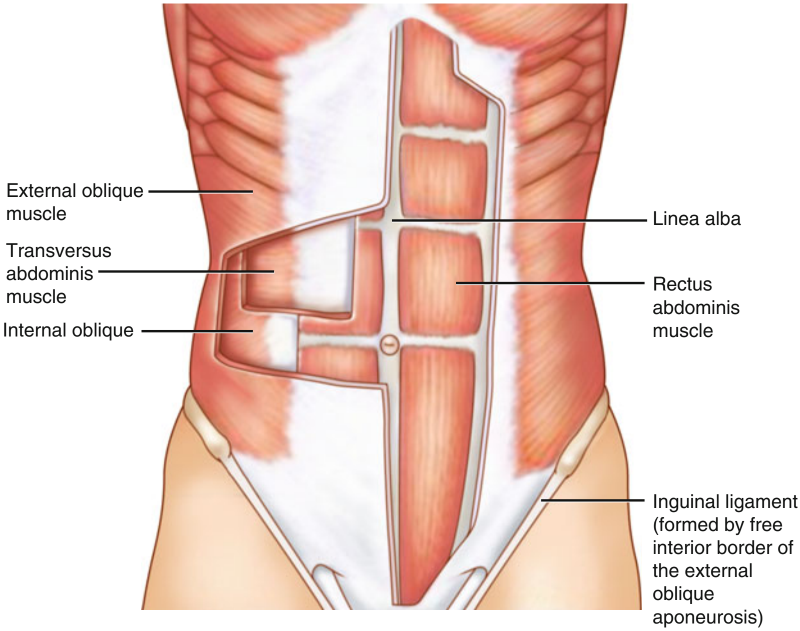

Fig. 2.1 Anatomy of the anterior abdominal wall

In a horizontal cut oriented by its cranial face, we can identify the planes of surgical interest from the surface to the peritoneal cavity [1, 2]. These are discussed in the sections that follow. See Fig. 2.1.

Skin (Integument)

The epidermis has great capacity for regeneration because its nutrition comes via diffusion from the underlying vascular planes. Arterial vessels form a subdermal plexus from which some branches leave to enter the subcutaneous tissue. In the subdermal plexus, arteriovenous anastomoses exist; some of these are glomus under the control of the autonomous nervous system.

The area least irrigated is the midline of the abdomen as the plexus comes from the back to the front area. The innervation is performed on all layers of the skin (organosensorial), and subdermal lymphatics are anastomosed at all levels, so a free exchange is produced between regions.

Subcutaneous Tissue (Adipose Tissue or Hypodermis)

This consists of areolar tissue and/or unilocular white adipose tissue (white fat) in proportion to and in variable arrangement by region, according to the constitution of the individual and the subject's nutritional status and according to factors of hereditary.

The mobilization and deposition of lipids are influenced by nerve factors (noradrenaline, which activates the lipase) and hormonal factors (insulin, thyroid hormones, glucocorticoids, and pituitary hormones).

In the subcutaneous tissue, the blood vessels are the vessels from perforating cutaneous branches of the direct and subdermal plexus. The nerves are perforating branches coming from the intercostal and first lumbar nerves.

Musculoaponeurotic Plane

This is comprised of three muscle groups [1–3]:

- Posterior muscles arranged in three planes:
  - Deep plane or vertebral channels:
    - Multifidus muscle
    - Lumbar sacral muscle
    - Spinous dorsal muscle
  - Medium shot:
    - Lower serratus posterior
  - Flat surface:
    - Dorsi muscle
    - Lumbar aponeurosis
- Muscles laterovertebrals:
  - Quadratus lumborum
  - Iliopsoas muscle
- Anterolateral muscles:
  - Transversus abdominis
  - Internal oblique muscle or minor
  - External oblique muscle or greater
  - Rectus abdominis

Transverse and oblique muscles go forward internally and externally forming the rectus sheath and the white line. Transversal fascia forms the semilunar line under the umbilicus, where the posterior fascia makes the anterior rectus sheath [4].

Irrigation of these muscles depends on the epigastric vessels, which come up from the external iliac vessels to get to the internal mammary artery and vein, in the thorax. Epigastric vessels are included in the rectus muscle inside the sheath [5].

Extraperitoneal or Subperitoneal Space

This is located between the inner surface of the abdominal wall, covered by its fascia, and the parietal peritoneum. It contains vessels, nerves, organs, and extraperitoneal adipose tissue, in a variable arrangement according to regions and subjects.

We can identify the following regions or extraperitoneal spaces [6, 7]:

- Lateroperitoneal spaces: a level of the iliac fossa internal to the external iliac vessels, gonadal, and nerve genitocrural.
- Preperitoneal spaces: at the round ligament and lower and include prevesical space (Retzius) and paravesical space (Bogros).
- Pelvic subperitoneal space: comprised of a visceral mediastinum, lateroviceral spaces.
- Retroperitoneal spaces: subperitoneal fascia is divided into a front sheet and another, post- or retrorenal.

Peritoneum

The definitive parietal peritoneum cavity limits are closed except at the level of the fallopian tubes in women. This contains intraperitoneal organs and is divided into areas and regions that are useful in surgical exploration and intraperitoneal pathways and structures ideal for transperitoneal/extraperitoneal approach. If we examine the abdomen through the sagittal front, we observe that the abdominal cavity is much vertically higher than its outer limits, contains the peritoneal cavity, and extends from the diaphragm to the thoracic abdominal pelvic diaphragm principal.

Topography of Anterior Abdominal Wall

In dissections performed by the authors, bands were found of different origins and terminations which overlap one another and have attached fascia that cover their superficial areas and deep areas. The origin of each band is in the outer and lower edge of the seven last ribs. While there may be variations, especially in the form of termination, the authors could distinguish two costoiliac bands which are by the insertion of the aponeurosis inguinal ligament and the anterior wall of the inguino-abdominal region; the rib-pubic band of the 9th rib (the pillars of the superficial inguinal ring); the band of the 8th rib ending in the upper half umbilicus-pubic line; the band of the 7th rib (which ends in the middle xifo-umbilical bottom line); and the bands of the 5th and 6th ribs, terminating in the upper half xifo-umbilical line [2, 8].

The external oblique bands are distinguished as follows:

- Sector I: costoabdominal epigastric or supraumbilical bands formed by the 5th, 6th, and 7th ribs
- Sector II: costoabdominal hypogastric or infraumbilical bands formed by the 8th and 9th ribs
- Sector III: costoinguinal, the band formed by the 10th rib
- Sector IV: costoiliacal, formed by the bands of the 11th and 12th ribs

Above and out of the upper branch of the semilunar line or Spiegel, the transversus abdominis muscle is limited so that the cleavage zone located in the backsheet of the rectal sheath has a lesser extent than in the previous sheet found. This is featured in classic anatomy texts, but is known to surgeons who perform laparotomies in this region: one sector consists of muscle, aponeurotic place, the section of the backsheet rectal sheath. The authors call this cleavage plane of the sheet rectal sheath back [4, 6].

Anatomy of the Inguinocrural Area

The surgical space called the Fruchaud triangle is an opening of the lower abdominal wall, bounded by the conjoint tendon, the iliopubiana branch, the rectus abdominis, and the iliopsoas. This triangle is divided by the inguinal ligament into two topographical regions: inguinoabdominal and inguinocrural.

Inguinoabdominal Region

Anatomically, this region has a triangular configuration, and as reference points we have the anterior superior iliac spine, the pubic body, and its spine.

Essentially, the function of the inguinal canal is for the passage of the spermatic cord from the scrotum to the abdominal cavity. The inguinal canal is approximately 4 cm long and is directed obliquely through the lower inferomedial part of the anterolateral abdominal wall. The canal lays parallel and 2–4 cm superior to the medial half of the inguinal ligament. This ligament extends from the anterior superior iliac spine to the pubic tubercle. It is the lower free edge of the external oblique aponeurosis. The main occupant of the inguinal canal is the spermatic cord in males and the round ligament of the uterus in females. The anatomic structures that describe the end of the inguinal canal are its previous and posterior wall and, finally, its floor and roof.

On the surface plane under the skin and subcutaneous tissue, it is extended:

- Camper's fascia, variable in thickness and structure
- Scarpa's fascia, including insertion into the spine of the pubis and pubic spermatic cord
- Innominated fascia overlying the external oblique muscle

As neurovascular elements in this plane, we find superficial epigastric arteries and veins and sensory nerves that are part of the lower intercostal and greater abdominogenitalis or iliohypogastric and minor ilioinguinalis.

In the muscular plane, the oblique muscle forms the anterior wall of the inguinal canal, and this area is reduced to a few bundles that occupy the upper outer and is directed inward and down with the aponeurosis of insertion. Below, the spermatic cord runs, and the bottom of the muscle fibers go downward obliquely to the iliac spine and the outer third of the inguinal canal.

The transverse muscle behaves in this area similar to the oblique muscle: its aponeurotic tendon fibers are superior to the rectus sheath and the lower are the conjoined tendon or Henle's ligament.

The posterior wall of the inguinal canal is formed by:

- Fascia transversalis: the layer of fibrous tissue that covers the back of the transversus muscle and aponeurosis
- Cellular preperitoneal tissue: above the parietal peritoneum and very thick in this area, forming the Bogros space along which the epigastric vessels and iliohypogastric, ilioinguinal, and genitofemoral nerves are located

Inguinocrural or Femoral Region

This area also has a flat surface consisting of skin, subcutaneous tissue, and a neurovascular bundle: abdominal subcutaneous vessels or superficial epigastric and external pudendal, saphenous vein, and sensory branches of the femorocutaneous trunks, femoral, obturator, and iliohypogastric.

The muscular plane is formed as follows: a surface portion by the sartorius muscle, the adductor longer and gracilis, and a deep portion by the rectus femoris or earlier, the vastus medialis, the iliopsoas, and the pectineus. The latter two constitute a channel containing the femoral vessels and part of the femoral canal.

The top of the duct or femoral ring is the space that communicates with the abdominal wall or femoral Scarpa's triangle. It is delimited by the inguinal ligament, laterally by the streak iliopectineal, and medially by the Gimbernat's ligament.

Through this ring run the femoral artery and vein and lymphatic vessels, and it hosts the Cloquet's ganglion. At the lower end of the femoral duct, the saphenous vein opens into the femoral one.

Elements in the inguinal area in laparoscopic intra-abdominal view are as follows: epigastric vessels (Fig. 2.2), spermatic vessels and vas deferens (Figs. 2.3 and 2.4), femoral vessels (Figs. 2.5 and 2.6), and weakness areas in inguinocrural region (hernia localization) (Fig. 2.7).

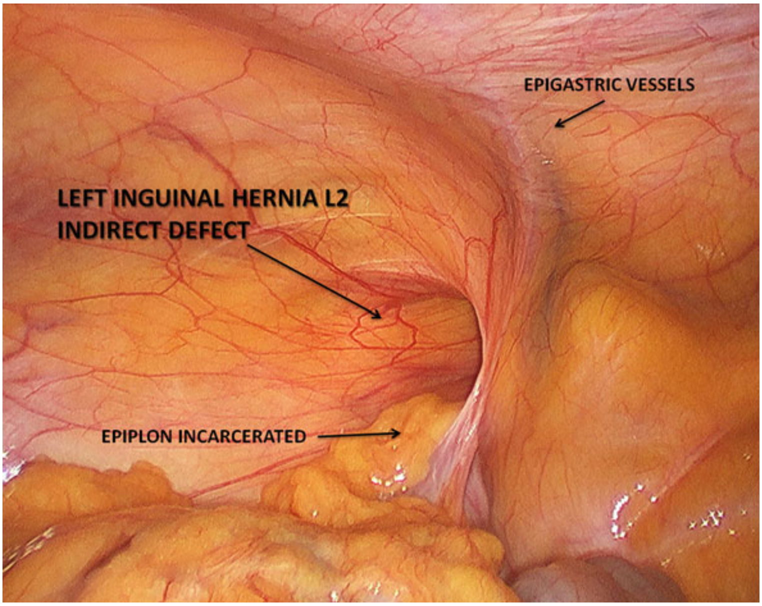

Fig. 2.2 Laparoscopic view of inguinal area in inguinal hernia: epigastric vessels

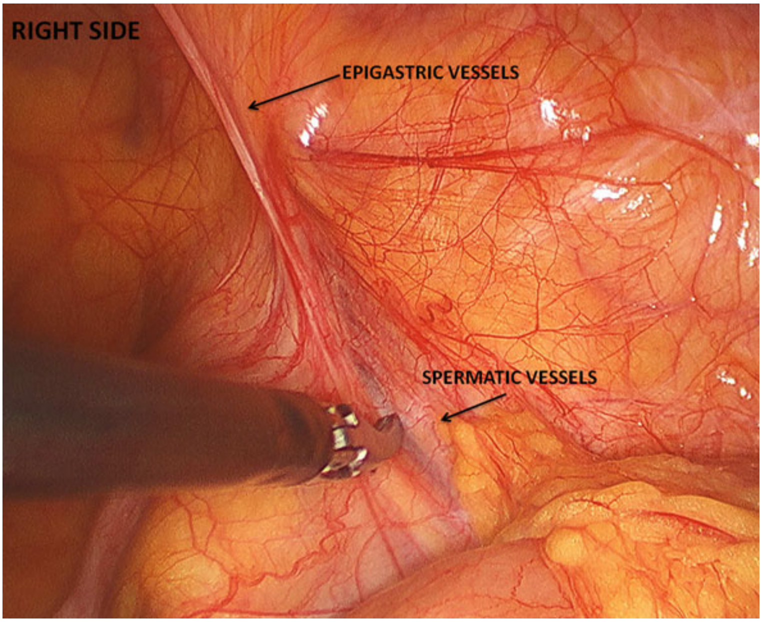

Fig. 2.3 Laparoscopic view of inguinal area in inguinal hernia: spermatic vessels

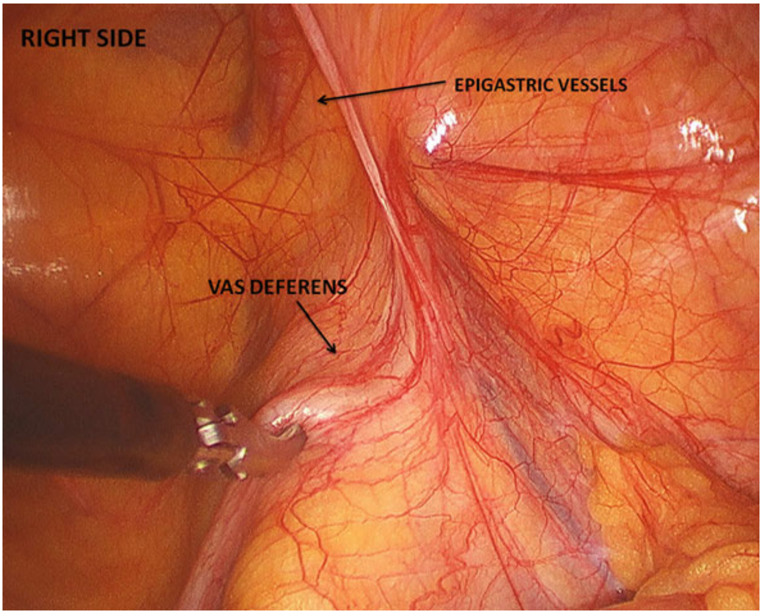

Fig. 2.4 Laparoscopic view of inguinal area in inguinal hernia: vas deferens

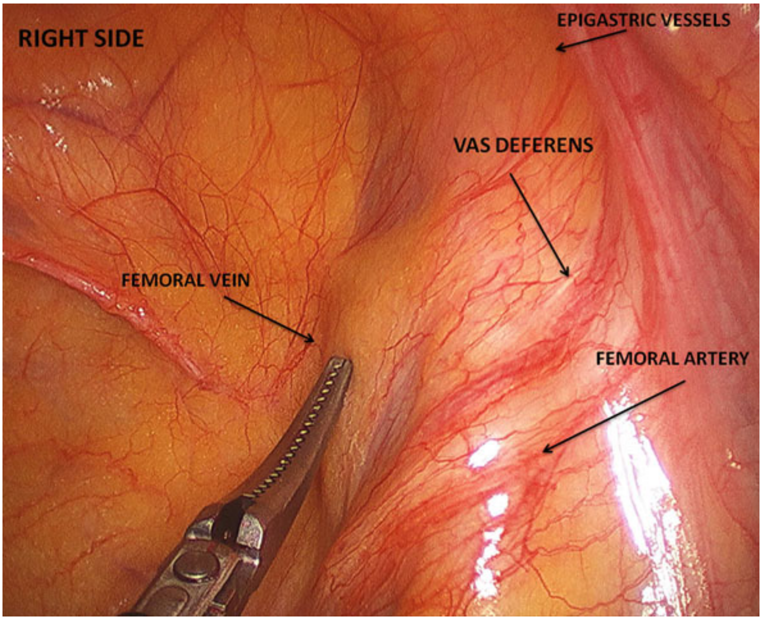

Fig. 2.5 Laparoscopic view of inguinal area in inguinal hernia: femoral vein and artery

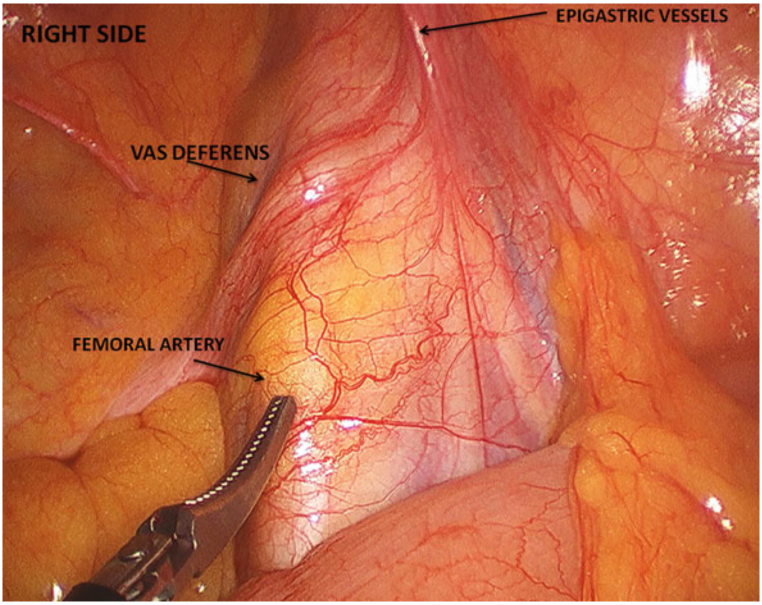

Fig. 2.6 Laparoscopic view of inguinal area in inguinal hernia: femoral artery

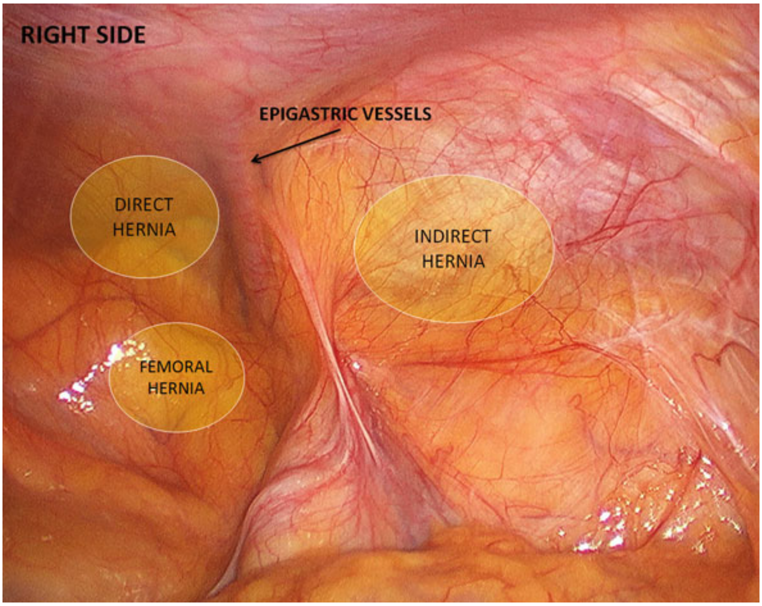

Fig. 2.7 Inguinal hernia: weakness areas in inguinocrural region (hernia localization)

Weakness Areas in Abdominal Wall

Abdominal wall consists of a complex of several muscle layers, and the crossing points of these layers are risk areas for developing hernias. Some of these weakness zones are discussed in the following sections [5, 8].

Areas of Anterior Wall Weakness

Semilunar Arch of Spiegel

The transition between transverse muscle and its aponeurosis describes a lateral convexity from the last rib to the pubis. Spiegel's hernias develop between this line and the lateral side of the anterior rectum vein.

Alba Line

This is located at the midline of the abdominal wall, just at the junction of both rectum muscles fascias where some congenital defaults or diastases take place (diastases recti).

Umbilicus

This is a natural default in the abdominal wall which is progressively closed leading to a duct limited by the umbilical fascia, alba line, and medial sides of both rectus muscles fascia. Sometimes, as a consequence of spoiling of the tissue around the umbilical ring, this could be a location of future hernias.

The Douglas Arch

This is a well-defined line which is found between the 2/3 superiors and the 1/3 inferiors of the anterior abdominal wall, posterior to the rectus muscles, where the insertion of the internal oblique muscles and transverses go on to integrally form part of the rectus muscle sheath. Under this, the posterior face of the rectus muscle will be without aponeurosis, being only covered by the transversalis fascia, a thin connective layer between the rectus and the preperitoneal fat.

Areas of Inguinal Weakness

The area of inguinal weakness is oval-shaped and is limited superiorly by the conjoined tendon (inferior border of the abdominal internal and transverses oblique muscle) and inferiorly by the inguinal ligament.

The Hesselbach's triangle is an anatomic landmark and is bounded by the rectus muscle medially, the inguinal ligament inferiorly, and the inferior epigastric vessels laterally.

Indirect inguinal hernias are produced by the area of weakness created by the deep inguinal orifice, in such a way that the hernia sac is directed into the interior of the spermatic cord towards the testicle.

Direct inguinal hernias are produced by the area of weakness localized medial to the deep inguinal orifice, so that the inguinal canal is only covered by the transversalis fascia.

Area of Femoral Weakness

The area of femoral weakness corresponds to the triangle defined superiorly by the inguinal ligament, inferiorly by Cooper's ligament, and laterally by the external iliac vein. Hernias localized in this space as a result of elevated intra-abdominal pressure are called femoral.

Other Weakness Areas

Superior Lumbar (Grynfeltt-Lesshaft) Triangle (Fig. 2.8)

This is formed medially by the quadratus lumborum muscle, laterally by the internal abdominal oblique muscle, and superiorly by the 12th rib. The floor of the superior

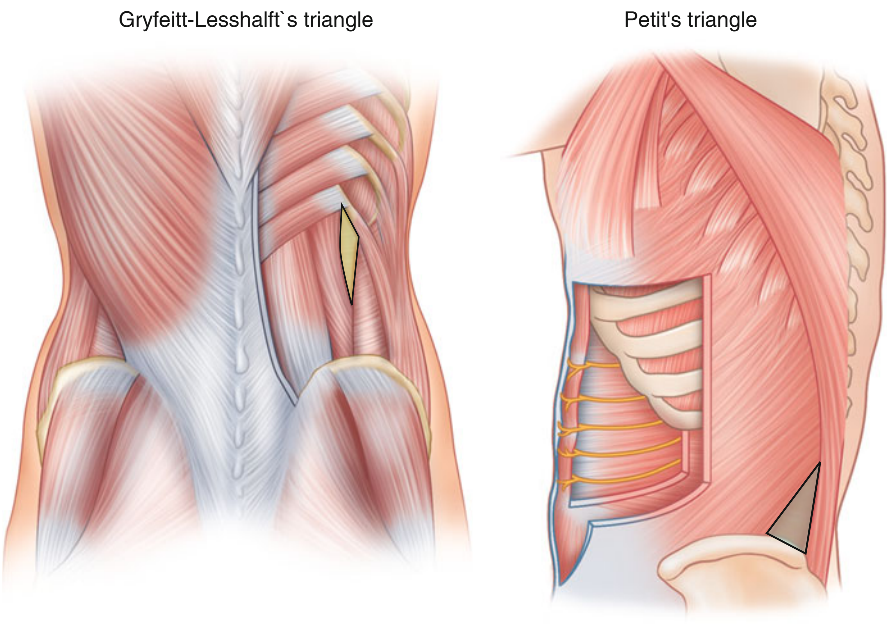

Fig. 2.8 Posterior lumbar triangles

lumbar triangle is the transversalis fascia, and its roof is the external abdominal oblique muscle.

Inferior Lumbar (Petit) Triangle (Posterior Abdominal Wall) (Fig. 2.8)

This has margins composed of the iliac crest inferiorly and two muscles: latissimus dorsi (posteriorly) and external abdominal oblique (anteriorly). The floor of the inferior lumbar triangle is the internal abdominal oblique muscle.

Major Sciatic Hole (Sciatic Hernias), Pelvic Diaphragm (Perineal Hernias), and Obturator Membrane (Junction Pubis and Ischiatic Bone)

These are other areas of weakness.

Dangerous Areas During the Surgical Treatment of Inguinal Hernias

Triangle of Doom (Fig. 2.9)

The artery and external iliac vein are found framed during laparoscopic inguinal hernia surgery by the "triangle of doom," which is found between the vas deferens and the gonadal vessels. It is not recommended to perform sharp maneuvers or indiscriminate cauterization in this area.

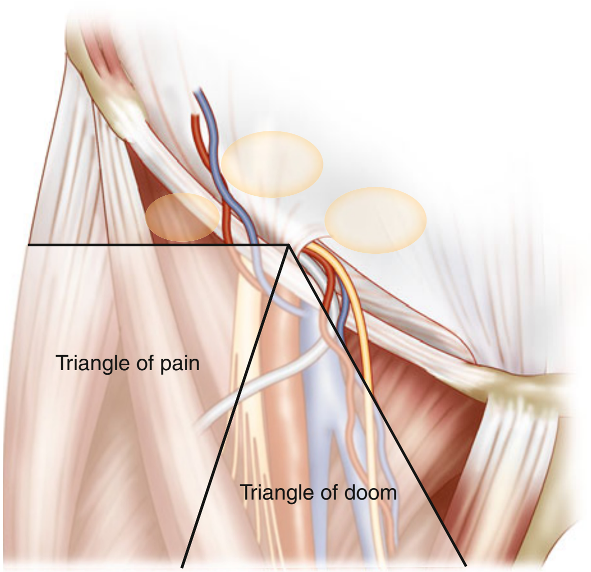

Fig. 2.9 Triangle of pain and triangle of doom

Triangle of Pain (Fig. 2.9)

The genitofemoral and femorocutaneous nerves are framed during laparoscopic inguinal hernia surgery by the "triangle of pain," which is found between the spermatic vessels medially and the inguinal ligament superiorly. In the same way, is advisable not to perform indiscriminate cauterization or place stitches or tackers to fix the mesh in this area.

Corona Mortis

Posterior to Cooper's ligament, we can see an arterial branch which comes from the external iliac artery known as the Corona Mortis. One has to be careful when dissecting Cooper's ligament, as bleeding from this arterial branch is very difficult to control.

Genital Branch of the Genitofemoral Nerve (Fig. 2.10)

The genital branch of the genitofemoral nerve enters into the deep inguinal hole in its superior and lateral portions. An injury at this point could be a cause of chronic postoperative pain.

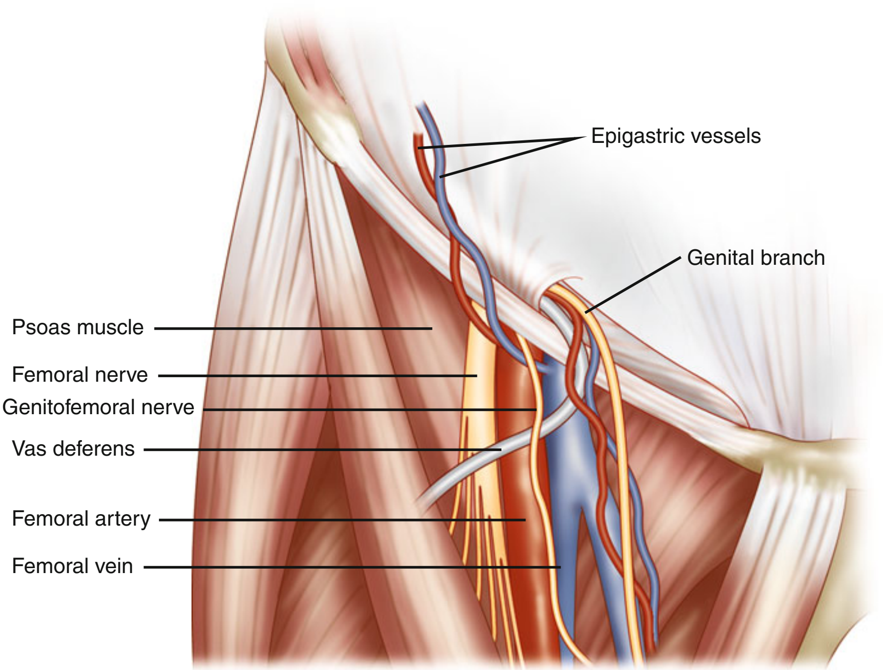

Fig. 2.10 Genital branch of the genital femoral nerve

Pathogenesis of Abdominal Wall Hernia

There are many factors implicated in the pathogenesis of abdominal wall hernias, so many that it is impossible to determine what they all are. Embryology, anatomy, and biochemistry have influence on the formation of muscles, fascias, and tendons and thus can have impact on future hernia formation. In any case, there are specific factors which definitively lead to the development of different kinds of hernias [9, 10], and these are discussed in the sections that follow. See Fig. 2.11.

Biomechanical Factors

Collagen

Published studies remark upon the way a decrease in the type I/type III collagen ratio as a result of an increase in the levels of type III procollagen mRNA, and a concomitant increase in the synthesis of type III collagen may alter the physical properties of the collagen matrix in the abdominal wall and thus predisposes individuals to the development of hernias [11, 12].

Obesity

To the extent that people gain weight, abdominal pressure is incoming, with the consequent risk of the appearance of abdominal hernias.

Genetic Factors

Chromosomal Disorders

Recent reports in animal models reveal how the downregulation in the expression of most genes involved in body wall formation could adversely affect abdominal wall development. Up to now, several sources using gene knockout mice have explained the basis of the pathogenesis of body wall defects as related to some congenital human birth defects. In particular, mutations identified in some of the genes for transcription factors, cell signaling molecules, and proteases are associated with various degrees of body wall developmental abnormalities [12].

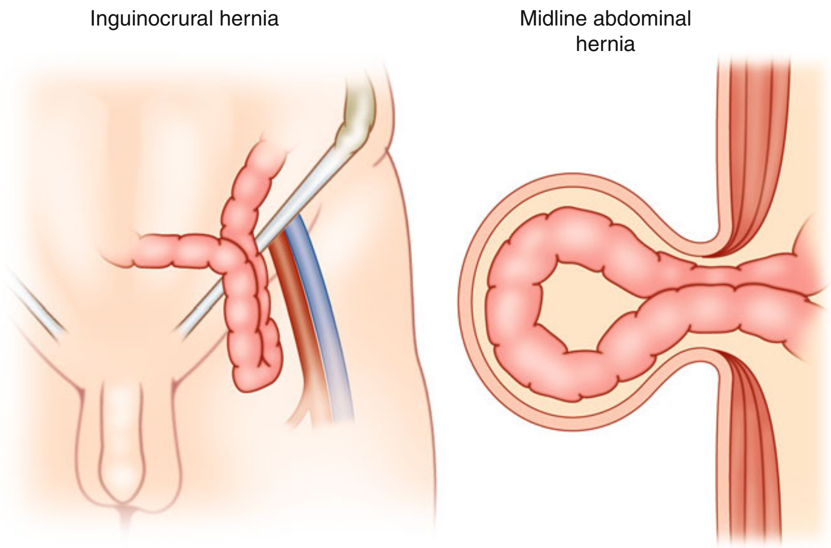

Fig. 2.11 Inguinocrural hernia and midline abdominal hernia

Environmental Factors [9–12]

Smoking

Tobacco has a pernicious effect over the α-1 antitrypsin, allowing an increasing elastolytic activity and the resulting connective tissue failure.

Physical Exercise

Some forms of physical actions (at work, at play, during participation in sports, etc.) could lead to high abdominal pressure.

Anatomic Position

Humans standing upright over their feet has supposedly led to displacement of the visceral contents of the abdominal cavity to the inguinal region, which in general is prone to more weakness than the rest of anterior abdominal wall.

Surgery

Opening of the abdominal wall during a surgical intervention leaves an area of acquired weakness where hernias could develop in the future. Moreover, many nerves could be damaged as a result of the surgery, and this resulting denervation might devalue the quality of abdominal wall muscles.

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Chapter 3
Classification of Ventral Hernias and Inguinal Hernias

Joaquín Luis García Moreno and Ignacio Durán Ferreras

Abstract In ventral and inguinal hernias, various classifications are used today. One of the most commonly used and accepted is the EHS for inguinal hernia and ventral hernias, and there is a great deal of consensus surrounding its use. It is a simple scale which includes recurrence, localization, width, and length for the entire abdominal wall. A global classification allows all surgeons to identify hernias correctly and uniformly and to perform a proper reparation after identifying the hernia according to criteria agreed upon by the entire surgical community.

Keywords Classification • Inguinal • Ventral • Incisional • Hernia • Hernioplasty • Surgery • EHS • Abdominal wall

Classification of Ventral Hernias

Abdominal hernias are defined as progression of the abdominal viscera through a defect in the wall of the cavity containing them. All classifications of hernias of the abdominal wall are somewhat arbitrary and artificial, and there is no consensus

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among general surgeons and specialists in hernias at the time of this writing regarding the best manner in which to catalog them.

The high incidence of abdominal wall hernias, including incisional hernias or eventration, represents a public health problem throughout the world. The frequency of these is estimated to be between 12 and 15 % of all completed laparotomies and between 3 and 8 % of all laparoscopic surgeries. The rate of mortality is approximately 0.24 %, including urgent and elective surgeries.

Its frequency is higher in the female population (3:1) due to a weakness and floppiness of the tissues of the abdominal wall in women, caused by reduced physical activity, pregnancy history, and greater frequency of surgical procedures when compared to the male population [1].

The classification of hernias is based on consideration of the following aspects: clinical and anatomical. The clinical classification is only a presumption; it is difficult, during clinical evaluation, to make a definitive diagnosis as to whether the hernia is direct, indirect, or femoral; primary or recurrent; or complicated or uncomplicated. The anatomic classification and the definitive diagnosis are made during the operative event. There are different classifications that take into account the pathophysiology of the hernia, the anatomical conditions of the ring, as well as the possible repair technique.

In hernia pathology, we find different types of hernias depending on the location, such as the inguino-crural, midline, incisional, and other special hernias.

Midline Hernias

Epigastric or Supraumbilical

These hernias are characterized by protrusion of preperitoneal fat and the peritoneum through the intermingling of aponeurotic fibers of the middle line, situated between the navel and the xiphoid. They account for between 1 and 4 % of the total number.

Umbilical

These hernias occur in the umbilical area. They are between 2 and 18 % of the total number. They are classified as type I or traditional and type II (secondary to laparotomy or laparoscopy). Within the first, we find the:

H. Umbilical H., small ring, which reduces
H. Umbilical voluminous
H. Umbilical cirrhotic

Infraumbilical

This kind of hernia is located between the navel and suprapubic area.

Yuxta or Paraumbilical

This hernia is topographically near the navel, but through a different hole in the linea alba.

Incisional Hernias

These hernias can be defined as any of the abdominal wall defects, with or without volume increase, in the area of a postoperative site, visible or palpable by clinical examination or imaging [2].

They can also be defined as a departure, accompanied by peritoneum or non-abdominal viscera, through an area or hole in the abdominal wall weakened by surgical or traumatic events and not through the natural orifices, from which emerge primarily ventral hernias. This pathology represents a failure in the reconstruction of the wall in abdominal surgery and reaches frequencies of presentation ranging between 23 and 11 % for patients undergoing general abdominal surgery when accompanied by infection of the operative wound [3].

In the era of laparoscopic surgery, the incidence of incisional hernia due to the holes of the trocars varies between 0.5 and 6 % in prospective studies and series with sufficient follow-up [4].

There are three important elements in all incisional hernias: ring, hole, or defect; the sac; and the contents. The *hole* of incisional hernias consists of muscle and/or aponeurotic edges retracted and invaded by fibrous tissue. The *sac* of the incisional hernia is formed by the separation of the largest muscle; many fibers that were uncemented or invaded by fibrous connective tissue will constitute the *sac* of incisional hernia and will quickly join the deep side of the skin scar to create the future “great bag.” From its inner side, the bag is shown with peritoneal aspect. The *contents* of the sac are variable, often being constituted of the omentum, small intestine, colon, etc., and this content can be reducible or irreducible; it can be incarcerated or strangulated, and evident data indicate that vascular suffering and/or necrosis, with the consequences that carry this complication, can occur.

Classification of Incisional Hernias of Jean Paul Chevrel [5]

This classification takes into account location, size, and previous recurrences.

Medial (M)

M1. Supraumbilical average
M2. Yuxtaumbilical
M3. Subumbilical
M4. Xifo-symphysis

Lateral (L)

L1. Subcostal
L2. Transverse
L3. Iliac
L4. Lumbar

Diameter of the Ring (W)

W1. Less than 5 cm
W2. Between 5 and 10 cm
W3. Between 10 and 15 cm
W4. Larger than 15 cm

Recurrences (R)

R. No recurrences
R1. 1st recurrence
R2. 2nd recurrence

Prior Repair

RA raffia
MP myoplasty
PR prosthesis

EHS Classification for Incisional Abdominal Wall

Following the classification by Chevrel, a new classification, modified from that of Chevrel, came into being. Its qualifying parameters are shown in Fig. 3.1.

According the Location

1. Vertical
   1.1. Midline supra- or infraumbilical
   1.2. Midline including navel (right or left)
   1.3. Paramedian (right or left)
2. Transverse infraumbilical
   2.1. Supra- or infraumbilical (right or left)
   2.2. Cross the midline or not
3. Oblique
   3.1. Supra- or infraumbilical (right or left)
4. Combined (midline mean + oblique, midline + paraostomal +, etc.)

EHS Incisional hernia classification		M	L	Recurrent incisional hernia?		Lenght cm	Weight cm	Width		
				Yes	No			W1 <4 cm	W2 4–10 cm	W3 >10 cm
Midline	M1 subxiphoidal									
	M2 epigastric									
	M3 umblical									
	M4 infraumbibcal									
	M5 suprapubic									
Lateral	L1 subcostal									
	L2 flank									
	L3 iliac									
	L4 lumbar									

Fig. 3.1 Template created for use in classifying incisional abdominal wall hernias (according to EHS classification) (Adapted with permission from Muysoms et al. [14])

According to Size

1. Small (<5 cm wide or long)
2. Medium (5–10 cm wide or long)
3. Large (>10 cm wide or long)

According to the Recurrence

1. Primary
2. Relapsed (1, 2, 3, etc. With the type of hernioplasties: suture, prosthesis, or both)

According to the Situation with the Ring

1. Reducible
2. Irreducible with or without obstruction

According to the Symptoms

1. Symptomatic
2. Asymptomatic

Other Hernias

Hernias of the abdominal wall of uncommon location can occur in less than 2 % of hernias. These are discussed in the sections that follow.

Lumbar Hernia

Lumbar hernias have been classified as:

1. Congenital: Grynfeltt when they appear in the upper triangle of the lumbar region and Petit when they appear in the lower triangle, comprising 10 % of lumbar hernias
2. Traumatic: with a rate of 25 %
3. Incisional: representing between 50 and 60 %, associated usually with lumbotomy-urological surgery and orthopedic surgery and large portions of iliac crest bone graft
4. Spontaneous: making up the remaining percentage and related to neurological disorders in the region [6]

Obturator Hernia

Obturator hernias are exceptional entities, and most surgeons will see very few throughout their careers. They consist of the protrusion of abdominal contents through the orifice shutter of the pelvis, preferably on the right side. They appear more frequently in older, thin, and multiparous women. The incidence is higher in Asian countries, so the older series are by Chinese and Japanese authors [7].

Spigelian Hernia

The Spigelian hernia is the most frequent of the rare hernias [8]. It is formed in the area of the Spiegel, the largest portion of the transverse and oblique minor muscles between the semilunar line (transition of muscle fibers to aponeurotics of the transverse muscle) and the lateral edge of the sheath of the rectum.

Parastomal Hernias

Parastomal hernias are incisional hernias associated with a stoma in the abdominal wall. Parastomal hernias are classified into four subtypes:

1. Subcutaneous type with a subcutaneous hernia sac
2. Interstitial type with a hernia sac within the muscle and the largest layers of the abdomen
3. Parastomal type with the bowel prolapsed through the circumferential hernia sac surrounding the stoma
4. Intrastomal type in ileostomies with a hernia sac between the intestinal wall and the intestinal layer everted

Perineal Hernias

Perineal hernias are the protrusion of abdominal viscera between the muscle and aponeurosis that form the floor of the pelvis. They are divided into primary, hernias that occur spontaneously, and secondary, hernias or perineal ruptures that occur after operations (prostatectomy, abdominopelvic amputation) that debilitate the pelvic floor.

Sciatic Hernia

These hernias are also called gluteal hernias. They are the major and minor protrusion through the sciatic holes. They are the least frequent of all the external abdominal hernias. They appear in both genders alike, usually in older people.

Classification of Inguinal Hernias

Hernias have historically been classified into three types: direct, indirect, and femoral (Figs. 3.2 and 3.3).

Indirect (lateral or external oblique) hernias are more common, comprising 2/3 of the total found in adult males. They develop through the deep inguinal orifice, with the hernia sac appearing in the anterior approach inside the cremasteric sheath and in the posterior or laparoscopic approach at the level of the deep inguinal ring, lateral to the epigastric vessels.

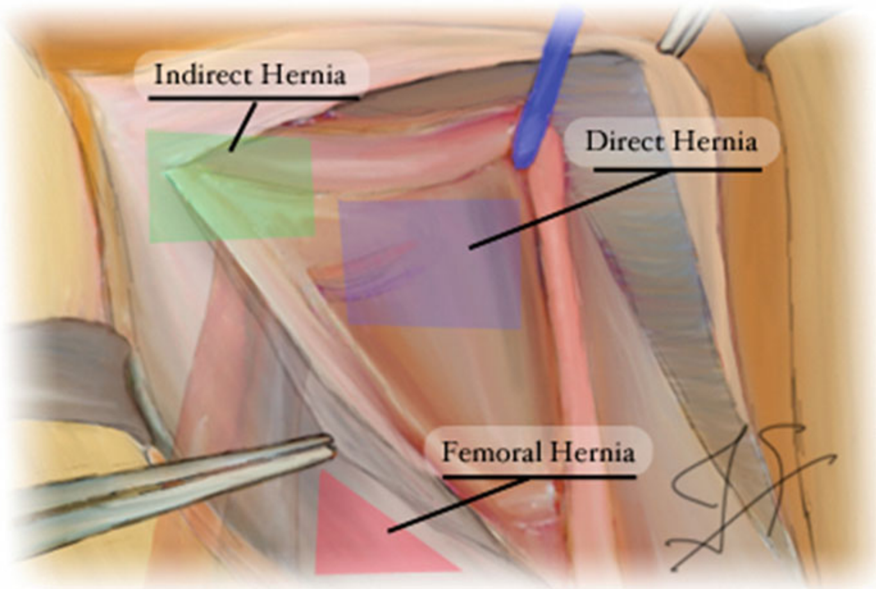

Fig. 3.2 Classification of indirect, direct, and femoral hernias (anterior approach)

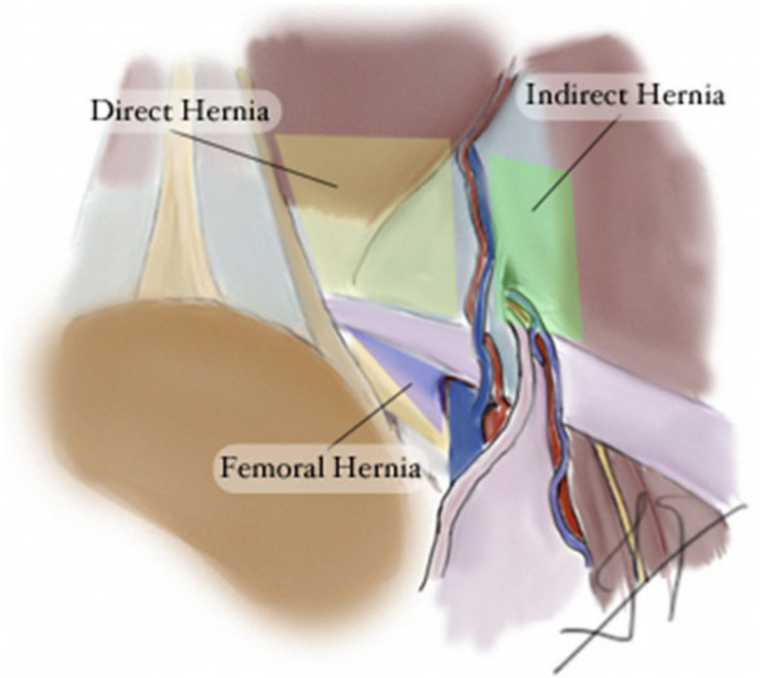

Fig. 3.3 Classification of indirect, direct, and femoral hernias (laparoscopic approach)

Direct (medial or internal oblique) hernias develop due to a defect in the transversalis fascia and can appear as a hernia with a well-defined orifice or as a disruption of the entire transversalis fascia. In the anterior approach, direct hernias appear medial to the spermatic cord and, in the posterior or laparoscopic approach, medial to the epigastric vessels.

Femoral (crural) hernias are much less frequent than inguinal hernias, appearing primarily in women. They develop through the femoral ring, medial to the femoral vein and below the iliopubic tract.

Knowledge of the pathophysiology of inguinal hernias has come to redefine the manner in which they are classified in order to adequately reflect the complexity of this disease.

In a disease as common as the inguinal hernia, the necessity of classification is shown to be more than obvious. An inguinal hernia classification should be concise and easily understandable and recognizable by any professional. Currently, thanks to the advances in laparoscopic surgery of inguinal hernias, applicability of a classification system to both open and laparoscopic approaches constitutes a crucial element for any classification of hernias.

The development of these classifications has allowed the standardization of criteria with regard to treatment and studies published in the scientific literature.

Table 3.1 Classifications of inguinal hernias

Harkins (1959)
Casten (1967)
Halverson and McVay (1970)
Lichtenstein (1987)
Gilbert (1988)
Nyhus (1993)
Gilbert modified by Rutkow and Robbins (1993)
Bendavid (1994)
Schumpelick-Aachen (1994)
Alexandre (1998)
European Hernia Society (2007)

Nevertheless, numerous classifications have been developed (Table 3.1) since the initial classification of inguinal hernias appeared, some of which are still in use, which only increases the necessity of standardization in order to improve the study and knowledge of inguinal hernias [9].

Next, we will present the classifications that are currently most commonly accepted: the Gilbert classification modified by Rutkow and Robbins and the classification created by the European Hernia Society (EHS).

Gilbert Classification

Gilbert classification was described in 1988 [10]. It analyzed intraoperative anatomical injuries by analyzing three items:

- Presence/absence of hernia sac
- Size of the deep inguinal ring
- Integrity of the transversalis fascia

By assessing these three elements, five types of hernias were described, of which types I, II, and III correspond to subtypes of indirect hernias, while types IV and V correspond to subtypes of direct hernias.

In 1993, Rutkow and Robbins expanded Gilbert classification to include pantaloon hernias (those with both direct and indirect components), such as femoral hernias [11].

This classification is as follows (Figs. 3.4 and 3.5):

- Type I: Indirect hernia, with a deep inguinal ring of normal diameter and an indirect hernia.
- Type II: Indirect hernia, with a deep inguinal ring smaller than 4 cm.
- Type III: Indirect hernia, with a deep inguinal ring larger than 4 cm; this kind of hernia is usually associated with a sliding component or scrotal extension and a usually deconstructed inguinal anatomy, including the displacement of the epigastric vessels.

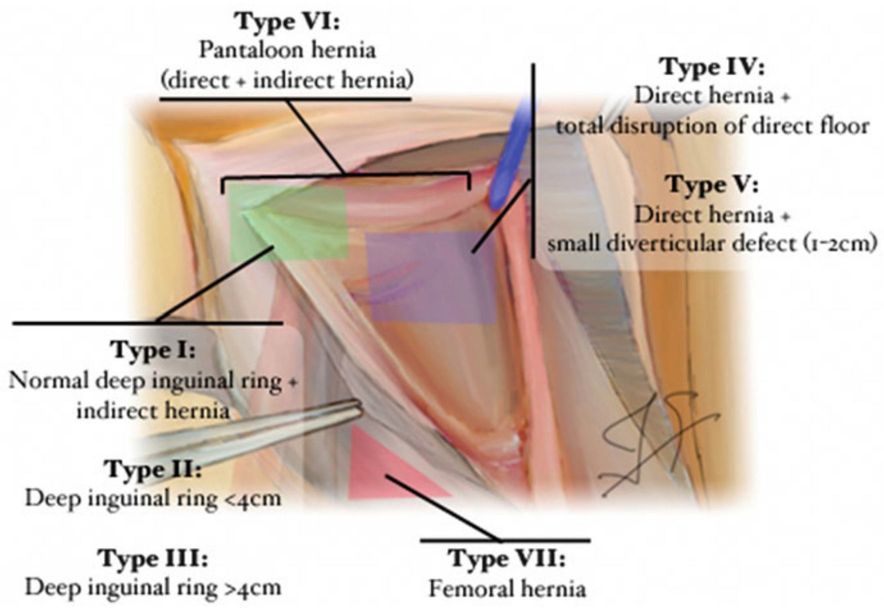

Fig. 3.4 Gilbert classification (anterior approach)

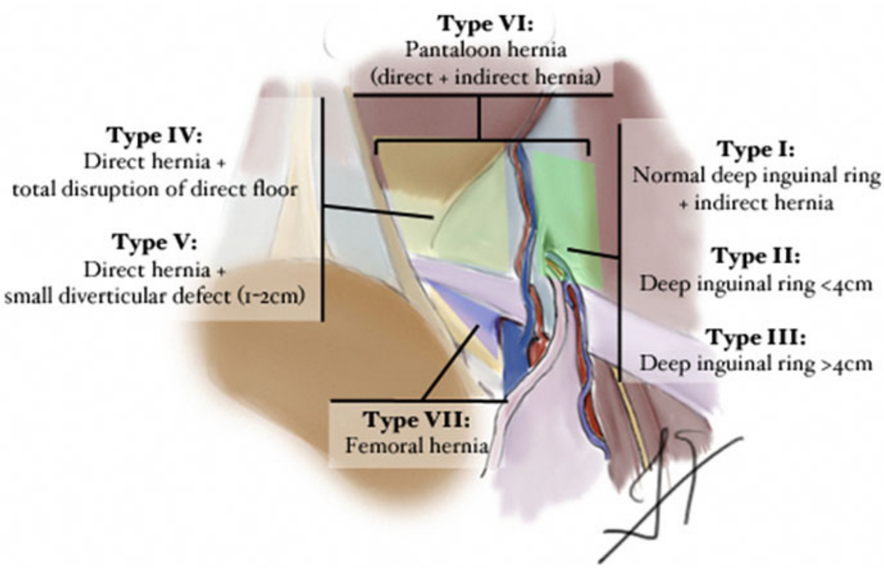

Fig. 3.5 Gilbert classification (laparoscopic approach)

- Type IV: Direct hernia, with a defect of the entire floor of the inguinal canal.
- Type V: Direct hernia, with saccular defect of 1–2 cm.
- Type VI: Hernias with direct + indirect components.
- Type VII: Femoral hernia.

EHS Classification

In recent years, the European Hernia Society (EHS) has proposed a classification that is simple and easy to memorize, with the aim of a systematic use in the daily surgical practice. See Figs. 3.6 and 3.7.

The EHS classification is based on the Aachen classification, proposed by Schumpelick in 1994, in which the hernias are classified according to the anatomic localization, such as the size of the hernia defect [12].

In the EHS classification [13], one evaluates the interoperative characteristics of every hernia, independently assessing:

- Anatomical location
- Size of the hernia defect

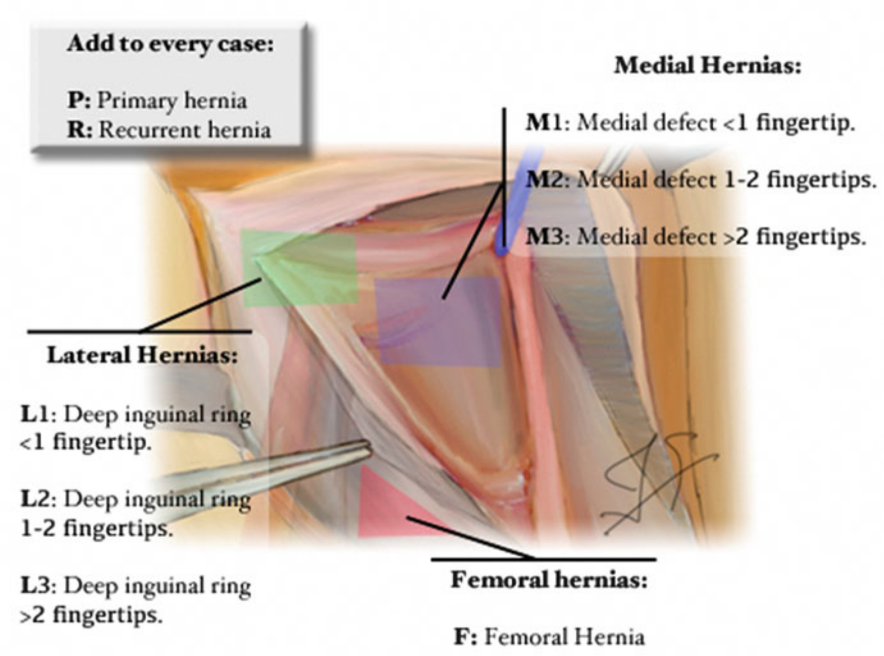

Fig. 3.6 EHS classification (open approach)

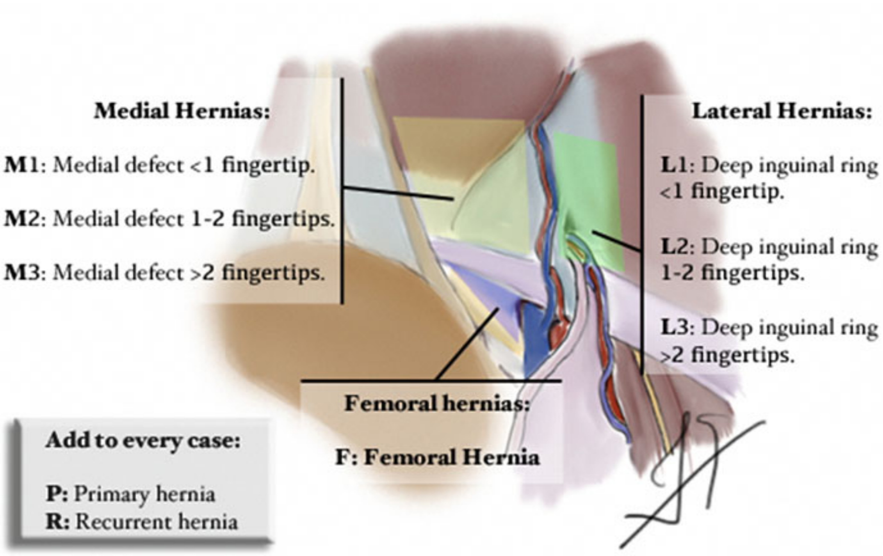

Fig. 3.7 EHS classification (laparoscopic approach)

The anatomical location is separated into three types: type M (medial or direct), type L (lateral or indirect), and type F (femoral or crural).

In the Aachen classification, different types of hernia defects were distinguished according to if they were smaller than 1.5 cm, from 1.5 to 3 cm, or larger than 3 cm.

To simplify the assessment of the hernia defect size, the EHS classification uses the size of the index finger (whose tip usually measures between 1.5 and 2 cm), and so hernia defects are usually classified as type 1 (smaller than or equal to a finger), type 2 (between one and two fingers), and type 3 (more than three fingers).

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Chapter 4
Basic Concepts in Laparoscopic Hernia Repair

Juan Antonio Martín Cartes, Juan Marín Morales, and Juan Manuel Suárez Grau

Abstract Laparoscopic surgery is the gold standard in multiple surgical fields. In abdominal wall surgery, it is becoming more frequently used, changing rapidly as one generation of surgeons who performed laparotomy incisions is replaced by another that tends towards the laparoscopic approach. One of the key steps is becoming more familiar with the laparoscopic technique, its instruments, and the basic principles of this procedure. Skills are very important as is knowledge about sectorization, triangulation, ergonomics, and the equipment needed to perform this type of surgery (optical, grasper, trocars, etc.).

Keywords Laparoscopy • Hernia • Hernioplasty • Mesh • Optic • Grasper • Trocar • Triangulation • Sectorization • Ergonomics

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Introduction

Although laparoscopy has a long history among general surgeons, it was used only as a diagnostic tool, usually in patients with recurrent abdominal pain of unknown cause. In the early 1970s, some gynecologists realized that the laparoscope could be used therapeutically. Therapeutic laparoscopy, now named minimally invasive surgery, began in the 1980s with the first laparoscopic cholecystectomy. After that, the range of laparoscopic procedures quickly expanded.

Basic Instruments in Laparoscopic Hernia Repair

Videoendoscopic, Light, and Insufflated System

- One or two monitors to obtain a perfect view of the intervention. The main surgeon and the instrumentist should see the intervention adequately with articulated monitors, which can change position according to the evolution of the surgical procedure.
- A system which creates and controls a correct pneumoperitoneum: pneumoflator (Fig. 4.1).
- A system that emits a light source. A fiber-optic light bundle. Illumination is provided by a high intensity but "cold" broadband light source.

Fig. 4.1 Pneumoflator

Fig. 4.2 Energy sources: LigaSure™ (*top*) (Courtesy of Covidien, Dublin, Ireland), UltraCision Harmonic (*center*) (Courtesy of Ethicon Endo-Surgery, Blue Ash, OH, USA), and Thunderbeat (*bottom*) (Courtesy of Olympus, Center Valley, PA, USA)

Energy Sources (Fig. 4.2)

- Electrosurgery to perform a cauterization of the structures. It could be by monopolar or bipolar electrode. Today, the best advance in electrosurgery is the LigaSure™ system (Covidien, Dublin, Ireland); it incorporates a microcomputer that allows correct vessel ligation according to the thickness of the structures.
- Ultrasonic energy (UltraCision Harmonic, Ethicon Endo-Surgery, Blue Ash, OH, USA): This makes a correct dissection by cavitation of the structures. It is able to perform a vessel ligation ultrasonically.

Fig. 4.3 Trocars (5 mm) and BTT trocar (Hasson)

Today, there are instruments that combine these two types of energies: Thunderbeat (Olympus, Center Valley, PA, USA), integration of ultrasonic and advanced bipolar energies delivered through a single multifunctional instrument, allowing a surgeon to simultaneously seal and cut vessels up to and including 7 mm in size with minimal thermal spread.

Trocars and Laparoscopic Dissecting and Grasping Instruments

Trocars (Fig. 4.3)

In ventral hernia repair, the most frequently used trocars are two 5 mm trocars and one 10–12 mm trocar. When the mesh is very large, it could be useful to have a 15 mm trocar.

In inguinal hernia repair, we use two 5 mm trocars and one 10–12 mm trocar. There are many variations, according to the two main types of surgeries:

- TAPP: 2 5 mm trocars and one 10 mm trocar, generally. But we can exchange the 10 mm trocar for a 5 mm trocar (optic) if we use a lightweight mesh, as it is able to handle a 5 mm trocar. We sometimes use a 3 mm trocar on the left side (for the nondominant hand) instead of the 5 mm trocar.

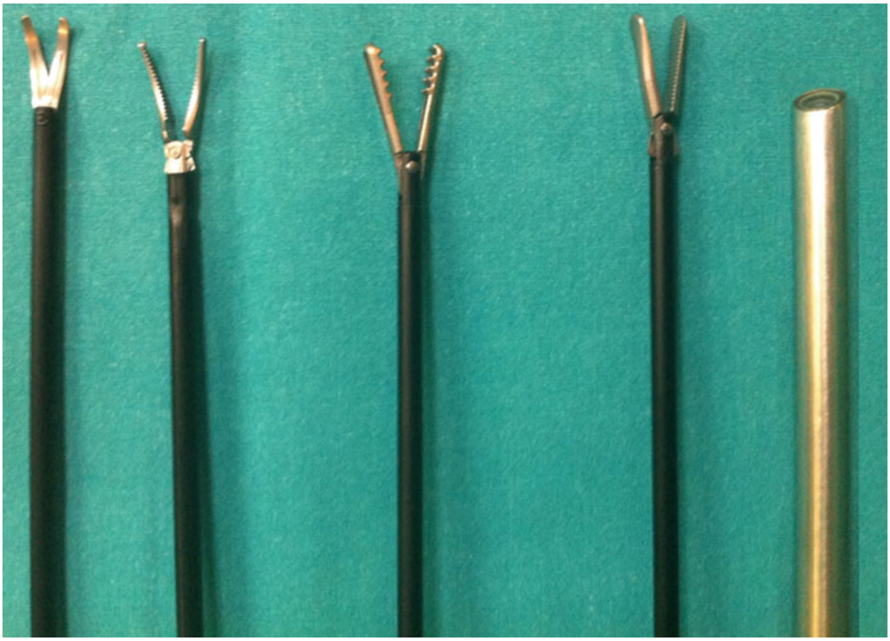

Fig. 4.4 Different styles of graspers, shears, dissectors, and 30° optic in laparoscopy

- TEP: 2 5 mm trocars and two special trocars: BTT and PDB.

There is a device that combines the two special trocars into one: spacemaker, which allows the balloon dissection of the preperitoneal space (usually created by the PDB) and fixes the fascia with a miniballoon in order to maintain that newly created preperitoneal cavity (usually performed by the BTT).

Instruments

- Endograspers (Endo Clinch™ and Endo Grasp™, Covidien, Dublin, Ireland), endoshears, and endodissectors are the main instruments in laparoscopic hernia repair. See Fig. 4.4.
- Other instruments such as an endohook, the Endoloop® (Ethicon Endo-Surgery, Blue Ash, OH, USA), or the Endo Stitch™ (Covidien, Dublin, Ireland) could be used according to the characteristics of the hernia surgery. In single-port surgery, we use roticulator instruments such as the roticulator-endodissector.

Optics

- 5 mm optic: With inclined end, to offer 30°, or normal end that offers 0°
- 10 mm optic: 30° or 0°

Fig. 4.5 (**a**, **b**) Basic instruments in laparoscopic hernia repair

- Other optics: 3 mm optic 0° (its use is rare), roticulator optics in robotic and single-port surgery

  See Fig. 4.5 a, b for the basic instruments used in laparoscopic hernia repair.

Role of Triangulation Techniques and Ergonomics in Laparoscopic Surgery

There is no uniform consensus regarding port placement for advanced laparoscopic procedures. The placement of ports is currently dictated by the surgeon's preference based on individual experience. To facilitate smooth instrument manipulation along

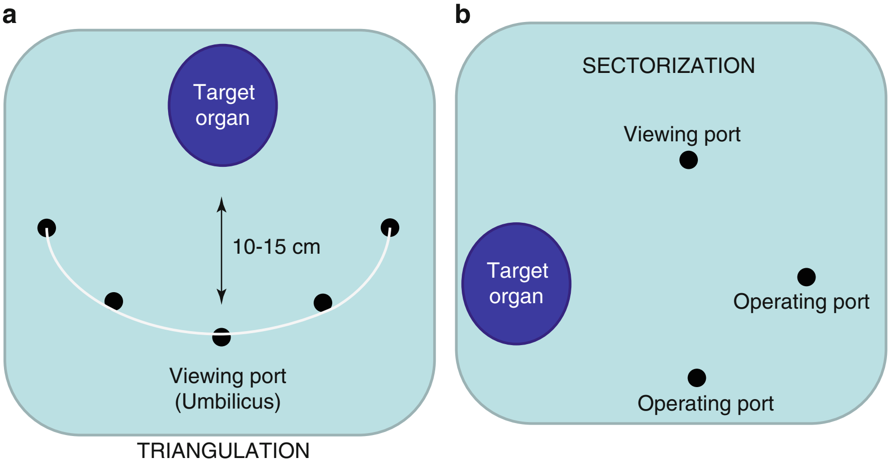

Fig. 4.6 (**a**, **b**) Triangulation (**a**) and sectorization (**b**) in laparoscopy

with adequate visualization during laparoscopy, trocars usually are placed in triangular fashion. This is termed triangulation. See Fig. 4.6a.

The target organ should be 15–20 cm from the central port used for placing the optical trocar [1]. Generally, the two remaining trocars are placed in the same 15–20 cm arc at 5–7 cm on either side of the optical trocar [2]. This allows the instrument to work at 60°–90° angles with the target tissue and to avoid problems of long handles due to port placement that is too distant or too close; it also avoids the problem of abdominal wall interference. If necessary, two more retracting ports can be placed in the same arc but more laterally so that instruments do not clash.

When the optical trocar is placed as one of the lateral port trocars, it is called sectorization. See Fig. 4.6b. Sectoring of instruments should be avoided by beginners since it requires a greater degree of understanding of laparoscopic views and significantly different one-eye coordination.

More specifically, there are ergonomic issues that are unique to laparoscopic hernia repair, such as the strain of working against the camera (mirror-image effect) and the complex movements required to repair hernia defects from underneath the anterior abdominal wall during ventral hernioplasty. The attention to the current operative environment and the selection of appropriate available instrumentation may improve operative efficiency and protect the health of the surgeon.

The etiology of the ergonomic problem in laparoscopy is multifactorial. Consideration should be given to instrumentation, image quality, the positioning of the patient, the surgical staff, and the equipment. Within the current ergonomic constraints of laparoscopy, changes can and should be made to increase the comfort of the surgeon and reduce muscular fatigue. Instrumentation should be selected not only for function but also for ease of use and proper individual surgical fit.

The operating table should be positioned so that the instrument handles are at the surgeon's elbow level [3]. Similarly, the video monitor should be positioned at or slightly above eye level. Suspended mobile monitors may facilitate this adjustment. The monitor should be in alignment with the operative target and the surgeon. Foot pedals that control energy sources should be placed within a small radius from the surgeon's feet to avoid stiffening and straining to maintain balance. Patient position is also crucial. The patient should be positioned to allow gravity to assist with operative exposure, reducing the exertion needed from the surgeon and assistants for retraction.

The patient's arms should be tucked during ventral herniorrhaphy to provide freedom of movement by the surgeon and assistants around the operating table. Attention to these details in positioning and operative setup should greatly improve operative efficiency.

Incisional Ventral Hernia

It was in 1991 that the first laparoscopic approach in the repair of incisional hernia was reported. Since that time, there has been a steady acceptance of this procedure because of the improvement in the recovery of the patient, the decreased rates in wound complications and mesh infections, and the notable decline in the recurrence rate compared with that of the open technique. In general, all the significant steps of the two different approaches are similar. The laparoscopic approach may be more suitable for straightforward hernias, with open repair reserved for the more complex hernias. Laparoscopic ventral hernia repair appears to be an acceptable alternative that can be offered by surgeons proficient in advanced laparoscopic techniques [4]. See Fig. 4.7.

Inguinal Hernia

With respect to inguinal hernia, we want to point out that since Bassini in the late nineteenth century, there was no area of surgery more controversial than the surgical repair of groin hernias. The search for the best way to repair this condition has produced a vast number of solutions. In the early 1990s, laparoscopic approach for inguinal hernia repair was introduced; as a result, the transabdominal preperitoneal approach (TAPP) and the totally extraperitoneal (TEP) became widely accepted. See Fig. 4.8.

Both the TAPP and the TEP approaches use the basic principle of placing a piece of mesh in the preperitoneal space as described by Stoppa. The optimal repair has been assessed by random controlled trials (RCT) and population-based studies.

With TAPP, the surgeon goes into the peritoneal cavity and places a mesh through a peritoneal incision over possible hernia sites. TEP is different in that the peritoneal cavity is not entered and mesh is used to seal the hernia from outside the peritoneum (the thin membrane covering the organs in the abdomen). This approach is

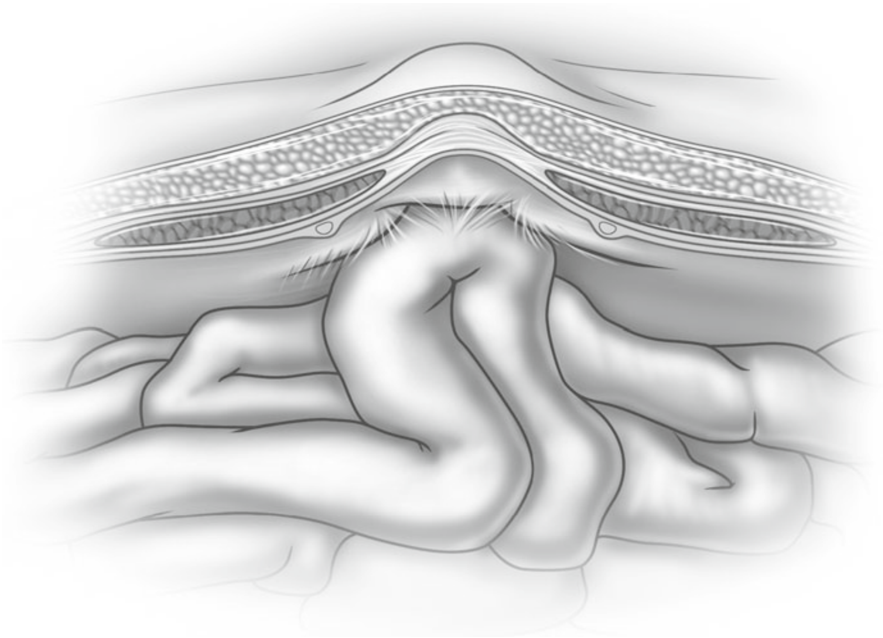

Fig. 4.7 Ventral hernia

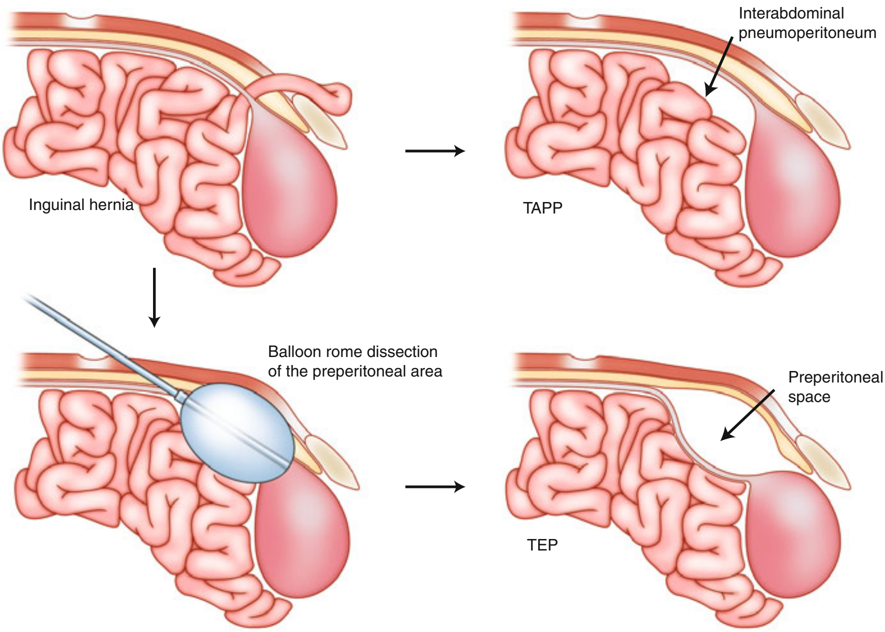

Fig. 4.8 Techniques in laparoscopic inguinal hernia repair

considered to be more difficult than TAPP but may have fewer complications. In both these repairs, the mesh is in direct contact with the fascia of the transversalis muscle in the preperitoneal space, allowing tissue ingrowth which leads to the fixation of the mesh. The surgeon's skill should determine the method used. There is no "best" form of hernia repair: it should be tailored to the nature of hernia, patient characteristics, and the preference of the surgeon and the patient

The advantages and disadvantages of TEP are the following: dissection is easy, anatomical landmarks are difficult to find, peritoneal tear may lead to conversion, and less of a chance of bowel injuries and intraperitoneal adhesions.

The pros and cons of TAPP are the following: anatomical landmarks are easily found, wide dissection is more challenging, the peritoneum can be divided and eventually closed, and it minimizes the risk of peritoneal adhesions.

Based on what we have learned from evidence and practice, the selective use of laparoscopic repair of inguinal hernias depends on the balance of costs, benefits, and risks. Laparoscopic repair is associated with less acute pain and faster recovery. Furthermore, available data suggest less chronic long-term pain after laparoscopic repair. In female patients, laparoscopic repair is the recommended method. Laparoscopic repair is preferred in patients with a previous open repair, while patients with recurrence after laparoscopic repair should undergo open mesh repair. Surgical services should review their current practice and adopt laparoscopic hernia surgery with appropriate training. This procedure at the present time can be indicated in incisional hernia, in bilateral hernia, in reproduced hernia, and in the obese patient (recommendation grade B).

Prosthetic Biomaterial to Repair the Incisional Hernia

Incisional Ventral Hernia

At present, there are several different products that are designed to be used specifically for this procedure [5]. In the vast majority of clinical centers, this procedure is performed entirely in the intraperitoneal position. Because of this, the biomaterial will contact the intestinal contents. The original description of this procedure used an early form of expanded polytetrafluoroethylene (e-PTFE). The use of this biomaterial is preferred in the majority of published series because it is much less prone to the development of adhesions.

Dualmesh® (W.L. Gore & Associates, Newark, DE, USA) products have been hailed as a successful advance; all those products are single components that have a rough surface and a visceral one (parietal and visceral).

The Dualmesh products are impregnated with silver carbonate and chlorhexidine diacetate, which act to inhibit microbial colonization of the device for up to 14 days post-implantation and resist initial biofilm formation. The silver in the product turns it to a brown color so that it can reduce the glare of the prosthesis when used laparoscopically.

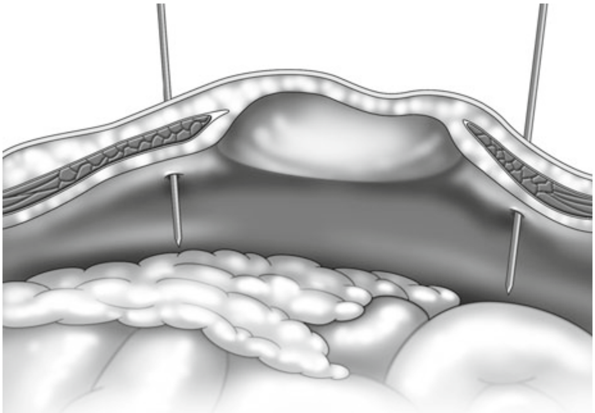

Fig. 4.9 Needles to identify the margins of the hernia

Recently, other, newer biomaterials such as Composix™ and Composix™ EX (both: Davol, Warwick, RI, USA) combine two different products into a two-layer prosthesis. Both have a polypropylene mesh (PPL) attached to a layer of e-PTFE.

Parietex™ and Parietene™ (both: Covidien, Dublin, Ireland) combine polyester and polypropylene materials in an attempt to prevent the development of peritoneal adhesions to the prosthesis.

There have been reports of pain and peritoneal adhesions that are quite significant with the use of those materials. Moreover, some authors reported that the use of e-PTFE over PPL does not appear to be protective against adhesions.

Biomaterials based on collagen matrix are the newest used for surgical hernia management. They are based on the noncellular collagen of either the porcine small intestinal submucosa or porcine dermal collagen or human cadaver dermis. Those biomaterials are penetrated and replaced by the native collagen of the patient so that a new fascial area will be created.

Overlapping the prosthesis is a very important aspect of this surgical technique; we have to consider that the prosthesis usually can shrink, so the recommendation is to leave an overlap ring of about 5 cm around it.

In the last few years, more and more prostheses have become commercially available, but the problem of large hernias and peritoneal adhesions is still an issue.

Double-Crown Technique in Ventral Hernia

Once the adhesiolysis process is completed, we proceed to identify the defect and the sac. The hernia defect must be delineated by marking the margins of the hernia (not the sac) on the skin of the patient. We insert an intramuscular needle through the skin and abdominal wall. The tip of the needle is visualized inside the abdominal cavity under laparoscopic vision to detect and trace the hernia defect on the patient's skin. See Fig. 4.9.

An exact measurement of the defect is determined when the abdomen is fully desufflated. The patch is then chosen to provide an overlap of at least 5 cm. Once the mesh is selected, several marks or sutures are traced on the mesh, and similar

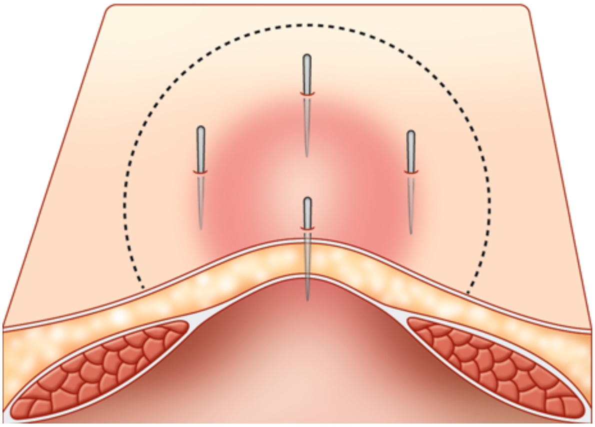

Fig. 4.10 Needles in the margins of the hernia and skin marked with the 5 cm overlap to determine the size of the mesh

marks are traced on the patient's skin in order to facilitate orientation of the prosthesis within the cavity. See Fig. 4.10.

Afterwards, we roll the mesh along its long axis. This will make it easier to perform the maneuvers needed to expand the mesh once attachment has begun. We introduce the mesh through one of the trocars to prevent potential contamination, which may occur if it is inserted through the skin.

After having put the mesh inside the cavity and unrolled it properly, it must be oriented by using the marks previously drawn or the sutures on the mesh. The corresponding area of the abdominal wall where the mesh is to be fixed is located by pushing on the abdominal wall at that site. We usually insert a needle at the level of the circle on the abdomen in order to locate the area where the first tack should be placed. When this tack is placed, we stretch the mesh in the caudal direction and perform the same maneuver, placing the second tack. A variation of the technique consists of hanging the mesh from the four cardinal points with transfascial sutures. Afterwards, we place the outer crown. The transmural sutures are cut and removed before we place the inner crown.

Once the mesh is fixed from the four cardinal points, we extend it adequately, adding an outer crown of tacks that is placed directly on the margin of the mesh.

The tackers are separated from each other by a distance of 1–2 cm, which is adequate to ensure that the intestinal loops do not slip between the tacks resulting in an acute incarceration.

Once the outer crown is finished, we add the inner crown of tacks. A needle can be introduced at this level, so that we can identify the area where the inner crown of tacks should be placed.

Inguinal Hernia

Open hernioplasty refers to insertion of a prosthetic mesh (e.g., polypropylene) to cover and support the posterior wall of the inguinal canal. The mesh is cut to size, with two limbs encircling the cord at the deep ring, and is then sutured to the posterior wall behind the cord. Alternatively, the mesh can be inserted via an extraperitoneal approach and placed deep into the defect in the posterior wall.

Laparoscopic repair is performed under general anesthesia, using either a transperitoneal or extraperitoneal approach [6, 7]. The technique is not appropriate for large or irreductible hernias. The sac is separated from the spermatic cord and excised, and a mesh is inserted to strengthen the posterior wall, with or without a small plug of synthetic material being inserted into the deep ring. Advantages of laparoscopic hernia repair include reduced postoperative pain and earlier return to work. Disadvantages include increased risk of femoral nerve and spermatic cord damage, risk of developing intraperitoneal adhesions with the transperitoneal procedure, and greater cost and duration than the other operation. Initial experience indicates that recurrence rates are similar to those associated with open operations.

Fixation of the Biomaterial

Ventral Hernia

Mesh should be appropriately fixed either with sutures, staplers, or tackers to prevent contraction and/or migration of the mesh. To fix it, we can use absorbable or nonabsorbable tacks or glues.

This is a frequent controversial area referred to in laparoscopic incisional ventral hernia. In the early 1990s, the majority of the published reports employed the use of transfascial sutures that could be associated to different types of metal fixation.

Transfascial stitches, despite having been preferred for a long time, have not demonstrated better results than tackers in reported series that have long-term follow-up.

In our center, we have used tacks in a "double-crown" technique for quite some time without association with transfascial stitches, and we are very satisfied with this technique. We want to emphasize that it is incumbent upon the surgeon to use the method that works best for him/her.

Inguinal Hernia

The debate whether or not to employ fixation is focused on two main issues: does lack of fixation lead to higher recurrence rates and does use of fixation lead to increased rates of chronic pain and neuralgias? Mesh fixation and nonfixation both have similar low recurrence rates in TAPP and TEP. Not fixing the mesh has less or similar incidence of chronic pain.

A secondary issue is related to cost: if fixation is eliminated, the cost of the procedure is reduced. Proponents of mesh fixation are concerned about mesh migration, rolling, or shrinking, leading to hernia recurrence. Tissue adhesives such as fibrin sealants may be used to fix the mesh.

Complications

Minor postoperative problems occur. More serious complications such as damage to the spermatic cord, nerve or major vascular injuries, bowel obstruction, and bladder injury have been reported with laparoscopic repair. Recurrence of a hernia is a major drawback.

Postoperative Seroma

The appearance of a seroma after undergoing a laparoscopic hernia repair is so common that many surgeons do not consider it a real complication. It should be expected due to the fact that the peritoneal sac is not removed. These can be managed expectantly in most cases [8].

Summary

Laparoscopic incisional ventral hernia repair is a feasible technique, but patient selection is very important. Currently, it requires intraperitoneal prosthetic material as a patch. Hernias up to 2 cm in diameter should not be undertaken with this approach nor should a multirecurrent incisional hernia in a patient having well-known or suspected severe intraperitoneal adhesions. As with other laparoscopic procedures, we need good patient selection, honest knowledge of the surgeon's laparoscopic skills, and the attitude that conversion to open repair is not a failure. Laparoscopic repair of ventral hernias is also an effective modality for recurrent hernias that have been repaired anteriorly (open).

Laparoscopic inguinal hernia repair is clearly indicated for bilateral and/or recurrent inguinal hernias and should be offered to select unilateral primary inguinal hernia patients because the pain and the recurrences, in an expert's hands, are minor.

In patients without previous preperitoneal dissection, the totally extraperitoneal (TEP) approach is the best choice due to avoidance of the peritoneal cavity and the resultant potential for fewer major complications. However, we should not be hesitant to employ the transabdominal preperitoneal (TAPP) repair for TEP difficulties requiring conversion or when previous preperitoneal dissection is present.

A large piece of mesh should be used with adequate fixation to minimize both chronic pain and recurrence.

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Chapter 5
Laparoscopic Inguinal Hernia Repair: TAPP

Juan Manuel Suárez Grau and Isaías Alarcón del Agua

Abstract Two laparoscopic techniques for laparoscopic inguinal hernia repair are used currently: a totally extraperitoneal technique (TEP) and a transabdominal preperitoneal technique (TAPP). In TAPP, the peritoneum is incised to gain access to the preperitoneal space, and similar surgical steps are performed in both techniques: hernia content reduction, treatment of hernial sac, and placement of preperitoneal mesh. Nowadays, it is accepted that TEP is preferred over TAPP because the TEP technique has a lower rate of trocar-site hernias and intra-abdominal injuries. However, TEP is a more demanding and complex technique, with a higher learning curve. For laparoscopic inguinal hernia repair, the TAPP intervention should be learned as a first step. TEP has a steeper learning curve, and after mastering TEP, performing TAPP will come easily.

Keywords Laparoscopy • Hernia • Hernioplasty • Mesh • Inguinal • TAPP • TEP • Fixation

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Introduction

There are currently two laparoscopic techniques for inguinal hernia repair: a totally extraperitoneal technique (TEP) and a transabdominal preperitoneal technique (TAPP). Both techniques access the same preperitoneal space, after opening of the parietal peritoneum and performing similar surgical steps common to both techniques: reduction of hernial content, treatment of the hernial sac, and placement of a preperitoneal mesh.

It is now generally accepted by the international surgical community that TEP is preferred to TAPP, as the latter is associated with a greater index of trocar hernias and intra-abdominal injuries (Evidence Level 2A) [1]. However, TEP is a more demanding and complex technique, with a steeper learning curve than TAPP.

Indications

The most widely accepted indications for laparoscopic hernia repair are [1–5]:

- *Bilateral inguinal hernias*: For every patient with a bilateral inguinal hernia, the laparoscopic approach is the most recommended choice, regardless of whether or not there are contraindications to general anesthesia, since it involves less surgical aggression resulting in an early return to normal activities (Evidence Level 1A) and both hernia defects are able to be treated/corrected through the same three trocar incisions.
- *Recurrent inguinal hernia*: The optimal surgical approach for a recurrent hernia depends on the previous hernia repair technique. In the cases of a conventional open approach, an endoscopic repair would be the best option, as the recurrent hernia would be repaired from a different plane, therefore avoiding fibrosis and adhesions related to the previous surgery (level of recommendation A). If the patient has a previously implanted mesh, this will cause a preperitoneal fibrosis which will impede the preparation of sufficient working space in order to reduce the sac and place the mesh correctly using the TEP technique. For this reason, the transabdominal approach is recommended to be used with these patients, since it provides us with better exposure of the operating field, makes it easier to free preperitoneal adhesions, and will minimize the high risk of tearing the peritoneum and the subsequent pneumoperitoneum.
- *Inguinal hernia in women*: It has been proven that after open surgery for an inguinal hernia in women, there is an increased risk of femoral hernia, due to the presence of an inadvertent femoral hernia during surgery or after surgery. Therefore, in order to avoid this complication, a laparoscopic approach is recommended, as the femoral ring is covered with the preperitoneal mesh.
- *Unilateral hernia in active patients and sportsmen*: In both of these groups, an early return to normal activities is extremely important, and laparoscopic

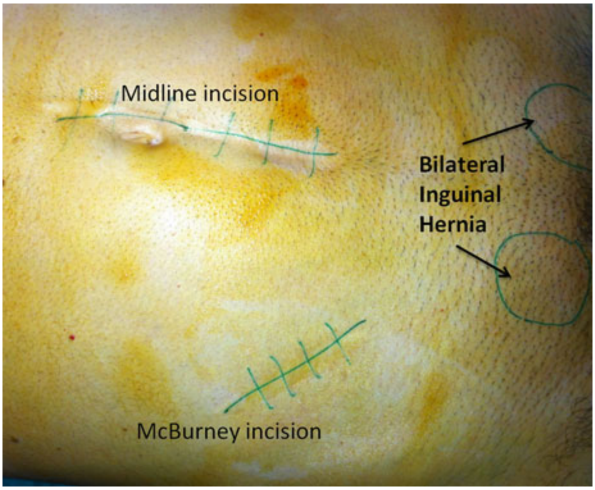


Fig. 5.1 Infraumbilical midline surgery

inguinal hernia repair provides earlier physical recovery compared to conventional open approach (Evidence Level 1A) [5].

The TAPP approach should also be considered in the following cases [3, 5]:

- *Patient characteristics*
  - Concomitant surgery: The laparoscopic transabdominal approach is preferred when the patient is suitable for such an approach and has an inguinal hernia.
  - Previous infraumbilical midline surgery: In these patients, the preperitoneal adhesions increase the technical difficulties when using the TEP approach; therefore, the TAPP approach would be more recommendable. In previous McBurney incisions, we can perform a TEP or TAPP approach depending on the surgeon's preferences, since the adhesions are easily detached when using both techniques. See Fig. 5.1.
  - Massive tear of the peritoneum during TEP: A change to TAPP is highly recommended.
  - Chronic inguinodynia: In those patients suffering from chronic inguinal pain, once osteomuscular and neuropathic etiologies have been discarded by imaging and physiological testing, a TAPP procedure should be performed if suspicion of an inguinal hernia exists.

- *Hernia-related factors*
  - Inguinoscrotal hernia: In patients with large inguinoscrotal hernias, the TAPP approach facilitates the reduction of hernia content and aids treatment of the hernia sac mesh placement.
  - Obesity: Fatty tissue in the abdominal wall in obese patients negatively interferes with the placement and maintenance of the pneumoperitoneum in the preperitoneal space due to the increased weight of the abdominal wall. Due to this, the TAPP approach is the most recommended for obese patients.

Contraindications

Absolute Contraindications

During the last few years, some absolute contraindications have switched to relative contraindications or have even switched to indications. This is due to surgeons' increased laparoscopic experience [4, 5]:

- The laparoscopic repair approach (TAPP) for an inguinal hernia requires a general anesthetic; therefore, patients with an anesthetic risk IV according to the ASA classification are not suitable, and these patients are candidates for a conventional open repair.
- Coagulation defects.

Relative Contraindications

- Strangulated hernia: The suspicion of hernia strangulated with constricting blood vessels and a difficult reduction of an incarcerated hernia are relative contraindications, as satisfactory results have been reported in such kinds of hernias.
- Young patients: Laparoscopic repair with a systematic use of mesh and general anesthesia in young patients is still under debate. For that reason, TAPP is not recommended in patients under the age of 18.

Surgical Technique

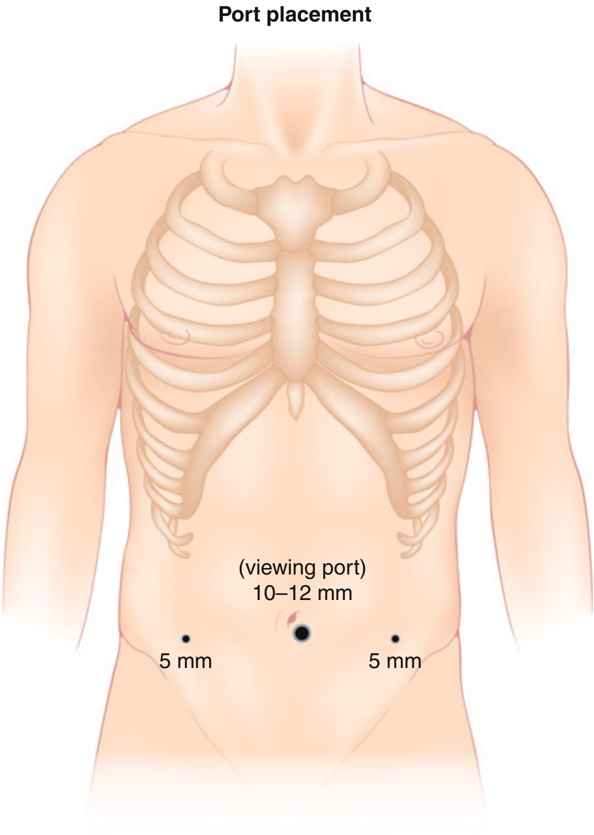
Position of the Patient

The patient is positioned in the supine position with both arms next to the body. A table is positioned in the reverse Trendelenburg position in order to push back the small bowel out of the surgical field. A bladder catheter is inserted, and the surgeon stands on the contralateral side to the hernia being treated.

Trocar Position

Once the pneumoperitoneum is established, a 10 mm trocar is placed slightly above the umbilicus. Both 5 mm trocars are placed on both sides of the umbilicus at the medioclavicular lines (Fig. 5.2). In unilateral hernias, an ipsilateral trocar is moved cranially and the contralateral caudally in order to facilitate surgical maneuvers.

Fig. 5.2 Port placement



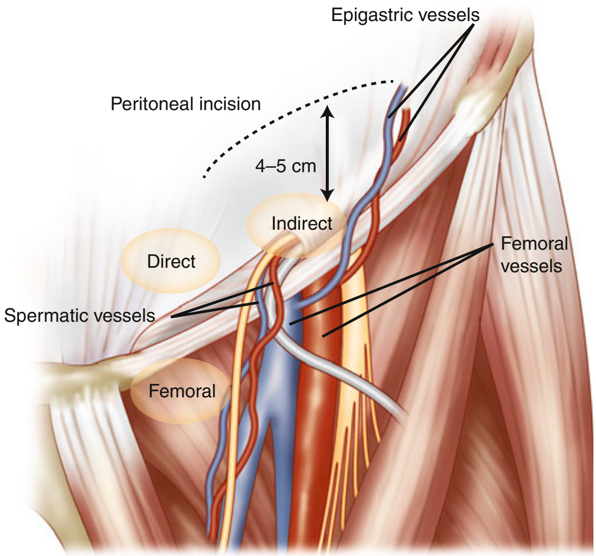
Recommended Instruments

- A 30° endoscope (10 mm or 5 mm)
- One 10 mm trocar and two 5 mm trocars
- Two endo-graspers, one endo-dissector, and one pair of endo-shears
- Polypropylene mesh (minimum size of 10 × 15 cm, preformatted or not)
- Mesh fixation: traumatic (tackers) or atraumatic (biological glues)

Operative Technique

After the creation of the pneumoperitoneum and the trocars are in place, a 30° scope is passed through the 10 mm trocar, the endo-grasper is placed through the 5 mm left-hand trocar, and the endo-shears are placed through the right-hand trocar. The

Fig. 5.3 Peritoneal incision



peritoneal cavity of the abdomen is explored. Indirect hernias will be observed laterally to the epigastric vessels and indirect hernias medially to them. The hernia content is gently reduced, and the hernia repair begins by following the next steps:

1. *Peritoneal incision*: A horizontal incision of the peritoneum is carried out, 5 cm above the inner inguinal ring, from the anterior superior iliac spine and leading to the paraumbilical ligament. See Fig. 5.3.
2. *Creation of the preperitoneal space*: Dissection of the preperitoneal space, Retzius and Bogros spaces, with identification of anatomical landmarks: epigastric vessels, symphysis, Cooper's ligament, and iliopubic tract. Laterally, psoas muscle and the femoral cutaneous nerve are observed.
3. *Hernia sac reduction*: In cases of direct hernias, the hernia sac is easily reduced with gentle traction caudally; the hernia defect is noted medially above Cooper's ligament. In cases of indirect hernias, the sac is a continuation of the spermatic cord. The separation of these structures (spermatic vessels and vas deferens) from the sac is mandatory. The vas deferens, a pearly white color, and the gonadal vessels are easily identified in order to try to completely reduce this using traction and contra-traction maneuvers. In cases of large indirect hernias, the sac can be divided with an ENDOLOOP suture. Once the sac is reduced, the preperitoneal space is completely dissected out by performing a parietalization of the cord with the aim of facilitating the proper placement of the mesh.
4. *Mesh introduction and extension*: Many meshes have been designed to be used for laparoscopic inguinal hernia repair. Polypropylene is the main polymer used in the manufacture of meshes. Flat or preformed (anatomical) meshes can be used. As to the size of the prosthesis, a minimum size of 10×5 cm is recommended (Grade D) in order to diminish recurrence rates. The mesh is introduced through a 10 mm trocar and completely extended in the preperitoneal space,

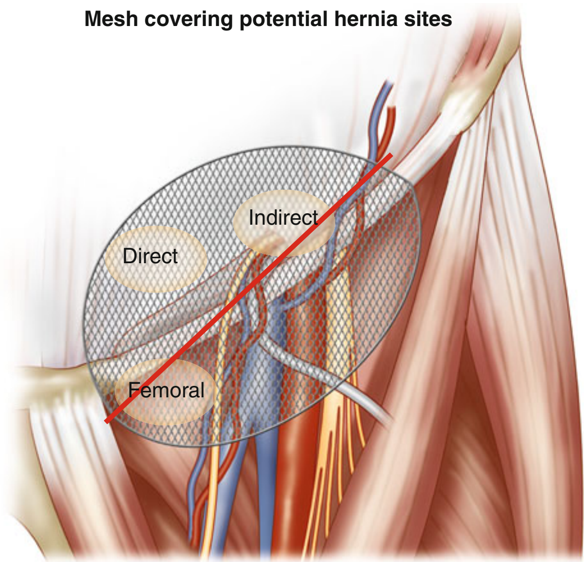


Fig. 5.4 Extended mesh covering potential hernia sites

widely covering Cooper's ligament and three potential hernia sites: the direct, indirect, and femoral rings. See Fig. 5.4.

5. *Mesh fixation*: The number of fixation points using helicoidal sutures has decreased over the last few years, from multiple points to just 1 or 2 tackers to Cooper's ligament, thereby avoiding postoperative pain without increasing recurrence rates. Equivalent results have been published for using non-traumatic fixation of the mesh with fibrin glue. In addition, there are new auto-adhesive meshes which have been developed where no fixation is needed since it is included in the mesh itself [6–8].
6. *The peritoneum is closed* over the mesh using a running suture or helicoidal tackers. Nowadays, new self-gripping sutures are used for the peritoneal closure. This kind of new suture facilitates the completion of the TAPP intervention.
7. *Abdominal wall closure*: Fascial closure of 10 mm trocar.

Potential Complications and Their Prevention

Intraoperative Complications

This includes all complications related to general anesthesia and the establishment of the pneumoperitoneum. As far as surgical complications are concerned, bleeding is not common and is mainly related to epigastric or gonadal vessel injuries. Electrocautery and/or clips are used to control this bleeding. In order to avoid this, it is necessary to implement gentle handling during traction and contra-traction and to correctly identify all the different structures.

Bladder injury is a very rare complication in the TAPP procedure (0.65 % vs. 0.17 % in the TEP procedure). It is recommended to empty the bladder preoperatively in order to avoid injury, and during the operation a Foley catheter to decompress the bladder is recommended. In the case of a bladder injury appearing, running sutures of the defect and placement of a bladder catheter for 2–3 weeks are mandatory [5, 6].

Postoperative Complications

The most common postoperative complications of the TAPP approach are hematoma, seroma, chronic pain, and recurrence:

1. *Hematoma*: The presence of postoperative hematoma ranges from 4.2 to 13.1 % according to the different published studies carried out. Usually, the hematomas are small and just require conservative management. Large hematomas which are under tension produce pain, and their evacuation is recommended [5].
2. *Seroma*: This appears in 5 % of patients, above all in direct hernias. It consists of a non-painful swelling which appears 4–5 days after the operation, starting with tender consistency and then turning harder later. Its position does not change with movement, and it disappears 6–8 weeks after the operation. Puncture of the seroma is not recommended due to the high risk of infection. Good results have been published on reducing the fascia transversalis and fixation to Cooper's ligament; using an ENDOLOOP suture reduces the risk of seroma formation [5, 7].
3. *Chronic pain*: Injuries or entrapment of the genitofemoral and femoral cutaneous nerves is possible (with helicoidal tackers or mesh fibrosis). In order to avoid this complication, we recommend not placing tackers close to the iliopubic tract or using atraumatic fixation such as fibrin glue and lightweight meshes. The triangle of pain must be left without sutures or tackers [6–8]. See Fig. 5.5.
4. *Recurrence*: Long-term recurrence with TAPP is similar to TEP and open surgery, ranging between 0 and 2 %. In order to achieve the best short- and long-term results, we must tailor each case depending on the patient and hernia being treated and by choosing accordingly the type of mesh and fixation method [9, 10].

Controversies

Nowadays, controversies regarding transabdominal laparoscopic hernioplasty can be put into two groups.

Mesh Selection

The new generation of lightweight macroporous meshes seems to have better functional outcome than heavy or normal weight microporous meshes. The

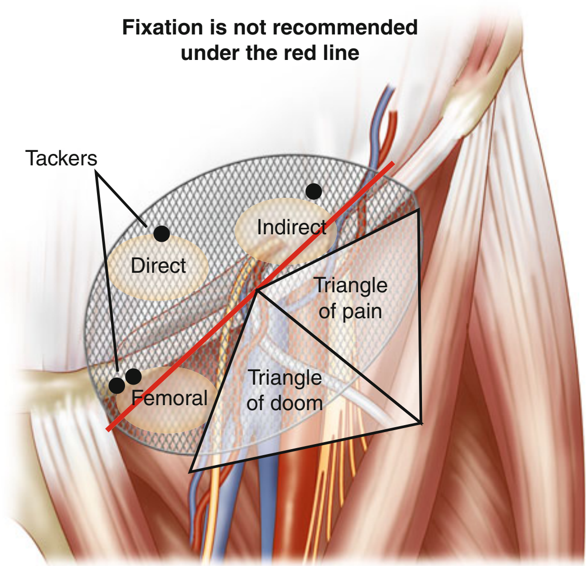


Fig. 5.5 Helicoidal suture at Cooper. Fixation is not recommended below the *red line*

recurrence rates are similar in both meshes. The only advantage of the new meshes is in relation to a low rate of chronic pain in the first 1–6 months of the recovery, but this is not such a big advantage that it should be used indiscriminately. The surgery time is longer with these meshes, requiring a steeper learning curve [11, 12].

The preformed normal weight meshes have the same results as far as recurrences are concerned and almost the same rate of chronic pain but with the advantage of an easy placement of the mesh and therefore a reduction in the surgery time [13].

Fixation Selection

We can select a traumatic fixation with absorbable or permanent tackers or use adhesives such as fibrin glue or cyanoacrylate. A new kind of mesh with a self-gripping system (absorbable polyglycolic acid grips) represents a new option which reduces surgery time (the mesh incorporates the fixation system) [5, 7, 8]. See Fig. 5.6a, b for the step-by-step TAPP technique.

Summary of Literature

See Table 5.1 for a summary and overview of the literature on TAPP [5, 14, 15].

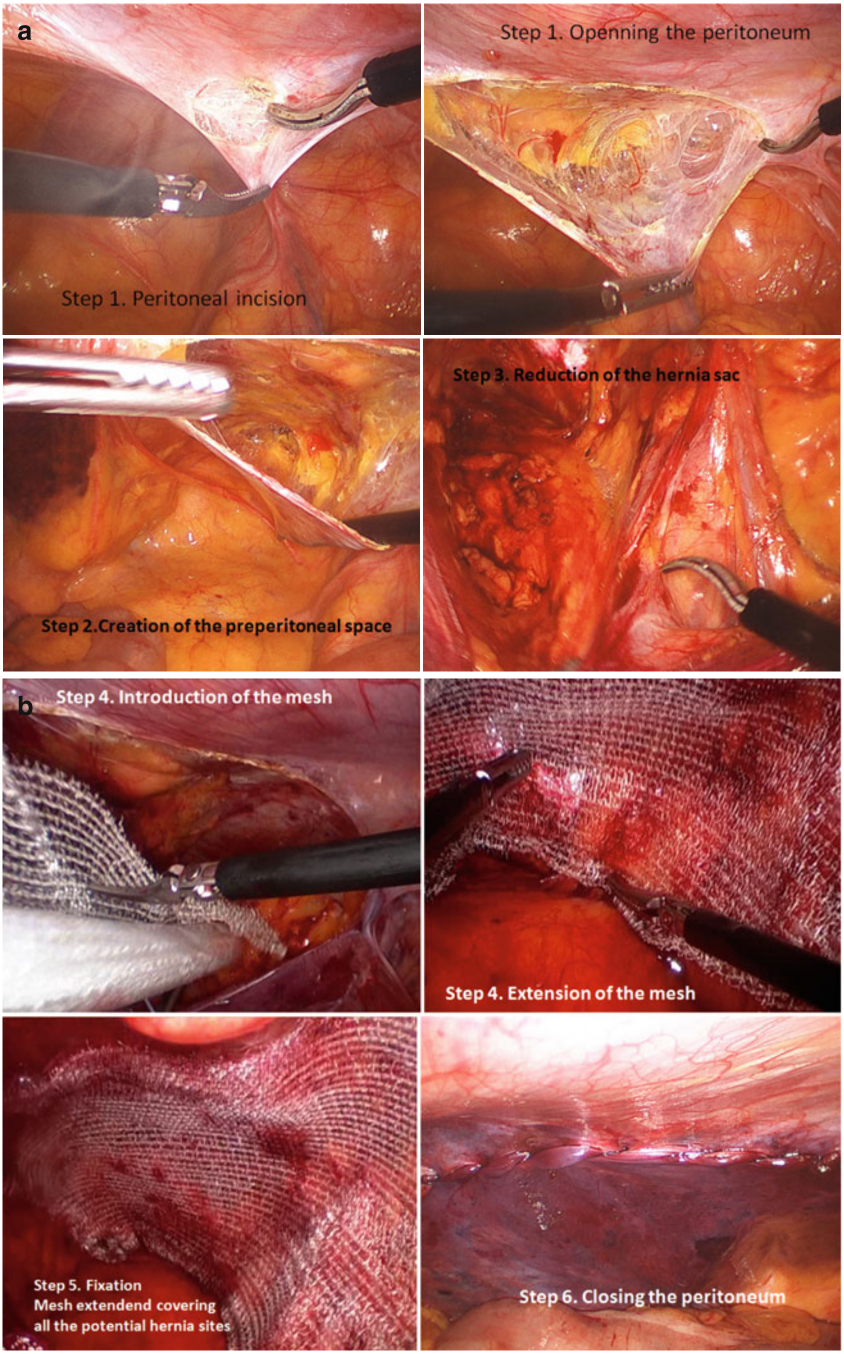


Fig. 5.6 (**a**, **b**) Step-by-step TAPP technique. (**a**): *1*: Peritoneal incision and opening the peritoneum; *2*: creation of the preperitoneal space; *3*: reduction of the hernia sac. (**b**): *4*: introduction of the mesh and extension of the mesh; *5*: fixation: mesh extended covering all the potential hernia sites; *6*: closing the peritoneum

Table 5.1 Literature on TAPP

Year	Author	Groups	Number of patients	Follow-up (months)	Recurrence (%)	Chronic pain (%)
2004	Koninger et al. [16]	TAPP vs. Lichtenstein	187	52	1.2 vs. 1.1	0 vs. 3.9
2007	Butters et al. [4]	TAPP vs. Lichtenstein	187	54	1.2 vs. 1.4	–
2007	Eklund et al. [14]	TAPP vs. Lichtenstein	147	61	1.9 vs. 1.8	0 vs. 0
2007	Lovisetto et al. [7]	TAPP fibrins vs. tackers	197	24	1 vs. 0	–
2008	Pokorny et al. [15]	TAPP/Lichtenstein vs. Shouldice	272	36	3.3 vs. 4.7	5.4 vs. 6.3
2009	Kapiris S et al. [8]	TAPP staple-free	91	50	1	0

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Chapter 6
Laparoscopic Inguinal Hernia Repair: TEP

Juan Antonio Bellido Luque and Maria Sánchez Ramírez

Abstract Laparoscopic approach to inguinal hernia involves access to the preperitoneal space without reaching the intraperitoneal compartment and, thus, without any disadvantages that ensue, such as the possibility of injury to viscera or postoperative paretic ileus. This path improves patient comfort by reducing pain after surgery and time off work. However, the main drawback is the difficulty of learning the technique. It is essential that surgeons performing this procedure complete a minimum of 25–50 tutored laparoscopic hernia repairs to be considered as having completed the learning phase.

Since performing a laparoscopic hernioplasty involves access to preperitoneal space, reducing the hernia sac, and placing a prosthesis, the approach to the preperitoneal space can be done by total extraperitoneal (TEP) or transabdominal preperitoneal access (TAPP).

Currently, it is accepted that TEP is preferred over TAPP because the TEP technique can result in lower trocar-site hernias and intra-abdominal injuries. However, TEP is a more demanding and complex technique, with a higher learning curve. The main technique in the learning curve in laparoscopic inguinal hernia repair should

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be the TAPP intervention as first recourse. After mastering the TEP intervention, performing a TAPP intervention will seem easy.

Keywords Laparoscopy • Hernia • Hernioplasty • Mesh • Inguinal • TAPP • TEP • Fixation

Introduction

The laparoscopic approach to inguinal hernias has shown its superiority in terms of pain and functional recovery in patients operated on using this approach. However, from the first laparoscopic hernioplasty carried out until the present day, there has not been sufficient awareness of the technique among the surgical community, as only 10 % of surgeons usually use this technique as an approach to inguinal hernias. There are principally two main reasons why it has not become a generalized approach. The first one is that it involves a steep learning curve. For a surgeon to be able to master hernioplasty laparoscopy requires a great amount of tutored cases in the presence of an expert surgeon. This is in order to minimize both intraoperative and postoperative complications caused by lack of experience, mainly due to the lack of knowledge in this surgical field. Although there is no consensus, it is estimated that a surgeon needs to have performed approximately 50 laparoscopic hernioplasty procedures in order to be able to carry them out without any complications.

The second reason for the slow pace in the dissemination of this technique is the high economic cost involved. In economic terms, if you compare the cost of conventional inguinal hernioplasty with that of laparoscopic, conventional surgery is much less expensive. However, if we look at the total cost, which not only includes surgical costs but also the cost of hospital stay and sick leave, laparoscopic hernioplasty is cheaper than that of open surgery.

As the carrying out of laparoscopic hernioplasty involves access into the preperitoneal space, reducing the hernial sac, and the placing of a prosthesis, the approach to the preperitoneal space can be carried out through completely extraperitoneal access (TEP) or transabdominal preperitoneal access (TAPP). We will focus on the TEP technique, as the TAPP technique is explained in another chapter.

Indications

At present, there is a consensus among the surgical community on the indications of laparoscopic hernioplasty. The European Hernia Society published a consensus document in 2009 which established levels of evidence and, as a result, some recommendation grades. The main indications for the laparoscopic procedure TEP, based on this document, are discussed in the following sections.

Bilateral Inguinal Hernia

Using the same entry incisions, we can correct both hernia defects. The laparoscopic access diminishes the functional recovery time in patients with a bilateral inguinal hernia [1]. Therefore, the laparoscopic approach is the best option for patients with an uncomplicated bilateral inguinal hernia.

Unilateral Inguinal Hernia

The laparoscopic technique is at present considered a first-rate alternative for adult patients suffering from an uncomplicated unilateral inguinal hernia, improving the chances of avoiding wound infection and postoperative hematomas and of offering a quicker functional return than with conventional open hernioplasty.

Recurrent Inguinal Hernia

In patients suffering from a recurrent inguinal hernia after having a hernioplasty or a conventional herniorrhaphy, the most recommended access is the posterior laparoscopic approach. As this will be virgin territory, the surgeon will be able to see more easily the structures and therefore reduce the probability of both intraoperative as well as postoperative complications.

Inguinal Hernia in Women

In over 40 % of women operated on for a second time with a suspected recurrent inguinal hernia, a femoral hernia has been diagnosed during this second operation. It is not known whether the femoral hernia was not seen during the first inguinal hernia operation or whether, on the other hand, it is a hernia which has appeared post-operation. The high frequency of femoral hernias in women previously operated on for an inguinal hernia is sufficient reason to justify laparoscopic preperitoneal access, which, by using a large-sized prosthesis, amply covers the inguinal orifice as well as the femoral.

High Suspicion of Inguinal Hernia

In the case of uncertainty of the existence or nonexistence of an inguinal hernia after a physical examination and image tests (Ultrasound, NMR), the current trend is for the use of the laparoscopic approach, as much for diagnostic confirmation as for correction, given that it provides an excellent view of the posterior wall of the inguinal region and of the possible hernia orifices.

Contraindications

If we focus on the TEP approach, in recent years the development of the laparoscopic approach has moved on from having no absolute contraindications to these becoming relative contraindications or outright contraindications. The reason for this change has been the experience of the surgical community in the laparoscopic approach which nowadays considers relative contraindications those which, a few years ago, were considered to be absolute.

Prior Infraumbilical Surgery

Any prior surgery below the navel in the patient contraindicates the laparoscopic TEP approach, due to the adhesions of the said intervention, which complicates the opening of the preperitoneal space, with the consequent risk of a peritoneal tearing and loss of the pneumoperitoneum and workspace. With these patients, a transabdominal preperitoneal TAPP access would have been carried out. However, currently and due to increasing surgical experience, previous McBurney scars make the TEP approach totally viable and without any complications. Moreover, laparotomy infraumbilical scarring does not impede access into the preperitoneal space and the correction of hernia defects. Even in patients with a prior prostatectomy in what is the Retzius space with intense adherence, this approach is therefore feasible. However, it is necessary to point out that these patients should be operated on by surgeons with experience in the laparoscopic approach in order to minimize the possible complications, both and postoperative.

Recurrent Inguinal Hernia with Mesh

In these patients, the previously placed mesh causes intense adhesions, both in the Retzius and Bogros' spaces, complicating the opening of the working space and the identification of structures. Due to this, it is recommended to use the TAPP approach on these patients for the two following reasons:

- The working space will be much greater once the peritoneum is opened. In the case of a peritoneal tear due to the adhesions, we will be able to continue with the procedure without loss of working space, as would occur in the case of the TEP procedure.

- The identification of structures, such as the inferior epigastric vessels, gonads, and the vas deferens, is carried out more easily, and therefore we reduce the possibility of an iatrogenic lesion.

Contraindications for General Anesthesia

Although studies have been published which show that the use of regional anesthesia is viable [2], we believe that with this type of anesthesia, in the case of CO^2 getting into the abdominal cavity, the patient will feel pain and have difficulty breathing, requiring a general anesthetic to finalize the procedure. It is for this reason that the majority of groups use general anesthesia for TEP laparoscopic hernioplasty.

Therefore, any patient in which general anesthesia is contraindicated, laparoscopic hernioplasty would be excluded from the possible surgical treatment of an inguinal hernia.

Special Situations

Inguinoscrotal Hernia

Inguinoscrotal hernia is referred to as such due to its size and the fact that it reaches the scrotal region. In the last decade, it was considered a contraindication for the TEP laparoscopy approach, given the high rate of conversion to TAPP or open surgery because of the limited working space. However, in recent years, various articles have been published which show the feasibility of surgical correction using the TEP technique with good results, due to the increasing experience of surgeons in laparoscopic approaches to hernias.

Incarcerated Hernia

The laparoscopic approach to an incarcerated hernia is challenging for the laparoscopic surgeon. The majority of surgeons use the TAPP approach for the correction of this type of hernia. The totally extraperitoneal approach is feasible, using different maneuvers, such as the opening of the deep inguinal ring in order to reduce the content of the hernial sac or the opening of the contralateral Retzius space in order to increase the working space. However, it is technically complex when compared with the TAPP approach, in which the reduction of the hernia content will be easier using direct traction. Due to this, for patients with an incarcerated inguinal hernia, the most recommendable approach would be TAPP.

Strangulated Hernia

The strangulated hernia is an emergency situation which surgeons face with relative frequency. In these cases, there is a vascular compromise of the herniated loop and therefore a higher or lesser probability of having to carry out an intestinal resection. In these cases, the TEP approach does not allow the testing of the hernial contents (epiplon or herniated loop) in order to assess its viability. Additionally, in the case of having to carry out an intestinal or epiplon resection, neither can be carried out as we are working in the preperitoneal space.

In these cases, TAPP would be more appropriate as it allows the reduction of the hernial contents more easily, the assessment of its viability, and even the carrying out of epiplon or herniated loop resections in the case of irreversible ischemia [3].

Patient Preparation and Positioning

As a main recommendation, the patient must enter the operating theater with the bladder completely empty. In this way, we will have an adequate preperitoneal Retzius space in order to be able to carry out the procedure.

The patient is positioned in supine with both arms next to the body. The surgeon and the assistant will position themselves on the contralateral side to the hernia being treated.

Necessary Equipment

In order to carry out the surgery, we will need a dissector, scissors, and grasping forceps. The optical used is 10 mm and 0°, although there are surgeons who prefer the use of a 30° optical in order to see more easily into the more lateral area of the Bogros' space. See Fig. 6.1.

Additionally, and in order to create more preperitoneal space, we will use a PDB balloon trocar and subsequently a 12-mm BTT structural trocar. See Figs. 6.2 and 6.3. The mesh and the fixation method used will be dealt with in other chapters.

Surgical Technique

Incision

The first technical movement is a 2-cm horizontal incision in the subumbilical region. After dissection of the subcutaneous cellular tissue, the superficial aponeurosis of

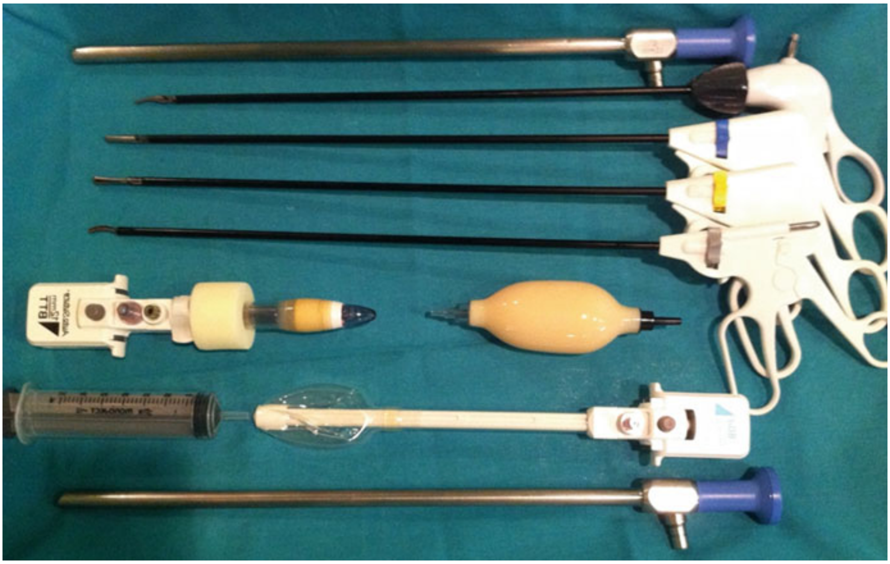


Fig. 6.1 Instruments in TEP technique

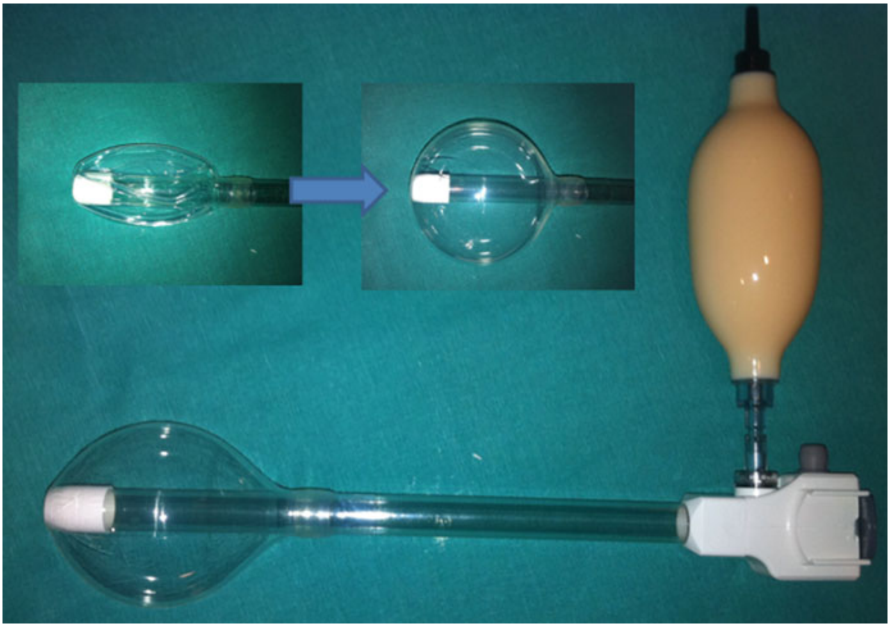


Fig. 6.2 PDB trocar

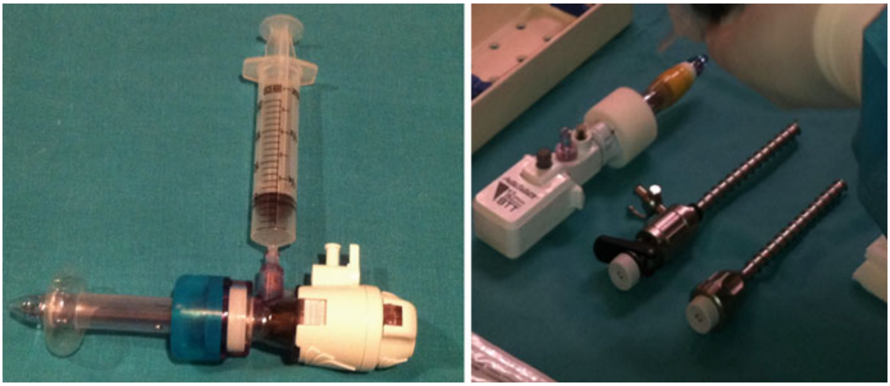


Fig. 6.3 BTT trocar and 5-mm trocars

the rectus abdominis muscle homolateral to the hernia is exposed. A 2-cm opening is made parallel to the direction of the muscle with the index finger and blunt dissection, and all of the rectus abdominis muscle is turned back, creating a retro muscular tunnel. See Fig. 6.4.

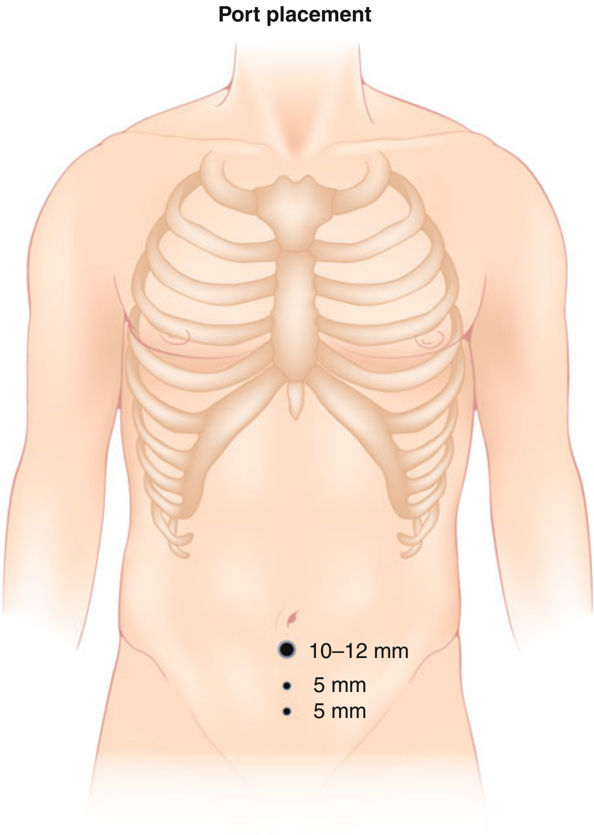
Creation of the Preperitoneal Space

Once this step has been carried out, the PDB balloon trocar is introduced and progressively inflated, achieving the opening of the entire preperitoneal space at the same time as the balloon is filled. The optic is introduced through the trocar in order to confirm the correct positioning of the balloon and begin structural identification. With alternating lateral movements of the optic introduced in the trocar, an opening in the Retzius space is achieved and more laterally in the Bogros' space. Subsequently, the balloon trocar is removed and the BTT trocar is put into place. After the establishment of the pre-pneumoperitoneum, two 5-mm trocars are placed on the infraumbilical midline separated by approximately 5 cm, under direct view. See Figs. 6.5, 6.6, 6.7, and 6.8.

Identification of Structures

It is necessary to identify the inferior epigastric vessels which are found in the most cranial area of the working space and Cooper's ligament. This ligament is easily recognized as it is pearly white and in the medial zone above the bladder. Once these structures have been identified, we should also be able to view the inguinal cord and the iliac vessels, which are found below and more medial to the cord.

Fig. 6.4 Port placement



Reduction of the Hernial Sac

In the case of a direct hernia occurring, the sac is generally completely reduced when the preperitoneal space is created with the PDB trocar, with one being able to see an orifice in the posterior wall of the inguinal region medial to the epigastric vessels, which is the direct orifice. In the case of it not being reduced in this manner, with simple traction of the sac in an inferior direction, it will be completely reduced, allowing a view of the transversalis fascia over the direct inguinal orifice. If the patient has an indirect hernia, the sac accompanies the elements of the cord (gonadal vessels and the vas deferens) for its most cranial and media portions. Using traction and contra-traction maneuvers, we will achieve the total reduction of the indirect sac, making sure at all times that we do not traction over the gonadal vessels or the vas deferens in order to avoid lesions.

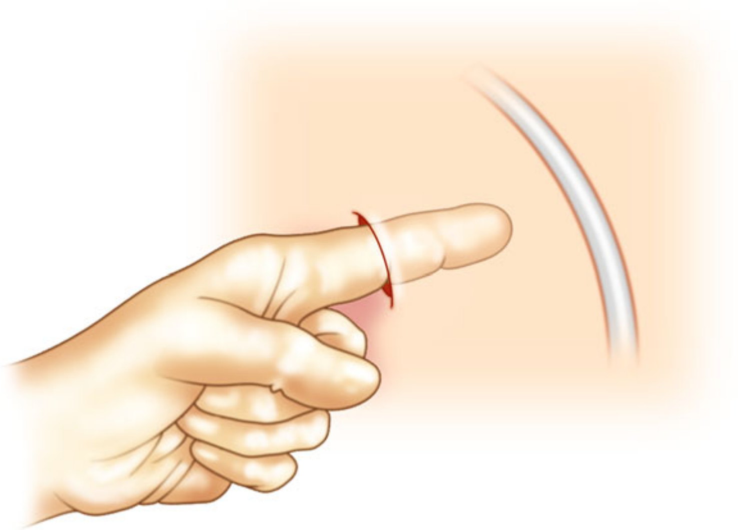


Fig. 6.5 Rome dissection with the finger until the Cooper's ligament

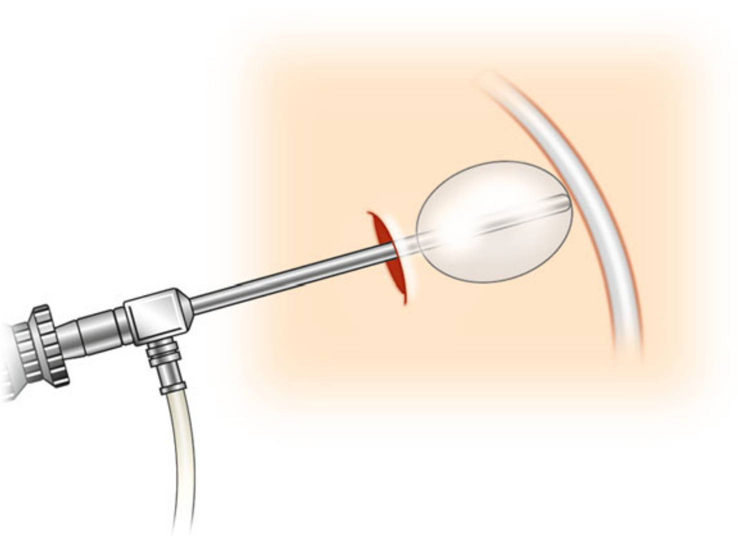


Fig. 6.6 6 PDB balloon trocar makes the preperitoneal dissection

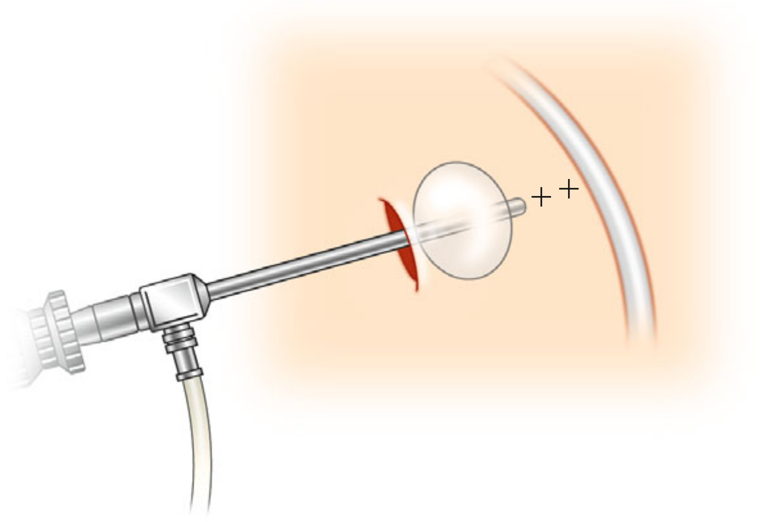


Fig. 6.7 BTT trocar and two infraumbilical 5-mm trocar

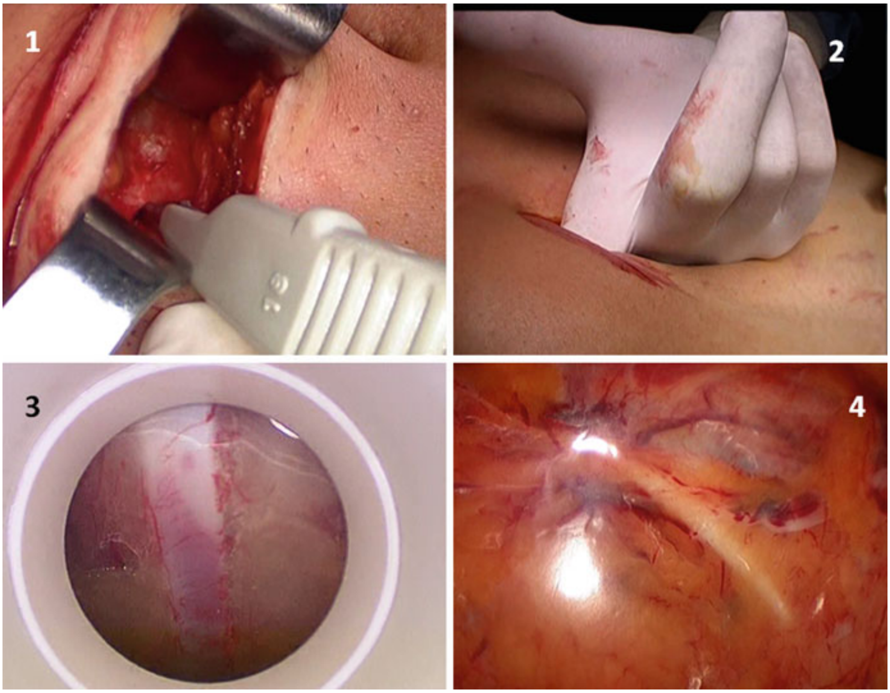


Fig. 6.8 Technique to open the Retzius space in TEP. *1* Opening the anterior fascia of rectus muscle, *2* Dissection with the finger the preperitoneal space, *3* PDB trocar: epigastric vessels, *4* PDB trocar: Cooper's ligament and epigastric vessels

The reduction of both direct and indirect sacs finalizes when we completely skeletized the inguinal cord and we see the iliopsoas muscle, the caudal margin of the dissection.

Opening of the Bogros' Space

Once the hernial sac has been reduced and the inguinal elements have been skeletonized, it is necessary to continue the lateral dissection, finalizing the opening of the Bogros' space. Laterally turning down the peritoneum, it is possible to reach the anterior superior iliac spine, the lateral margin of the dissection. During this step, it is common to observe nerve structures such as the femoral nerve and the femoral branch of the genitofemoral nerve, which need to be avoided in order to rule out chronic pain in the inguinal region.

Introduction of the Mesh

The prosthesis is rolled up and inserted through the BTT trocar and is unrolled in the preperitoneal space. A consensus exists among the surgical community as to the minimum size of the mesh to be used. This should be a minimum of 10×15 cm in order to reinforce all the possible hernial orifices (direct, indirect, and femoral). The positioning of the mesh in the said space is vital in order to avoid an early recurring hernia, and for this reason we will give special attention to this step. It should totally surpass Cooper's ligament and the pubis (even more so in the case of direct hernias), covering adequately the inguinal cord and the deep inguinal orifice and reaching the most lateral area of the Bogros' space. See Fig. 6.9.

Prosthetic Fixation

For prosthetic fixation in the preperitoneal space, we can use different methods: absorbable or nonabsorbable tackers, glues, biological glues, or even no fixation method. The indication of one or another method will be discussed in another chapter.

Evacuation of the Pre-pneumoperitoneum and the Closure of Trocars

Evacuation of CO^2 must be done slowly, without moving the mesh during this stage, at all times observing with the optic. Simultaneously, it is convenient at this time to evacuate the CO^2 that could have been retained in both scrotal regions by diffusion

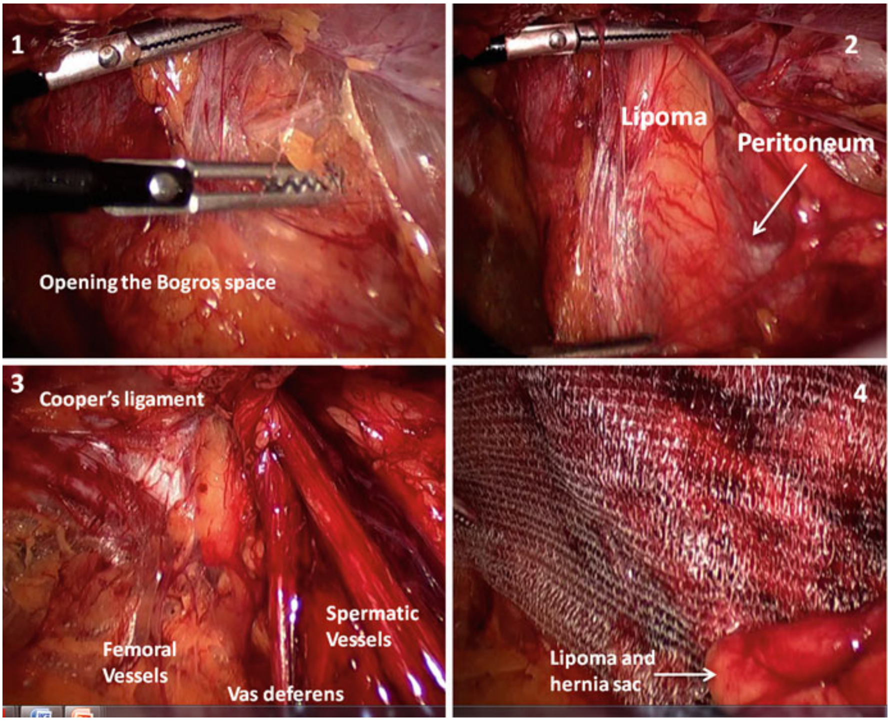


Fig. 6.9 Introducing the mesh. *1* Opening the Bogros space, *2* Reduction of the hernia (lipoma and the sac), *3* Identify the structures, *4* Mesh placement: the lipoma and the hernia sac are placed against the mesh

throughout this operation. Once the pre-pneumoperitoneum has been evacuated, the surgery is completed with the closure of the superficial aponeurosis orifice and the incisions in the skin.

Complications

The complications which can arise in a laparoscopic hernioplasty inguinal TEP procedure can be classified into the categories discussed in the following sections.

Intraoperative

Hemorrhage

Few hemorrhages occur during a TEP procedure, and those which do are easily controlled with cauterization. Lesions on the inferior epigastric vessels, the obturator artery, or collateral arteries are produced by inadequate traction and are controlled using metal clips. Hemorrhage from iliac vessels is incidental.

Damage to the Inguinal Cord

Lesions of the vas deferens are rare due to the easy identification of this medial structure to the inguinal cord, which appears as a pearly white cord. The gonadal vessels are situated posterior and lateral to the inguinal cord, underneath the indirect hernial sac. In order to avoid lesions to both structures, it is essential to achieve a precise identification, separating them from the indirect hernial sac with smooth maneuvers, avoiding excessive tractions.

Peritoneal Rupture

This is the most frequent complication, with an incidence rate of between 13 and 24 %, and in 7 % of patients the tear is massive, losing the preperitoneal space and therefore forcing a TAPP approach or open surgery. The surgeon's experience is vital in order to maintain a low conversion rate.

The best way of avoiding this complication is to identify at all times the peritoneum margin and the hernial sac, carrying out traction and contra-traction maneuvers in a smooth manner.

Although various studies with positive results have been published in which the peritoneal small defect is not closed [4], we believe that in all of the cases in which a peritoneal rupture is identified, it is recommendable to close it in order to avoid the loss of the CO^2 in the intraperitoneal cavity and the consequent diminishing of the work space, as well as to reduce the probability of an introduction of a bowel loop through the orifice and the immediate postoperative appearance of an obstruction.

There are several methods of peritoneal closure, such as continuous suturing, the use of clips, or the use of preformed loops (Endoloops®, Ethicon endosurgery, Blue Ash, OH, USA). This last option is the quickest and simplest. See Fig. 6.10.

In the case of a loss of the pre-pneumoperitoneum in the intraperitoneal cavity which produces a slight reduction of the working space, we can increase this space with the introduction of a Veress needle in the left hypochondrium, facilitating the exit of intraperitoneal CO^2.

Postoperative

Seroma

This is the most common postoperative complication, above all in patients with direct or medial hernias. It appears as a non-painful lump in the inguinal region, from the 4th or 5th day post-operation, starting with a soft consistency and afterwards a hard consistency. During examination, it does not reduce or change with

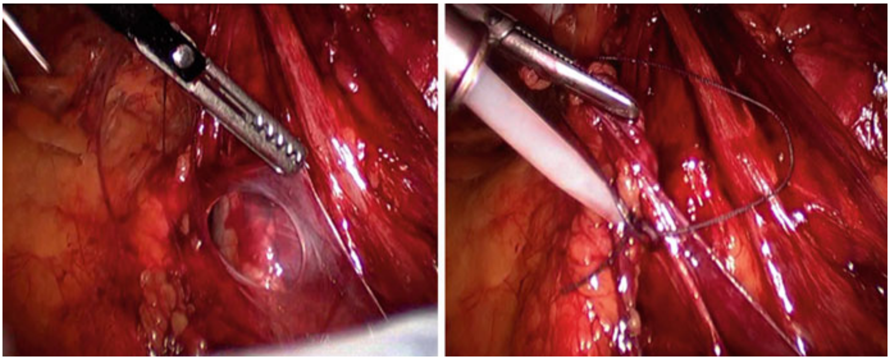


Fig. 6.10 Closure of peritoneal tear with Endoloops (Endoloop®, Ethicon Endosurgery, Blue Ash, OH, USA)

pressure or when lying down. It does not require treatment and usually disappears approximately 1 month after the operation. Only in those symptomatic cases and those in which it does not disappear can puncture aspiration be recommended.

Various techniques have been published in order to diminish the incidence of seromas. In the case of direct hernias, we can invaginate the transversalis fascia, fixing it to Cooper's ligament with a helicoidal suture or by using an Endoloop. If we come across large direct hernias, it would be recommendable to completely reduce the hernial sac, as this has been shown to reduce the incidence of seromas. If it is not possible to completely reduce it, once the sac is selected and bound to the nearest ending, we can fix the distal end of the sac to the posterior wall of the inguinal region in order to diminish the dead space which would remain if we were to leave it without fixing it.

Scrotal Hematoma

This complication is usually quite frequent in patients who have been operated on for an inguinoscrotal hernia, with an incidence rate of between 4 and 22 % according to publications. The treatment is conservative with relative rest and anti-inflammatories. Only in those cases showing an organized hematoma, clinically very symptomatic, should this be surgically drained.

To avoid this complication, it is necessary to carry out a careful dissection and hemostasis during the surgical procedure, above all in those patients with inguinoscrotal hernias and those patients receiving an anticoagulant treatment. In these cases, the use of aspirational drainage can help to diminish the incidence of scrotal hematomas.

Ischemic Orchitis

The appearance of pain or testicular inflammation in the first 5 days after the operation should make us consider ischemic orchitis. Its incidence varies between 0.05 and 0.1 %, above all in patients with inguinoscrotal hernias with a larger dissection of the hernial sac. It is believed that it is due to a thrombosis of the pampiniform venous plexus more than an arterial lesion and should be differentiated from a scrotal hematoma or testicular torsion. A scrotal ultrasound helps with diagnosis, and treatment is based on anti-inflammatories, relative rest, and scrotal suspensory. The majority of patients recover completely without developing testicular atrophy.

Chronic Pain

Chronic pain is that which persists for longer than the third month after surgery. The following have been confirmed through evidence-based medicine:

1. The laparoscopic approach to inguinal hernias produces less acute and chronic pain than conventional surgery (1A).
2. There are no differences in terms of acute or chronic pain between TEP and TAPP (1B).
3. The risk of acute and chronic pain after fixation with helicoidal sutures is greater when compared to fixation with fibrin and non-fixation (1B).
4. The risk of acute and chronic pain after a laparoscopic hernioplasty in a recurrent inguinal hernia is less when compared to conventional surgery (1B).
5. There are no differences in chronic pain with the use of high- or low-weight meshes in laparoscopic hernioplasty (1B).

In order to attempt to diminish the incidence of chronic pain, we should avoid lesions of three nerve structures which are involved in the occurrence of chronic pain:

- Genital and femoral branches of the genitofemoral nerve
- Lateral cutaneous nerve of the muscle
- Cutaneous branch of the femoral nerve

Due to the mechanisms of the lesions not being well defined, diagnosis is usually imprecise and difficult. Therefore, the best treatment is usually prevention. The best way to avoid this complication is to minimize the preperitoneal dissection in the posterior pelvic wall and not place helicoidal sutures under the iliopubic tract.

The treatment of this complication is controversial, there being different methods. The initial treatment with nonsteroidal anti-inflammatory drugs (NSAIDs) and rest, together with an infiltration of local anesthetics, is usually useful in controlling this complication.

Faced with a persistent inguinodynia in spite of treatment, associated with motor or sensorial deficit, the most sensible solution would be another operation and exploration of the whole inguinal area and removal of the helicoidal sutures.

Controversies in Laparoscopic Inguinal Hernia Repair

The development of polypropylene prosthetics revolutionized surgery in the repair of abdominal wall hernias. A tension-free mesh technique has drastically reduced recurrence rates for all hernias compared to tissue repairs and has made it possible to reconstruct large defects that were previously irreparable. In 2002, the EU trialist collaboration analyzed 58 randomized controlled trials and found that the use of mesh was superior to other techniques. They noted fewer recurrences and less postoperative pain with mesh repair [5].

The repair of abdominal wall defects is one of the most commonly performed general surgical procedures, with over one million polypropylene implants inserted each year. There are many points of controversy in laparoscopic inguinal hernia repair as outlined next.

TEP Versus TAPP: Which Is Better for the Patient?

There are two standardized techniques for uncomplicated laparoscopic groin hernia repair (LIHR): transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP) repair. There is a paucity of published data with level 1 evidence comparing TAPP to TEP, with there being advantages and disadvantages to both procedures. There is no statistically significant difference regarding postoperative complications, in particular recurrence rates and chronic groin pain. It is generally believed that TAPP is easier to teach and learn, although there is no level 1 evidence in the literature to support this belief.

The laparoscopic approach chosen depends upon the surgeon's level of experience, the type of hernia, and the patient's medical history. The TEP approach is chosen sometimes because it avoids entering the peritoneal cavity, requires less operative time, and has less potential for complications than the TAPP approach, except in a few cases such as in incarcerated hernias in female patients with abdominal pain and when the etiology of such pain may be in question (difficulty in differentiating between secondary pain due to a groin hernia and other possible causes).

The laparoscopic approach is ideally suited to recurrent hernias. The surgeon's view of the posterior wall is unobstructed and allows for complete identification of the recurrence site and repair of the entire posterior pelvic floor. The decision as to whether a TAPP or a TEP approach should be employed is dependent upon the expertise of the surgeon.

The age of the patient may influence the type of hernioplasty chosen. In general, laparoscopic hernioplasty should be reserved for adults, specifically to working younger adults, due to the rapid recovery and return to normal activity.

There are more advantages to the TEP approach for the repair of bilateral and recurrent hernias, where the correction using this surgical procedure has shown benefits when compared to the previous route. The approach is carried out using a common access and through a virtually untouched field in recurrent hernias with less risk of nerve damage as well as damage to the spermatic cordon. Therefore, the majority of patients selected by our group for the TEP technique have the characteristics that make this the technique of choice. Calado-Leal et al. in their study analyze the results of TEP endoscopic hernioplasty. In this study, they focused on the repair of bilateral hernias and recurrences or multiple recurrences where a total of 250 TEPs had been performed on 150 patients in the last 5 years. The majority (63 %) of the patients subjected to surgery had bilateral hernias, and 16 % had recurrent hernias.

The conclusion was that TEP endoscopic hernioplasty is an extremely effective and safe procedure in the hands of experienced surgeons with specific training. It is an interesting option in bilateral and recurrent hernias as it obtains satisfactory results in terms of postoperative pain and morbidity [6].

Krishna et al. in a prospective randomized controlled trial compared the totally extraperitoneal (TEP) and transabdominal preperitoneal (TAPP) techniques of laparoscopic inguinal hernia repair; they included 100 patients suffering from uncomplicated primary groin hernia. In this study, TEP had a significant advantage over TAPP for significantly reducing postoperative pain up to 3 months after surgery, which resulted in a better patient satisfaction score. The other intraoperative complications, postoperative complications, and cost considerations were similar in both groups. In terms of results, both repair techniques seemed equally effective, but TEP had a slight advantage over TAPP [7].

Bansal et al. concluded that the TEP and TAPP techniques of laparoscopic inguinal hernia repair have comparable long-term outcomes in terms of incidence of chronic groin pain, quality of life, and resumption of normal activities. TAPP was associated with significantly higher incidence of early postoperative pain, longer operative time, and cord edema, whereas TEP was associated with a significantly higher incidence of seroma formation. The cost was comparable between the two [8].

Totally extraperitoneal (TEP) repair and transabdominal preperitoneal (TAPP) repair are the most used laparoscopic techniques for inguinal hernia treatment. However, many studies have shown that laparoscopic hernia repair compared with open hernia repair may offer less pain and shorter convalescence time. A few studies compared the clinical efficacy between TEP and TAPP technique.

Bracale et al. performed an indirect comparison between TEP and TAPP techniques by considering only randomized controlled trials comparing TEP with open hernia repair and TAPP with open hernia repair in a network meta-analysis. They concluded that TEP and TAPP were equivalent for operative time, postoperative complications, postoperative pain, time taken to return to work, and recurrences, whereas TAPP was associated with a slightly longer hospital stay [9].

A high incidence of bilateral inguinal defects found in laparoscopic evaluation during hernia repair has been reported. The bilateral inguinal defects in patients who are diagnosed with a pure unilateral hernia might be underestimated.

Bochkarev et al. performed a study on 100 male patients with primary unilateral inguinal hernias, while patients with known bilateral inguinal hernias as well as femoral, giant, and combined hernias were excluded. All patients underwent TEP with exploration and evaluation of the contralateral groin. This revealed 22 % occurrence of bilateral inguinal defects in patients diagnosed with a pure inguinal hernia before surgery, with a higher incidence for those with left inguinal hernias. It appears that routine contralateral groin exploration and evaluation during TEP is valuable. Patients with occult bilateral hernias benefit from bilateral TEP [10].

Pawanindra Lal et al. performed a study in order to investigate the feasibility of bilateral laparoscopic exploration on all unilateral cases using laparoscopic TEP to compare complications, recurrence rates, postoperative pain, patient satisfaction, and return to work times retrospectively with a similar number of age-matched retrospective controls. In this study, bilateral TEP was performed in three types of patients: those with clinically bilateral hernias, those with clinically unilateral hernias but with an occult contralateral hernia, and in truly unilateral hernias. All of these were compared with unilateral TEPs in clinically unilateral hernias and demonstrated no significant increase in morbidity, pain, recurrence, or complications in bilateral repairs. Surgeons experienced in laparoscopic TEP and in high-volume centers can provide bilateral repairs in patients with inguinal hernias, bearing in mind its advantages and comparable morbidity.

In this way, the patient should be given the option of bilateral repair. Bilateral repair does not add to the risk of surgery in experienced hands, and unilateral TEP is not a complete solution [11].

There are some advantages of the TAPP technique over the totally extraperitoneal (TEP) approach, such as (1) after the insertion of the laparoscope, one can assess immediately the hernial situation on both sides and recognize the landmarks that are important for dissection; (2) intestinal adhesions in the hernial sac (sliding hernia) can be recognized immediately; and (3) control of any bleeding is possible by appropriately aimed electrocoagulation, thereby avoiding injury to the adherent intestinal wall. It is also possible to diagnose accompanying pathological conditions as well as to carry out additional surgery in the abdominal space (e.g., cholecystectomy) without conversion to an open procedure.

Hernia in Sportsmen: Diagnosis and Treatment

A sportsmen hernia is a controversial cause of this chronic groin pain, as it is difficult to define, and is one of the least understood and under-researched maladies to affect the human body. It reflects a compilation of diagnoses grouped together with a wide range of other pathologies that need to be excluded before it can be considered as a diagnosis [12].

Sports hernias occur more often in men, usually during athletic activities that involve cutting, pivoting, kicking, and sharp turns, such as those that occur during soccer, ice hockey, or American football.

In the majority of athletic maneuvers, a tremendous amount of torque or twisting occurs in the midportion of the body, and the front or anterior portion of the pelvis accounts for the majority of the force. The main muscle inserting at or near the pubis is the rectus abdominis muscle, which combines with the transversus abdominis. Across from these muscles and directly opposing their forces is the abductor longus. These opposing forces cause a disruption of the muscle/tendon at their insertion site on the pubis, so the problem could be related to the fact that forces are excessive and imbalanced, and a weak area at the groin could be increased due to the forces produced by the muscles. The forces produced by these muscles may be imbalanced and could produce a disruption of the muscle/tendon at their insertion site on the pubis, or/and a weak area may be increased due to the forces produced by the muscles; this last possibility could be defined as sportsmen hernia [13].

The clinical presentation is a chronic groin pain which develops during exercise, aggravated by sudden movements, accompanied by subtle physical examination findings, and a medial inguinal bulge appearing on an ultrasound. Pain persists after a game, abates during a period of layoff, but returns on the resumption of sport.

Certain risk factors have been identified, including reduced hip range of motion and poor muscle balance around the pelvis, limb length discrepancy, and pelvic instability. The suggested etiology of the injury is repetitive athletic loading of the symphysis pubis disc, leading to accelerated disc degeneration with consequent pelvic instability and vulnerability to micro-fracturing along the pubic osteochondral junction, periosteal stripping of the pubic ligaments, and para-symphyseal tendon tears, causing tendon dysfunction.

Diagnostic imaging includes an erect pelvic radiograph (X-ray) with flamingo stress views of the symphysis pubis, real-time ultrasound, and, occasionally, computed tomography (CT) scanning and magnetic resonance imaging (MRI), but seldom contrast herniography. Other imaging tests occasionally performed can include nuclear bone scan, limb leg measurement, and test injections of local anesthetic/corticosteroid [14].

In patients with chronic groin pain and clinically uncertain herniations, magnetic resonance imaging (MRI) and ultrasound (US) are valid diagnostic tools, with a level 2A evidence.

Ultrasound is a useful adjunct diagnostic tool, not only to evaluate the groin for hernias, with high overall accuracy, but also in sportsmen hernias to identify inguinal canal posterior wall deficiency in young men with no clinical signs of hernia with chronic groin pain. This has a level 3 evidence.

This global entity could be considered an imbalance of the muscles (abductor and abdominal) at the pubis, which leads to an increase of the weakness of the posterior wall of the groin and produces a tendon enthesitis [15].

Sportsmen hernias (also called athletic pubalgia) are a deficiency of the posterior wall of the inguinal canal, which is often repaired by laparoscopic mesh placement. Endoscopic mesh repair may offer a faster recovery for athletes with sportsmen hernias than nonoperative therapy.

Paajanen et al. performed a randomized and prospective study with 60 patients with a diagnosis of chronic groin pain and suspected sportsmen hernia.

Clinical data and magnetic resonance imaging were collected on all patients. After 3–6 months of groin symptoms, the patients were randomized into an operative or a physiotherapy group ($n = 30$ patients in each group). Operation was performed using a totally extraperitoneal repair in which a mesh was placed behind the symphysis and painful groin area.

This randomized controlled study indicated that the endoscopic placement of retropubic mesh was more efficient than conservative therapy for the treatment of sportsmen hernias (athletic pubalgia) [14].

In the indication for surgery with a level 1A evidence, the IEHS concluded that an active physical therapy program designed to strengthen the muscles in order to stabilize the hip and pelvis has positive effects and leads to an earlier return to sports at the same level and is superior to a physiotherapy treatment without active training.

Until now, there has been no evidence-based consensus available to guide decision-making (level 3A evidence). The methodological quality of the studies available or analysis is low (level 3A evidence).

A single entheseal pubic cleft injection can be expected to afford at least 1 year of relief from abductor-related groin pain in a competitive athlete with normal findings on a magnetic resonance imaging scan (level 3A evidence).

Surgery seems to be more effective than conservative treatment for sportsmen hernias (level 3A). Good results can be obtained with surgery when posterior inguinal wall deficiency is the sole diagnosis (level 3A evidence).

Information on specific conservative interventions is poorly presented, and well-designed studies are lacking (level 3A evidence).

An IEHS recommendation with a grade B of evidence states that a multidisciplinary approach to groin pain should be adopted. Generally, conservative measures should be tried first, consisting of an initial period of rest or restricted activities, followed by physical therapy designed to stabilize the pelvis and hip and, when conservative management has failed, surgical intervention should be carried out [15].

Finally, the management of groin injuries demands the recruitment of a team with experience with different aspects of groin pain (level 4 evidence).

Coagulation Disorders and TEP

Increasing numbers of patients now receive oral anticoagulant therapy to reduce their risk of stroke from atrial fibrillation and other cardiac disorders that require an inguinal hernia repair.

Canonico et al. performed a randomized controlled trial of 50 patients with coagulation disorders and hernia repair. Patients had concurrent coagulopathies as a consequence of liver disease or long-term treatment with anticoagulants. Coagulopathies were defined according to the following criteria: prothrombin time <10.5 s, activated partial thromboplastin time <21 s, and fibrinogen <230 mg/dL. The patients were randomized in a 1:1 ratio with (group A) or without (control group B) use of human fibrin glue.

This study showed that human fibrin glue is effective in preventing local hemorrhagic complications after inguinal hernia repair in patients with concurrent coagulation disorders. This implies that the use of human fibrin glue reduces the costs of prolonged hospitalization related to such complications [16].

Which Technique of Space Creation Best Achieves the Required Extraperitoneal Space?

Laparoscopic hernioplasty has been criticized because of its technical complexity and increased costs. Disposable dissection balloons can be used to gain the initial working space in totally extraperitoneal endoscopic (TEP) hernioplasty, but this increases its cost. Dissection with the laparoscope is a frequently used method.

Totally extraperitoneal (TEP) laparoscopic repair of an inguinal hernia involves the creation of an extraperitoneal space by blunt dissection or the use of commercial balloons. This technique demonstrates that the creation of this extraperitoneal space using a glove balloon is simple, cost-effective, and easy to teach, without the need for any commercial balloons.

The technique of balloon dissection provides adequate extraperitoneal space creation and is evolving as a method of choice; locally produced balloons contribute to cost-effectiveness (level 1 evidence [17]).

Anatomical delineation of the inguinal area and dissection in the extraperitoneal space in TEP repair were equally satisfactory in both the balloon dissection and the laparoscope dissection group (level 1B evidence).

The use of a dissection balloon in TEP reduces the conversion rate and may be especially beneficial early in the learning curve (level 1B evidence).

Balloon dissection is the most commonly used method to create extraperitoneal space. Balloon dissection is associated with significantly reduced postoperative pain at 6 h, scrotal edema, and seroma formation compared with telescopic dissection; however, at 3 months follow-up, balloon dissection did not offer any significant advantages over direct telescopic dissection.

A randomized, prospective, multicenter study showed that a dissection balloon made the dissection of preperitoneal space easier and safer and reduced operative time, conversion rate, and the number of complications.

The IEHS recommend with a grade A of recommendations that the balloon dissection should be considered for extraperitoneal space creation, especially during the learning period, when it is difficult to find the correct plane in the preperitoneal space [15].

Modifications to the technique of balloon dissection are needed for patients with previous lower abdominal surgery. The balloon is distended much less than in those without previous surgery and away from the scar site to prevent tearing of scar tissues and thereby decreasing the potential for tearing of bowel, bladder, or peritoneum.

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Chapter 7
Prostheses in Laparoscopic Inguinal Hernia Repair

Antonio Tejada Gómez and Araceli Bellido Luque

Abstract The prostheses used in inguinal hernia repair have ranged from preformed polypropylene to the current three-dimensional meshes consisting of little material and large pores. Today, mesh pores and material content (polypropylene, polyester mostly) are very important when considering the lifestyles of the patient. Correctly choosing the mesh according to the characteristics of the patient and the hernia is essential.

Keywords Prosthesis • Mesh • Fixation • Laparoscopy • Inguinal • Hernia • Polypropylene • Pores • Lightweight

Introduction

The history of surgery is strongly influenced by technological advances. This is particularly evident in the field of hernia surgery, which has experienced a revolution with the introduction and use of biomaterials that enable a true "replacement" abdominal wall. Since 1944, when Aquaviva and Bounet published their use in Marseille for the first time of the prosthetic polyamide (Nylon®), a hydrocarbon polymer, for ventral hernia repair [1], many biomaterials for this purpose have been developed and are at our disposal, thanks mainly to the advances experienced by the industry in recent decades.

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The use of nylon was followed by other polymers, such as polyethylene (Dacron®) by Usher in the USA [2], and a few years later, in 1954, the discovery of polypropylene (PP, Marlex®), which earned Italian Giulio Natta and his German colleague Karl Ziegler the Nobel Prize in chemistry in 1961; this latter event was crucial in the evolution of surgery of the abdominal wall [3]. After being introduced to the market by Usher in 1958, this material has become the most used in abdominal wall surgery, thanks to its excellent biocompatibility; having been developed from a very wide variety of prostheses, PP only or in combination with other materials and with different characteristics in terms of porosity, molecular weight, and flexibility allows us to now virtually individualize the surgical treatment of abdominal wall hernias.

After PP, other polymers have appeared that have broadened the spectrum of biomaterials by providing new features; the most significant is the expanded polytetrafluoroethylene (PTFE, Gore-Tex®, L. Gore & Associates, Newark, DE, USA), on the market since 1963, which has allowed, thanks to its microporosity, contact with the abdominal viscera and the tension-free repair of large abdominal wall defects and laparoscopic use [4]. Finally, the need to repair contaminated tissues has prompted calls for bioprostheses, made from denatured and acellular collagen from animals or humans. The goal is to repair and regenerate tissue by stimulating the receptor extracellular matrix and angiogenesis.

Definition of Abdominal Wall Prosthesis

The Biomaterial Consensus Conference in 1983 agreed on the definition of biomaterial as the "substance or combination of substances (other than naturally occurring or synthetic drugs) usable alone or in combination and for a variable time span to treat, augment, or replace a body function." Therefore, we can consider as biomaterials many of the raw materials in the market such as metals and alloys, ceramics, carbon derivatives, hydrocarbon polymers, and biological tissues [5]. Of these, only some hydrocarbon polymers and biological materials are components of the prostheses used in surgery of the abdominal wall, and, if one looks at inguinal hernia surgery, the use of biological materials is exceptional. In this chapter, we will focus on biomaterials developed from hydrocarbon polymers.

Types of Materials

Knowledge of different biomaterials we have at our disposal is a necessity for the surgeon, especially if one is dedicated to abdominal wall surgery. Industry continually offers us the possibility of having new varieties of biomaterials and is involved in a continuous process of renewal that seeks to improve the behavior of these biomaterials at interfaces, in terms of where to apply them and how to avoid complications.

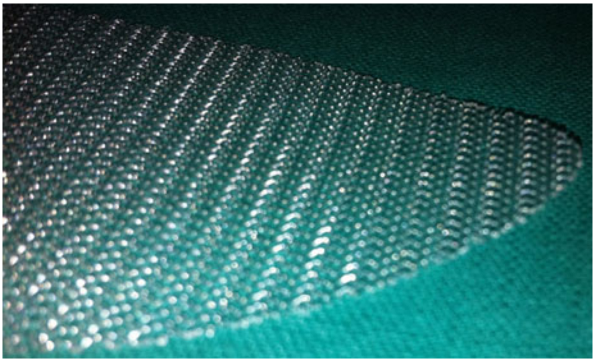

Fig. 7.1 Polypropylene mesh. Normal or standard macroporous monofilament PP

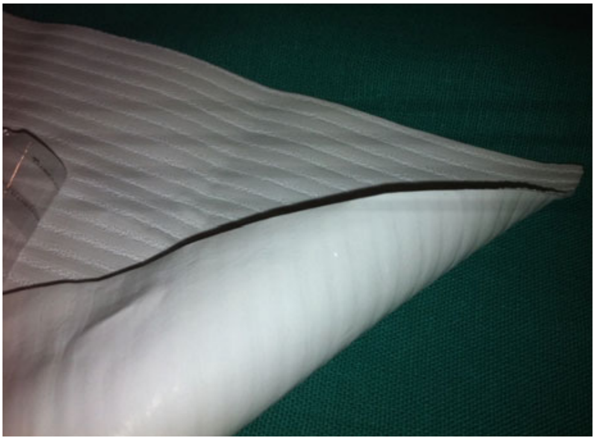

Fig. 7.2 Mycromesh® (L. Gore & Associates, Newark, DE, USA) PTFE-e. Biomaterial incorporates a microporous node and fiber structure with regularly spaced macropores. This structure ensures early fixation to host tissue with minimal foreign body response and extensive vascularization

This makes it necessary to have a classification to assist the surgeon in decision making when choosing the most suitable prosthetic material for each patient.

The first classification of biomaterials was proposed in 1997 by Amid [6], who based the classification on the pore size of the prosthesis. Four categories were constructed:

Type I: Macroporous prosthesis, with a pore size greater than 75 μm, which is necessary for proliferation through macrophages, fibroblasts, and blood vessels. Its exponents are Marlex® mesh and Prolene™ (Ethicon Endosurgery, Blue Ash, OH, USA), made from PP. See Fig. 7.1.

Type II: Artificial microporous, with pores smaller than 10 μm in at least one of its three dimensions. The best example is the mesh Gore-Tex®, made with PTFE. See Fig. 7.2.

Type III: Prosthetic components, macroporous or microporous multifilament (mixed mesh). Examples are braided polyethylene mesh (Mersilene™, Ethicon Endosurgery, Blue Ash, OH, USA), PP braided (Surgipro™ (Covidien, Dublin, Ireland)), or PTFE perforated (MicroMesh®, L. Gore & Associates, Newark, DE, USA). See Fig. 7.3.

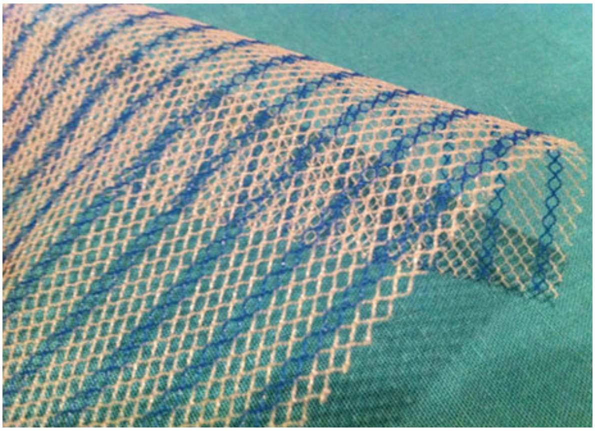

Fig. 7.3 Light Mesh. Ultrapro™ (Ethicon Endosurgery, Blue Ash, OH, USA) Partially Absorbable Lightweight Mesh is a unique and superior macroporous partially absorbable mesh

Type IV: Prostheses with pores smaller than 1 μm, such as silastic, and pericardium or dura substitutes. These meshes are not suitable for hernia repair, although biomaterials in combination with type I can make a surface suitable for intraperitoneal implantation.

Constant evolution has made the Amid classification obsolete. Reticular PP prostheses tend to have a smaller amount of the biomaterial in order to enhance integration into the host tissue and patient comfort, without compromising on the strength of the parietal repair. These prostheses also are associated with absorbable material, forming hybrid prostheses, leaving an even smaller amount of foreign material in the host organism [7].

PTFE also has been subjected to changes in its structure, after initially evolving toward a "multiperforated" patch without developing better biomechanical strength. In subsequent generations of this material, innovations have appeared: incorporation of a roughened surface which promotes integration via its outer face (DualMesh ®, L. Gore & Associates, Newark, DE, USA), argentic impregnation to prevent bacterial adhesion in the early stages after implantation.

Fully absorbable biomaterials have been incorporated into the context of prosthetic laminar: tissue extracted from its natural environment and serving as support for cell colonization. These are called biological prostheses; they achieve both repair and regeneration of host tissue, ultimately forming a "neopared" for the repair of the hernia defect. These natural prostheses require stringent controls given their animal origin, as they are not risk-free for possible transmission of disease as has happened in lyophilized dura prosthesis. The most commonly used are derived from the submucosa of porcine small intestines and collagen of human or porcine origin.

Finally, the composite type prosthesis or "composite" has opened a wide range of possibilities in the repair of large hernia defects in which the biomaterial must be left in contact with the visceral peritoneum. These prostheses have two

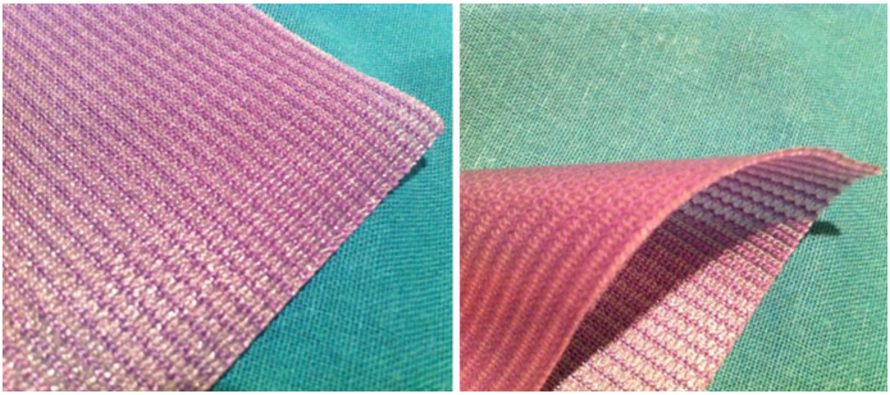

Fig. 7.4 Sepramesh™ (Davol, Warwick, RI, USA). Combines the strength of polypropylene mesh with a bioresorbable hydrogel coating for ventral hernia repair

components: one is the main or first biomaterial component, to which another is added in order to meet the specific function that can be performed first, so that the first material assumes the role of tissue integration, while the second is in contact with the peritoneal surface and modulates the behavior of this interface. The first component is usually a reticular prosthesis PP or polyester type; the latter may be absorbable or nonabsorbable, constituting a real barrier between the core material and the peritoneum and, in turn, promoting the generation of a mesothelial layer which prevents adhesions [7]. See Fig. 7.4.

Thus, the new classification is as follows:

- Reticular prosthetics

  Not absorbable: polypropylene (high or low density), polyester
  Partly absorbable: polypropylene/polyglactin 910
  Polypropylene/poliglecaprone
  Absorbable: polylactic, polyglactin 910

- Laminar prosthetics

  Not absorbable: expanded polytetrafluoroethylene (ePTFE)
  Silicone, polyurethane
  Absorbable: porcine intestinal submucosa (SIS)

- Composite prosthesis

  Components nonabsorbable polypropylene/ePTFE
  Polypropylene/polyurethane
  Components absorbable polyester/polyethylene
  Polypropylene/polyethylene
  Polypropylene/hyaluronan
  Polypropylene/polydioxanone/cellulose

As previously noted, research in the field of the host response to the implantation of the prosthesis has led to the modification of the PP reticular prosthesis in the sense of creating meshes with fewer biomaterials to expand the size base of pores and lower spatial rearrangement of the filaments, which will facilitate tissue growth between collagen fibers. This has led to the concept of “pore PP prosthesis, broad, and low density,” also called “lightweight,” with a similar behavior in terms of the tissue integration of classic PP meshes; this causes less foreign body reaction and maintains receptor tissue elasticity after implantation [7].

In an extensive and recent review published by Coda et al. [8], a total of 166 products registered as prosthetic biomaterial for abdominal wall repair were identified, of which 80 were made of PP, suggesting the following classification of biomaterials:

1. Prostheses that are composed of a single biomaterial (PP, PET, PTFE, or PU PGA) with the same texture on both sides, mono- or multifilament, with or without drugs included
2. Composite prostheses: made of two or more layers, one of which is simple, while the other or others are resorbable (A) or non-resorbable (B):
   (A) The non-resorbable layer or layers with or without drugs can be of PTFE, PU, PET, PP silicone, or condensed.
   (B) The layer or layers may be resorbable collagen, collagen + PEG+ glycerol + ORC PDO, CMC + HA, PVP + PEG, or O3FA.
3. Prostheses composed of two woven materials:
   (A) Both materials nonabsorbable:
      - With coated filaments (e.g., titanium PP)
      - With interwoven strands (e.g., PP + PVDF)
   (B) Only one filament absorbable:
      - PP monofilament + PGCA
      - PP monofilament + PLA
      - PP multifilament + PG910
      - PET monofilament + PLA
      - PP monofilament + PGACL

This complex classification has been complemented with additional function of molecular weight of the prosthesis, a characteristic, as previously has been mentioned, that is gaining increasing interest. In the aforementioned review, 70 of the 80 registered PP prostheses had no information about molecular weight expressed in g/m^2, and 40 of these also reported on thickness. This has given rise to proposing a classification that focuses primarily on PP reticular prostheses, which is justified because it is the most universal biomaterial used in the repair of abdominal wall hernias [8]:

1. Ultralight prosthesis: <35 g/m^2
2. Artificial light: > 35 <70 g/m^2
3. Prosthetics standard: > 70 <140 g/m^2
4. Heavy prosthetics: > 140 g/m^2

These new classifications of biomaterials are justified by the need to systematize the characteristics of the flood of products that the industry offers. The goal should be to agree on a "common language" that is being used by both surgeons and by the manufacturers of meshes, to collect the important features of the prostheses for application (molecular weight, thickness, tensile strength, wing rupture, elasticity, pore size, etc.) and to establish rules regarding the information that companies are required to provide about their products.

Relevance of the Molecular Weight, Pore Diameter, and Other Prosthetic Features

The purpose of surgical meshes in hernia repair is to reinforce and replace tissue for long-term stabilization of the abdominal wall. The introduction of meshes for inguinal hernia repair has reduced recurrence rates significantly.

The type of prosthetic mesh used for inguinal hernia repair is controversial. The traditional densely woven PP mesh induces a profound inflammatory reaction, leading to a firm scar plate with reduced elasticity of the abdominal wall. Theoretically, a lighter and softer mesh might be more beneficial by decreasing nerve entrapment and related pain by creating less fibrosis; it also appears compliant against surrounding tissues. The extent of the foreign body reaction with its provoked scar tissue formation depends on the amount and structure of the incorporated material [9].

The portfolio of meshes should be cost-effective, have no adhesion potential, exhibit excellent tissue integration and minimal shrinkage, have good memory, and be easy to use. Ideal meshes should not promote infection, fistula, or seroma formation and should not limit or negatively affect a patient's normal activity.

Looking for the ideal mesh, the surgeon must now be familiar with their characteristics:

1. *Pore size and molecular weight*
   These two characteristics, closely related, can affect formation of adhesions following intra-abdominal placement, tissue integration, active surface area, elasticity, and memory.

   The monofilament mesh with a pore size of 2.5 mm seems ideal because a bigger pore size improves the integration into the tissue and also preserves a high degree of elasticity and stability in the implant matrix.

   Prosthetics with small pores (<1 mm) are "heavyweight," whereas those with large pores are "low" weight. However, there are some meshes with low weight but small pores, and some heavyweight polymers have large pores.

   Because porosity is more difficult to measure than weight, the term most often used by manufacturers is "weight," so the molecular weight-related classification of prosthetics becomes important.

   The use of lightweight meshes seems to reduce acute postoperative pain and discomfort compared with the use of traditional heavyweight meshes [10].

2. *Tensile strength*
   A strong mesh is important for augmentation of the abdominal wall and to prevent recurrences. A tensile strength of 16 N is probably more than sufficient to augment the abdominal wall [10].
3. *Flexibility*
   Prosthetics should be flexible but also have a good memory and should have elasticity in more than one dimension, allowing stretching in more than one direction and then allowing return to original shape. In this way, the mesh should match the abdominal wall dynamics as closely as possible. Flexibility and memory, which make a mesh more adaptable, are also important to optimize the surgical handling of the mesh. The mesh should have an adequate adhesive quality that requires minimal or no additional fixation.
4. *Size*
   Mesh size may have a greater impact on recurrence than surgical technique. A small mesh has been shown to be an independent risk factor for recurrence compared with a large one, irrespective of the type of mesh.

   Mesh size is much more important than the prosthetic biomaterial used. A mesh size of 10 × 15 cm is recommended. If the patient is big or has a large hernia defect, it is advisable to use a larger mesh [11]. A significant trend toward reduced recurrence rates with increasing mesh size was noted (a "large" mesh was most often 10 × 15 cm). Indeed, the use of a small mesh almost doubled the risk for recurrence [12].

   The mesh should overlap the hernia defect by at least 3 cm in all directions. For this goal, the dissection of the preperitoneal space has to be adequate for the size of mesh to ensure that the mesh lies flat against the abdominal wall [13].

   It is not necessary to cut the mesh in order to make it curved. Instead, the dissection should be thorough with a complete parietalization and a wide exposure of the entire preperitoneal space to ensure a flat positioning of the mesh.

In summary: The hernia repair in the TAPP/TEP technique uses a monofilament implant with a pore size of at least 1.0–1.5 mm (usually meaning low weight) consisting of a minimum tensile strength in all directions (including subsequent tearing force). 16 N/cm appears to be most advantageous, summarizing personal and published clinical and experimental experiences.

The Prosthetic Mesh in TEP

A prospective randomized clinical trial that compared early and late outcome measures with the use of a lightweight (Ultrapro™, Ethicon Endosurgery, Blue Ash, OH, USA) mesh and heavyweight (Prolene®™, Ethicon Endosurgery, Blue Ash, OH, USA) mesh in endoscopic totally extraperitoneal (TEP) groin hernia repair concluded that lightweight meshes appear to have advantages in terms of lesser pain and early return to normal activity. However, more patients had hernia recurrence with lightweight meshes, especially for larger hernias; although it failed to reach statistical significance, the difference in recurrence with lightweight mesh was higher. See Figs. 7.5 and 7.6.

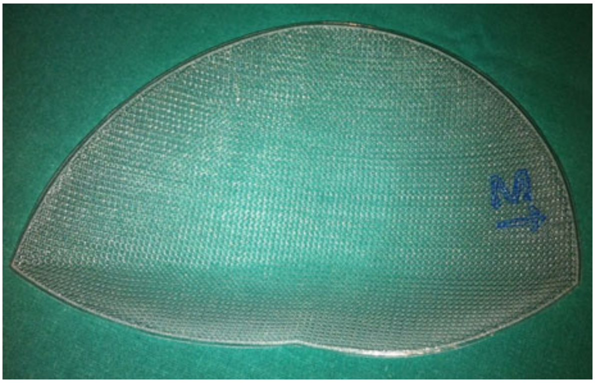

Fig. 7.5 3D Mesh of polypropylene (normal or standard PP)

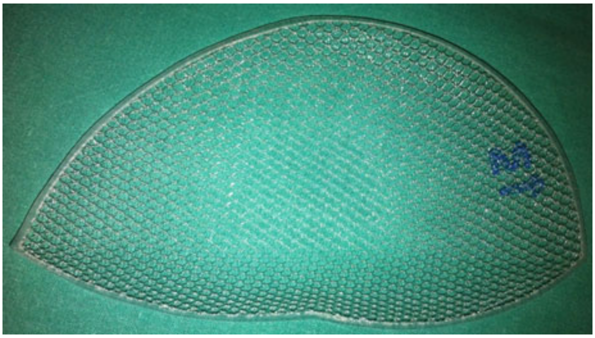

Fig. 7.6 3D light mesh. Light PPL with large pores

Related to the recurrence, the most important factors are the size of the mesh, the friction against the surroundings, and the flexural stiffness of the mesh. Excessive flexure and insufficient friction between the abdominal wall and the mesh may cause the mesh to slip into the opening, and, thus, this will lead to hernia recurrence. As the hernia defect increases in diameter, the adhesion strength between mesh and abdominal wall becomes insufficient to prevent displacement of the mesh into the defect. This effect could be counteracted by using a larger, lightweight mesh or properly fixing the mesh. With the lightweight mesh, there was a tendency for the proximal margin of mesh to roll back during exsufflation. This occurred due to reduced stiffness of the Ultrapro™ mesh that predisposed it to dislocation during exsufflation [14].

In accordance with this, Akolekar et al. compared the outcome following the use of a new lightweight vs. a standard heavyweight mesh during TEP hernia repair. The use of LWM significantly increased patient comfort and reduced long-term chronic pain. However, in patients with larger hernial defects, simple placement of 15 × 10 cm LWM without additional measures to prevent early mesh displacement resulted in an increased risk of recurrence.

Lightweight mesh is exceptionally strong, and any increase in recurrence is not likely to be due to an intrinsic lack of strength. When staples are not used, the surgeon depends on the adhesion between the mesh and abdominal wall to prevent retraction of the mesh into the abdominal wall defect. Also, the intrinsic mesh stiffness plays a part in holding the mesh in place. The adhesion strength must relate to the relative area of adhesion in comparison to the area of the defect.

When the hernia defect increases in diameter, the adhesion strength between mesh and abdominal wall is insufficient to prevent the displacement of the mesh into the defect. This effect could be counteracted by using a larger LWM, thus increasing the adhesion area relative to the defect area. Alternatively, the surgeon could use glue to increase the adhesive bond between mesh and muscle. The use of a heavier and stiffer mesh would have the same beneficial effect [15].

A combination of the laparoscopic TEP approach and use of lightweight mesh without fixation may have advantages over a heavyweight mesh in improving quality of life outcomes after groin hernia repair and provides better functional results than a heavyweight mesh in the long term [14].

The Prosthetic Mesh in TAPP

A randomized trial published by Bittner compares the laparoscopic hernia repair (TAPP) with a standard heavyweight mesh (HW), a pure middle-weight polypropylene mesh (MW) (Fig. 7.5), a lightweight composite polypropylene mesh (LW) (Fig. 7.6), or a titanized lightweight mesh (TLW) using fixation with fibrin glue. The primary endpoint of the study was the incidence of chronic pain of any severity at the site of hernia repair at 1 year.

Chronic pain at 1 year after surgery was cited by 2–8 % of patients depending on the kind of physical activity being carried out; however, no statistically significant difference was found among the four mesh groups. Although there may be some advantages in favor of lightweight meshes during the early postoperative period, at 1 year after surgery no significant differences were found between the HW group and the MW, LW, and TLW groups [16].

Other studies with similar results have been published.

A randomized, controlled clinical trial has compared the outcome after laparoscopic inguinal hernia repair (TAPP) of using titanized-ultralightweight polypropylene mesh without any fixation to using traditional heavyweight polypropylene mesh fixed in a very standardized way by two superficial absorbable sutures.

The use of an extremely lightweight mesh does not play a significant role in the frequency and intensity of chronic pain after inguinal hernia surgery, but it may be able to improve the comfort of the patient during the early postoperative period.

The different anatomical situation of the nerves in the preperitoneal space might explain in part the lower pain experienced after TAPP compared to after open surgery that is seen in the literature and might explain why there is no significant difference between the use of different meshes [17, 18].

Anatomical studies have shown that the preperitoneal space consists of a visceral (approaching the peritoneum) compartment and a parietal compartment (neighboring the abdominal wall) separated by a thin fascia layer (spermatic or lumbar). The nerves are located behind this fascia and thus are in some way protected against the inflammatory foreign body reaction when, as in TAPP, the operation is carried out in the visceral compartment only, thus avoiding direct contact between the mesh and the nerves. This might also explain why there is no difference between the heavyweight mesh and the extra lightweight mesh with respect to long-term pain results. However, in the early postoperative period after implantation of the very lightweight mesh, significantly less seroma production and less impairment of physical activities suggest less acute inflammatory foreign body reaction.

In a systematic review published recently, the goal was to compare the outcomes of laparoscopic inguinal hernia repair (TAPP and TEP) using new lightweight or traditional heavyweight mesh in published randomized controlled trials.

This meta-analysis demonstrated that the use of lightweight mesh in laparoscopic inguinal hernia repair did not offer a reduced risk of chronic pain or any change in risk of recurrence over standard heavyweight mesh. Lightweight mesh offered no improvements in terms of postoperative pain or shortening the time to return to work after operation. No subset changes in the primary outcomes were noted within the TEP and TAPP minimally invasive approaches.

No significant differences were noted in the secondary outcomes of seroma development, pain score at 7 days, or return to work. This is likely due to the low levels of complications in these variables seen in laparoscopic inguinal hernia repair. Systematic reviews have noted that significantly reduced postoperative pain and faster return to normal daily activities are seen with the minimally invasive as compared to the open approach in primary and recurrent inguinal hernia repair [19].

The New Materials: Biological Mesh

The mechanism of action of a permanent prosthetic mesh is to incite an intense fibroblastic foreign body response, resulting in the development of a strong scar plate interface. Although this may provide a strong and durable repair, the chronic inflammatory response to the mesh may also lead to chronic pain in some patients, a sensation of being able to feel the mesh, and stiffness of the abdominal wall with loss of compliance.

Strategies to address these undesirable effects of the chronic inflammatory response are now the focus of intense research. Several comparative studies have shown that reducing the weight (g/m^2) and increasing the pore size of the mesh result in an improvement in postoperative discomfort. Another approach to reducing the problem of postinguinal herniorrhaphy discomfort is to utilize human or animal tissue to create a “biologic prosthesis.” It has been theorized that biologic grafts that guide tissue regeneration might result in less chronic pain and better postoperative recovery than synthetic polymer meshes, though this remains unproven.

These biologic tissue grafts are prepared in order to have characteristics that allow them to perform as a surgical prosthesis for soft tissue repair and are all essentially composed of an extracellular matrix stripped of its cellular components; they all differ substantially only in their source (porcine small intestine submucosa, porcine dermis, or cadaveric human dermis).

In contrast to current prosthetic repairs, where the prosthesis is intended to strengthen the defect lifelong, the extracellular matrix implanted into the host has a direct strengthening function only initially. Subsequently, the matrix is gradually degraded while inducing neovascularization and colonization by host cells that progressively cause a site-specific “remodeling process” until the reconstruction of a new and mature autologous fascia is complete. Finally, this mature structure restores the original supportive function of the abdominal wall.

The arguments for using biologic tissue grafts are that they resist infection and, by remodeling to more normal tissue rather than simply inciting scar tissue as with the plastic meshes, they are more physiologic. It is theorized that this might translate into fewer long-term complications, including less postherniorraphy groin pain [20].

At the present time, the best indication appears to be soft tissue repair in a contaminated or potentially contaminated field where a synthetic permanent prosthesis is contraindicated. A more contentious indication is the routine use for abdominal wall reconstruction, as in elective inguinal or ventral/incisional hernia repair. One argument against their routine use is their cost.

Biologic tissue grafts can be useful in sports hernias, and also in young people, where potential scar formation might cause infertility or future vascular or urologic complications. It is also useful in patients in whom technical difficulties, such as peritoneal flap closure, might arise during TAPP procedure [21].

Widespread adoption of these biological materials for routine uncomplicated hernia repair cannot be justified without clinical evidence of superior value over less expensive prosthetic materials.

Appendix 7.1 Biomaterials Abbreviations

PET	Polyester (polyethylene terephthalate)
PEU	Polyether urethane
PG 910	Polyglactin 910
PGACL	Polyglycolic acid-caprolactone
PGCA	Polyglecaprone acid
PLA	Polylactic acid
PGA	Polyglycolic acid
PP	Polypropylene
cPP	Condensed polypropylene
PTFE	Polytetrafluoroethylene
ePTPE	Condensed polytetrafluoroethylene
ePTFE	Expanded polytetrafluoroethylene
PVD17	Polyvinylidene fluoride
prp	Polyvinylpyrrolidone
PU	Polyurethane

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Chapter 8
Prostheses Fixation During Laparoscopic Inguinal Hernia Repair

Salvador Morales Conde and María Socas Macías

Abstract Surgeons have traumatic and nontraumatic techniques available for the fixation of meshes. The first group includes sutures, staples, and tackers; while some of these are permanent (made of metal and plastic), others are created from absorbable substances and disappear between 3 and 6 months after surgery. However, atraumatic fixation with glue has been one of the most analyzed recent medical advances in abdominal repair surgery, with there being synthetic or fibrin adhesives derived from human plasma, either from a plasma bank or from the patients themselves. As regards the fixation of meshes during laparoscopic repair of inguinal hernias, it is currently being debated whether there is actually a need for the fixation of meshes in certain specific cases.

Keywords Prosthesis • Mesh • Fixation • Laparoscopy • Inguinal • Hernia • Glue • Fibrin • Polypropylene • Cyanoacrylate

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Introduction

In the last 15–20 years, the surgical principles of abdominal wall repair have developed from primary suture techniques of the hernia orifice to ones which involve repair without tension using a synthetic or biosynthetic mesh. This type of repair has led to a reduced number of recurrences and improved functional recovery for patients.

Surgeons have traumatic and nontraumatic techniques available for the fixation of meshes. The first group of techniques includes sutures, staples, and tackers; some can be permanent, created using metal and plastic, and others consist of absorbable substances which disappear between 3 and 6 months after surgery. However, atraumatic fixation with glue has been one of the most analyzed recent medical advances in abdominal repair surgery, since now we have available synthetic or fibrin adhesives derived from human plasma, either from a plasma bank or from the patients themselves. As regards the fixation of meshes during laparoscopic repair of inguinal hernias, it is currently being debated whether there is actually a need for the fixation of meshes in certain specific cases.

The Importance of Fixation Methods in Laparoscopic Inguinal Hernia Surgery

One of the main problems which has been most recently studied in hernia repair has concerned the functional recovery of patients and postoperative pain, both acute and chronic. These factors have been closely related to the prosthetic materials used in fixation in order to carry out the repair without tension. The objective for an ideal fixation method would be to reduce the pain, as much in the short to medium term as in the long term, and to help the patient's functional recovery, while at the same time not increase the number of recurring hernias in the long term [1].

Postoperative pain causes functional limitation to the patient after surgery and a subsequent delayed return to work. It can be acute in the first days after surgery or chronic in the long term. A direct link has been established between the type of mechanical fixation used and the pain, there being at present a tendency towards the use of absorbable sutures and the use of glue, or even no fixation at all. Glues conceptually reduce pain in the short term as well as in the long term, while absorbable sutures reduce the presence of chronic pain, without affecting short-term postoperative pain.

Therefore, in short, we could say that the ideal fixation method would be one which achieves good fixation of the mesh, while avoiding relapses in the long term, as well as the emergence of complications derived from its use. It would also be preferable for it to be technically easy to use and acceptable from an economic point of view.

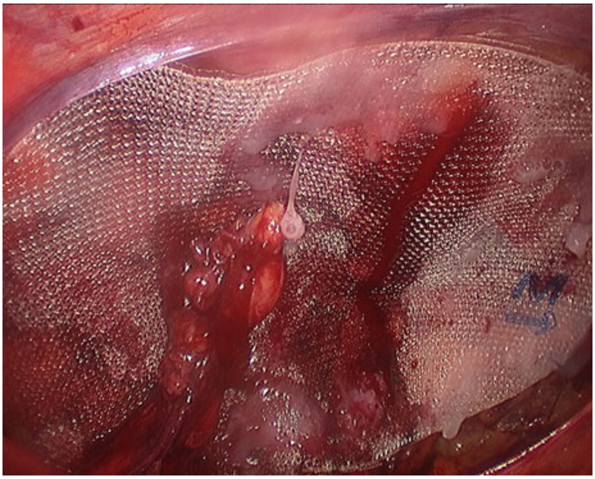


Fig. 8.1 Mesh fixation in TAPP with fibrin glue

Atraumatic Fixation

Tissue adhesives have been the dream of many surgeons in the search for alternatives to sutures or metal staples used in various surgical procedures to join together natural and/or synthetic tissues. The need of surgeons in this case is to avoid the adverse effects, which occur in some occasions related to these mechanical methods, such as nerve entrapments and osteitis. They also reduce the time necessary to carry out these surgical procedures. One of the most important aspects of these adhesives is determined by the fact that these substances have a certain effect on mechanical fixation, in the sense that they stabilize the two joined tissues, maintaining them close for the necessary amount of time to assist the natural healing process of the two affected areas. It is also the case that some of these substances naturally aid the healing process [2, 3]. See Fig. 8.1.

Independently of this adhesive effect, it is advisable to take into account that some of these substances have been associated with a series of collateral effects which can be of benefit to the surgeon, these being either hemostasis actions favoring the closure of surgical wounds and line sealants of suture lines in anastomosis or favoring the handling of intestinal fistulas.

Tissue adhesives can be classified in various forms according to various parameters such as those shown in Tables 8.1 and 8.2.

Using the Liechtenstein method on 21 patients with inguinal hernias, Farouk et al. in 1996 [4] described the repair of a series of hernias using butyl-2-cyanoacrylate adhesive. The study received some critical reviews related to the toxicity of this adhesive associated with the production of local heat and a consequent lesion of tissues and nervous structures. In 1997, Chevrel and Rath [5] described for the first time the use of fibrin glue (FG), a biological glue previously used for the closure of surgical wounds in the fixation of meshes during abdominal hernia surgery.

Table 8.1 Classification of tissue adhesives based on its composition

Naturals	Fibrin (homologous)	Tissucol® o Tisseel® (Baxter, Westlake Village, CA, USA)
	Fibrin (autologous)	Vivostat® (Vivolution A/S, Birkerød, Denmark) Cryoseal® (Thermogenesis, Rancho Cordova, CA, USA)
Semisynthetics	Bovine albumin and glutaraldehyde	BioGlue® (Cryolife, Kennesaw, GA, USA)
Synthetics	Cyanoacrylate	Histoacryl® (Braun, Aesculap AG, Tuttlingen, Germany) Glubran 2® (GEM Srl, Viareggio, Italy) Dermabond® (J&J, Somerville, NJ, USA) Indermil® (Covidien, Norwalk, CT, USA)

Table 8.2 Classification of tissue adhesives based on their mechanism of action and secondary actions

Groups of adhesives/ main composition	Primary mechanism of action	Properties derived from its primary mechanism of action
Fibrin glue	Formation of a stable fibrin clot	Hemostatic, sealant, adhesive, healing
Bovine albumin/ glutaraldehyde	Bonding of tissues and natural-synthetic structures	Adhesive (sealant, hemostat)
Cyanoacrylate	Bonding of tissues and natural-synthetic structures	Adhesive (sealant, hemostat)

Various studies have analyzed the advantages and limitations of the different commercial types of FG: Tissucol® (Baxter, Vienna, Austria), Quixil® (Omrix Biopharmaceuticals, Ethicon Inc. Somerville, NJ, USA), and Vivostat® (Vivolution A/S, Birkerød, Denmark), with the aim of achieving an optimal integration of FG in the surrounding tissues. First of all, the mechanism effect of Tissucol® and Quixil® is based on the reproduction of the final steps of coagulation cascade, thanks to its simultaneous application on its two components: (1) concentrate of human fibrinogen and factor XIII lyophilization, which is reconstituted with aprotinin (antifibrinolytic) and (2) thrombin, reconstituted with calcium chloride. The difference between both lies in thrombin of bovine origin in the first and of human origin in the second.

For its part, Vivostat® is an autologous FG created from the extraction of 120 ml of a patient's blood mixed with sodium citrate. Autologous FG provides increased safety compared to non-autologous FG. The use of the patient's own blood eliminates the risk of the introduction into the organism of infectious material of human or animal origin, as well as hypersensitivity reactions to human and bovine proteins. However, for the time being, there has been no evidence of the transmission of viral hepatitis or HIV infection by this means. In fact, Tissucol® uses plasma obtained in official European plasmapheresis centers and is submitted to a screening process for antigens and antibodies beforehand through thermal inactivation.

The results of the use of autologous and non-autologous FG were compared in a case–control study. It focused on surgical meshes Vypro II® (Ethicon Inc., Norderstedt, Germany) in a group of 20 patients with autologous FG (Vivostat®, Vivolution A/S, Birkerød, Denmark). The results were compared with a group of 20

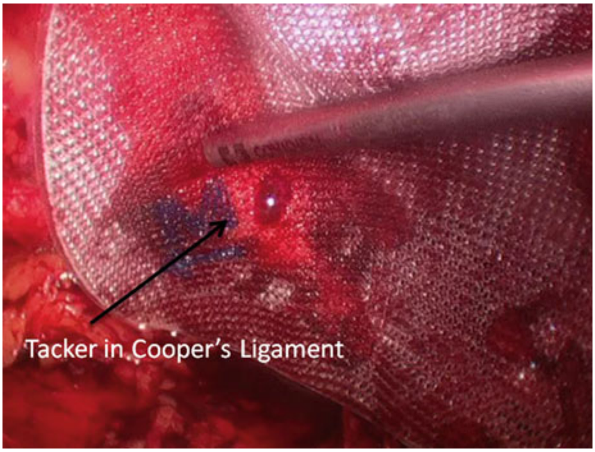


Fig. 8.2 Absorbable tacker in Cooper's ligament

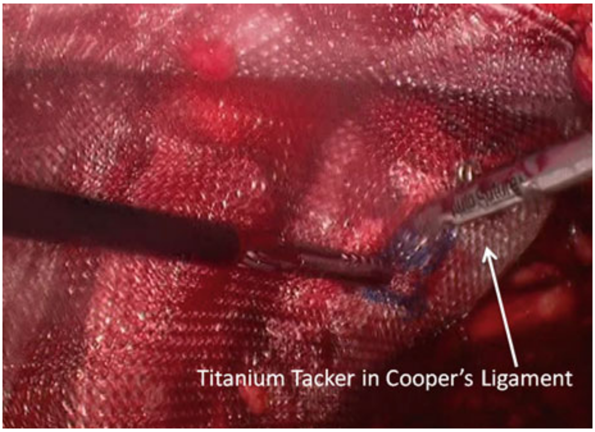


Fig. 8.3 Titanium tacker in Cooper's ligament

patients in which the mesh was fixed with non-autologous FG (Tissucol®, Baxter, Vienna, Austria). The authors highlighted that the level of performance of both products was similar. As a matter of fact, no differences were found in the amount of complications at day 7 and at 6 months, although the cost of autologous FG was higher [6, 7].

Traumatic Fixation Methods

For mechanical traumatic fixation, we can opt for long-life absorbable staples (reabsorption in 1 year) made of polyglycolic and polylactic acid, which maintain tensile strength for up to 3–5 months (Fig. 8.2). Alternatively, we can opt for nonabsorbable staples (Fig. 8.3), usually made of titanium (an inert material, biocompatible and hypoallergenic), which provide a great resistance to traction, making them suitable when attempting to obtain a good grip on the tissues, which guarantees anchorage and firm fastening. They are presented in different formats by different companies (Table 8.3). It is convenient to remember that at present, there are plastic nonabsorbable fixation methods on the market.

When proceeding with the fixation of the mesh using staples or tackers, and with the aim of minimizing the risk of lesions and chronic pain, which is the main inconvenience connected to their use, it will be vital to know with accuracy the anatomy of the area and the location of inguinal nerves. Staples or tackers should be avoided in the "triangle of pain" and in the "triangle of doom" as well as in the area of exposure of nerves by leaving the fascia protector of the nerve intact and minimizing the use of electrocautery (Fig. 8.4). It is well known that the traumatic anchorage of the mesh to the pubis will invariably determine postoperative pain in a high percentage of cases, although many laparoscopic surgeons continue to carry this out. It is fundamental to avoid these "hot spots" for the development of pain and lesions, as well as reduce the number of tackers used in each patient (maximum of 4), in order to improve results in the short and long term.

Fixation Versus Non-fixation

With the aim of minimizing the risk of chronic pain comes the idea of eliminating traumatic fixation of the meshes, as this type of system is associated with possible nerve entrapment causing acute long-term pain, as well as a higher risk of vascular and secondary visceral lesions. As a result of this, different authors started to consider not fixing the mesh as an alternative, analyzing whether this increased the recurrence rate. This showed a recurrence rate of between 0.7 and 0.5 % in those controlled studies which compared fixation with staples to non-fixation, respectively, and between 0.6 and 0.4 % in those which compared fixation with staples compared to fixation with fibrin. With regard to chronic pain, the different studies published highlighted a significant reduction in chronic pain in those patients which were operated on using staple fixation, as opposed to those in which the mesh was not fixed. Likewise, there was a reduction of pain in those patients which were operated on using fibrin fixation as opposed to fixation with staples. However, controlled studies do not currently exist which compare non-fixation to fixation with fibrin. There are also few cases which compare fixation with absorbable staples; therefore, it is not possible to reach a conclusion.

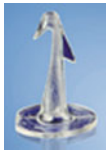
As a result of this, "non-fixation" of the mesh is proposed as a cost-effective alternative, since in the different published series, it is not seen as increasing the recurrence rate, and it is also associated with a lower cost, less operating time, and a shorter stay in hospital. It is due to these points that a policy of non-fixation is recommended, but in a selective manner, depending on the type of hernia. As a result of this, non-fixation of the mesh could be considered in the case of types L I-II and M I-II hernias, while in cases of direct and large hernias (MIII and LIII),

Table 8.3 Devices for mechanical traumatic fixation

Staplers	Metallics	Absorbables	Plastics
Helicoidals	ProTack® (titanium) 	AbsorbaTack® (massif) 	
		SorbaFix® (hollow) 	permafix® (hollow) 

(continued)

Table 8.3 (continued)

Staplers	Metallics	Absorbables	Plastics
U-shaped	EMS® Stapler® 	Securestrap® 	
Circulars	SALUTE® 		
Others			PermaSorb®  I-Clip® 

Images courtesy of Covidien, Dublin, Ireland (I-Clip®, ProTack®, AbsorbaTack®); Davol, Warwick, RI, USA (Salute®, permafix®, SorbaFix®, PermaSorb®); Ethicon Endo-Surgery, Blue Ash, OH, USA (EMS®, Securestrap®)

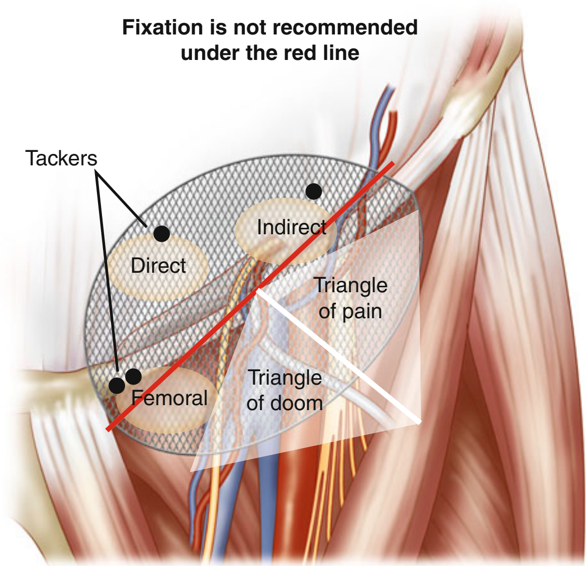


Fig. 8.4 Traumatic fixation must respect the triangle of doom and the triangle of pain

fixation using fibrin glue for the fixation of the mesh is recommended, minimizing the risk of acute and chronic pain, as opposed to the use of staples.

The Influence of Fixation Methods in Recurring Hernias

Studies related to the use of meshes in the repair of hernias show a very low level of recurrence. At present, there is a revolution in this aspect, moving from the use of a high number of permanent sutures and metal staples towards a tendency of reduction in these permanent fixation methods, or even substituting them with absorbable methods or glues and analyzing whether these changes are going to influence recurrences.

The use of glues as the only fixation method or assisting in the reduction of mechanical means without influencing the number of recurrences is being widely studied. The results of existing studies have shown a minimal percentage of recurrences when using hernioplasty with mesh and fixation with FG, something which has not increased in comparison with mechanical fixation or stitches [2, 8, 9].

As regards the repair of inguinal hernias via laparoscopic surgery, there are studies that show no significant differences exist between the groups in which meshes were fixed with FG or staples, using a transabdominal preperitoneal approach or TAPP. A study which also provides information regarding this is the case–control study developed by Langrehr et al. [10], in which a group of 14 patients were operated on using this approach (TAPP) using a Vypro II® mesh (Ethicon Inc., Norderstedt, Germany) fixed with FG. These patients were monitored after the first week and then 3 and 6 months after surgery. These were compared with a group of cases which were analyzed retrospectively in which the same type of mesh was fixed using metal staples; no recurrences were observed in either of the two groups.

In the repair of inguinal hernias using a totally extraperitoneal endoscopic technique (TEP), the number of recurrences is also low with no significant differences compared to when a fixation method is used. The study carried out by Schwab et al. [11] found the rate of recurrences, with a follow-up on average at 24 months, of 2.3 % and of 5.7 % (p-value = 0.443) using fixation with FG and with metal staples, respectively. The authors attribute the lesser rate of recurrences in the FG group to the uniform fixation of the mesh in the inguinal region, including areas which are inaccessible to fixation with staples. The combination of FG with other types of meshes using the TEP approach found the same results, taking into account that the study by Edelman et al. [12] was initially designed to compare the results between a bioactive extracellular matrix mesh and another polypropylene mesh, both being fixed with FG.

The Influence of Different Fixation Methods on Postoperative Pain

One of the main complications derived from the repair of hernia defects is the emergence of acute postoperative pain with the risk of it becoming chronic. Its repercussion to quality of life of patients is indisputable. The use of mechanical means (sutures, staples, etc.) has been highlighted as one of the possible causes of the appearance of postoperative pain due to the damage that it causes in the muscular, bone, and nerve structures. The patient's perception of pain is of great importance as a measurement of the success of hernia repair. For its evaluation, the majority of analyzed studies have used the Visual Analogue Scale (VAS), in spite of the critical reviews received for the high subjective component associated with it.

Acute Pain

Acute pain has been defined as that which appears during the first 3 months after surgery. Its presence is practically constant after hernia repair; however, its intensity is light or moderate in the majority of cases, and in only 3 % of these cases is it of high intensity.

Various studies have shown that the occurrence of acute pain diminishes after abdominal wall surgery when fixation with mechanical methods has been avoided. Those using FG produce a uniform fixation of the prosthetic materials which is related to a decrease of nerve entrapment associated with staples and stitches. In spite of the majority of studies making reference to laparoscopic inguinal hernia approach, the study by the Hidalgo et al. [13] group stands out. In this study, the results of the pain incurred by 55 individuals with a bilateral hernia, operated in open surgery following the Lichtenstein technique, were compared when the polypropylene mesh was fixed on the left-hand side of the inguinal area with FG (Tissucol® Duo S Immuno, Baxter, Vienna, Austria) and on the right side with sutures, with follow-up monitoring of patients in the short term (48 h and 7 days) and long term (1, 3, 6, and 12 months). In the short term, the individuals referred to more pain on the right-hand side of the inguinal area (the side fixed with stitches), although this was always of a tolerable level.

The majority of studies are related to the fixation of meshes in laparoscopic inguinal hernia surgery. The first of two random clinical trials using laparoscopic surgery following TAPP repair had a total of 600 patients divided into four treatment groups of 150 in each. The method used for the fixation of the polypropylene mesh was different in each one of the groups. Short-term monitoring was carried out, which included pain evaluation by a surgeon who was unaware of the procedure used, at 6, 12, 24, 48, and 72 h and at 7, 15, and 30 days after surgery. A 4-category VAS was used to measure the amount of pain. The authors also evaluated the time it took for the patient to return to work. The patients in which a mechanical fastening means was used referred to the main point of pain as being at 48 h after surgery. This peak was brought forward by 24 h in those patients in which FG had been used. The patients treated with Tissucol® referred to low-intensity pain, which then disappeared by the seventh day. This intensity was less than that shown by the rest of the groups. The patients in the group which had their meshes mechanically fixed were those which referred to greater pain, which could continue even up to 1 month after surgery. The average number of days in which the patients treated with Tissucol® returned to work was 5 (the range being between 3 and 8), while for the other groups it oscillated between 7 and 9 (p-value $<$ 0.05).

The second study referred to is the random clinical study by Lovisetto et al. [14], which involved the participation of 197 individuals with a femoral or inguinal hernia for which a hernioplasty was carried out. These also followed the laparoscopic TAPP technique, using a macroporous polypropylene mesh. Two groups of patients were set up: in the first, the mesh was fixed with FG and in the second with staples. The main point of interest was early and delayed neuralgia defined as the presence of hyperesthesia, a burning sensation, and a sharp stabbing pain in the inguinal area. In addition to this, the patients were examined by an assessor, who was unaware of the type of repair used, at 1, 3, 6, and 12 months after surgery, in order to determine the presence or absence of postoperative neuralgia. The first month after surgery, the average score on the VAS was significantly less in the Tissucol® group compared with that of staples (19 mm vs. 26 mm, respectively p-value $<$ 0.05). The effects of pain on the functioning state of the patients were evaluated using a modified version of the quality of life survey related to the 36-item Short-Form General Survey (SF-36). The results for those items referring to pain and its interference with normal working activity were significantly different in the first month of monitoring (p-value $<$ 0.01). According to the score, once the first month had passed after surgery, postoperative morbidity was reduced in the Tissucol® group compared to the staples one. This was accompanied by a faster return to daily activity in the first ones (23.2 vs. 22.6; p-value $<$ 0.05). A reduction in the number of recuperation days before a return to normal daily activity was observed between the FG and staples groups (7.9 days vs. 9.1 days, respectively; p-value < 0.001). Even so, we should mention the criticisms received by the authors for the use of an instrument which was not validated for the measuring of quality of life related to health.

There are also case–control studies on the subject. One of these included 250 individuals operated on using a laparoscopic approach, also following a TAPP repair. FG was used for the fixation of 170 polyester meshes and 75 monocryl-prolene meshes, which were compared with 245 patients in which titanium tackers were used for the fixation of the meshes. During the monitoring of patients, which included evaluation at 10 days and 3 and 12 months, the authors did not find any significant differences in postoperative pain. In addition to this, approximately 90 % of the patients who had undergone atraumatic fixation returned to work 7 days after surgery, while the rest did so in less than 14 days. Another case–control study using the same TAPP technique compared 2 homogenous groups of 68 patients, each one with meshes fixed using FG and with conventional staples. The authors evaluated the pain with a VAS ranked from 0 to 10, after a week, a month, and a year from the date of the operation. Some patients in the staple group referred to pain in the area of the operation even 30 days after surgery (AF = 0.0 % vs. staples = 5.9 %, p-value < 0.05). Lastly, Olmi et al. [15] published a series of 230 operated cases of inguinal hernia with a polypropylene or polyester mesh, fixed with FG following the TAPP approach, with none of them showing any signs of pain on the seventh day after surgery.

As regards the published studies developed using laparoscopic repair following the TEP technique, Lau [16] carried out a random clinical test of 93 patients, all of which had a bilateral inguinal hernia. The sample was divided randomly into two groups: fixation of a polypropylene mesh with staples and another group with FG. The author evaluated the intensity of postoperative pain using a VAS and the need for analgesics during postoperative hospitalization. Short- (up to 6 days) and long-term (3, 6, 12, and 24 months) monitoring were carried out, observing how postoperative pain was assessed short term, when resting or as a result of a cough reflex. It did not show any significant differences between the two groups. Even so, the average analgesic requirement was significantly less in the FG group as opposed to the staples group (p-value $= 0.034$), with no statistically significant difference in the time needed to return to carrying out physical and work activity between both groups.

Chronic Pain

Chronic pain is defined as any postoperative pain which lasts for more than 3 months after surgery. The data analysis by the Swedish Hernia Register [17] shows a prevalence of chronic pain in 29 % of patients operated on for an inguinal hernia, which shows the importance this has on hernia surgery.

Existing studies on open inguinal hernia surgery show a decrease in chronic long-term pain when meshes are fixed using FG. Benizri et al. [18] developed a case–control study in which they carried out an open technique through the use of a tampon and polypropylene mesh. The authors monitored 57 individuals in which FG was used to fix the mesh. As a control group, patients were selected retrospectively who had had surgery using the same technique, but using nonabsorbable sutures, observing that the incidence of chronic inguinal pain was significantly less in the FG group (3.5 % vs. 22.8 %, p-value = 0.042). In respect to the study on the Lichtenstein technique previously referred to in relation to chronic pain, Hidalgo et al. [13] monitored participants in the long term (1, 3, 6, and 12 months), showing that a year after surgery, not a single patient was suffering from chronic pain.

With regard to the laparoscopic approach, in the clinical trial by Lovisetto et al. [14] in which the TAPP technique was used, the patients were assessed at 1, 3, 6, and 12 months after surgery in order to determine the presence or absence of postoperative neuralgia. Significant differences were observed in the third month (11 mm vs. 23 mm; p-value < 0.001 with FG and staples, respectively) and in the sixth (11 mm vs. 20 mm; p-value < 0.001). In addition to this, a modified version of the quality of life questionnaire related to health SF-36 was used in which scores for those items referred to as pain and its interference with working life were significantly more favorable in the third and sixth months of monitoring in the group treated with FG (p-value < 0.001). For its part, the previously described case–control studies carried out using the same TAPP technique by Santoro et al. [19] and Ceccarelli et al. [20] did not show significant differences in chronic pain.

With regard to the publications referring to long-term pain after surgery using the TEP technique, Lau [16], in his random clinical trial, evaluated the intensity of chronic pain during long-term monitoring (3, 6, 12, and 24 months). The prevalent differences in chronic pain among both groups during the monitoring were not statistically significant [FG = 20.0 % (IC 95 %, 7.6–32.3 %) vs. staples = 13.2 % (IC 95 %, 2.5–23.9 %), p-value = 0.418]. For his part, Schwab et al. [11], in his case–control study using the same TEP technique, included 87 patients in whom four titanium tackers were used to fix the mesh and another 86 individuals in whom FG was used to fix the mesh. The authors observed significant statistical differences in the percentage of individuals suffering from chronic pain, defined as persistent pain 3 months after surgery (FG = 4.7 % vs. staples = 20.7 %, p-value = 0.002). Similar results were shown by Topart et al. [21], who compared a series of 66 cases in which the fixation of the mesh through the TEP approach was carried out with FG, with results observed in 102 patients in whom two or three titanium tackers were used. The authors of this last study highlighted a significant decrease in chronic pain with FG using a VAS (p-value = 0.037). However, the heterogeneity of the two groups compared should be noted (e.g., the greater percentage of women and recurring hernias in the staples group).

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Chapter 9
Laparoscopic Ventral Hernia Repair

Juan Guadalajara Jurado and Julio Gómez Menchero

Abstract Ventral hernias are exciting surgical challenges that encompass both treatment and prevention. Between 3 and 13 % of all laparotomy incisions will later develop ventral hernias; this rises to 40 % for those cases that develop surgical wound infections during the postoperative period. This high percentage produces important consequences, economic ones that impact the individuals who experience them as well as the healthy population. In 1991, Leblanc et al. compared the laparoscopic approach in ventral hernia to conventional ventral hernia surgery, in order to compare the results in terms of recurrence and morbidity, as well as the comfort of the patients. Since the beginning of the laparoscopic approach, there have been controversies regarding its indications, surgical techniques, materials, fixation methods, complications, and results. We demonstrate the advantages of this technique, as well as the principal steps that should be taken for a successful ventral laparoscopic hernia repair.

Keywords Hernia • Ventral • Incisional • Surgery • Laparoscopy • Mesh • Midline • Fixation • Complications

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Introduction

Ventral hernias are exciting surgical challenges that encompass both treatment and prevention. Between 3 and 13 % of all laparotomy incisions will later develop ventral hernias; this rises to 40 % for those cases that develop surgical wound infections during the postoperative period [1]. This high percentage produces important consequences, economic ones that impact the individuals who experience them as well as the healthy population.

In 1991, LeBlanc and Booth [2] compared the laparoscopic approach in ventral hernia to conventional ventral hernia surgery, in order to compare the results in terms of recurrence and morbidity, as well as the comfort of the patients. Since the beginning of the laparoscopic approach, there have been controversies regarding its indications, surgical techniques, materials, fixation methods, complications, and results. Some of them are still ongoing [3].

Definition

The origin of the ventral hernia is a fascia defect of the abdominal wall generally occupied with any part of the intra-abdominal content [4], commonly intestine or the omentum.

Classification

The reason why there are no common criteria for the surgical treatment of the ventral hernia is the absence of uniformity by the different authors in naming and classifying this pathology in their studies.

We present the classification of the European Hernia Society (EHS) [5], recognized by many groups because of its simplicity and clarity. According to the EHS, ventral hernias are divided in two groups:

1. *Primary*: there are many factors involved in its origin.
2. *Secondary or Incisional*: it appears subsequent to a previous surgical incision in the abdominal wall.

Both groups have been further subdivided, by location and size.

Primary hernias (Fig. 9.1) are classified by size and location (Fig. 9.2), and incisional hernias are classified by the size (length and width), location, and rate of recurrence (Fig. 9.3). In cases of multiple hernias, the most distal edge is used to measure the diameter (Fig. 9.4).

In this chapter, we will focus only on midline ventral hernias.

EHS Primary Abdominal Wall Hernia Classification		Diameter cm	Small <2cm	Medium ≥2–4cm	Large ≥4 cm
Midline	Epigastric				
	Umbilical				
Lateral	Spigelian				
	Lumbar				

Fig. 9.1 EHS classification for primary abdominal wall hernias (Reproduced with permission from Muysoms et al. [5])

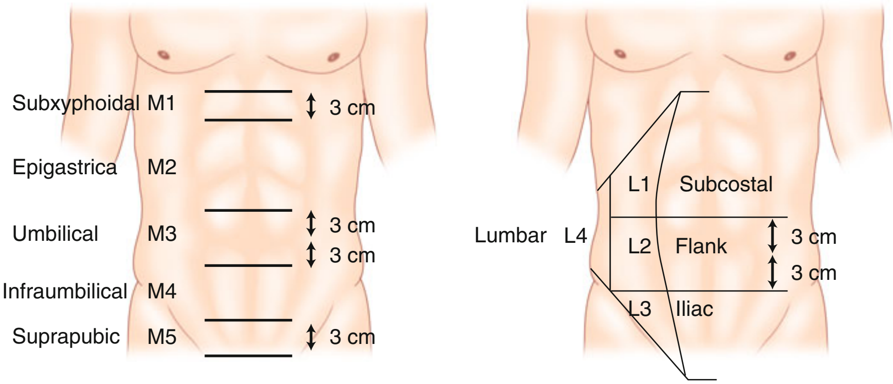

Fig. 9.2 Classification according to the location of incisional ventral hernias (Adapted with permission from Muysoms et al. [5])

Indications

The risk of developing, at any time during the hernia evolution, strangulation of the hernia content [6], damage of the skin that covers the hernia, or loss of home of the herniated intestine always makes it necessary to repair ventral hernia in adults by open or laparoscopic approach [7], avoided only in cases of absolute contraindications to the surgical procedure. There is no hernia measure that indicates or dismisses the laparoscopic approach to ventral hernia.

It is accepted that hernias under 3–4 cm can be repaired using conventional surgery and local anesthesia in an ambulatory setting [8]. Some authors establish 10 cm

EHS Incisional Hernia Classification		M	L	Recurrent incisional hernia?		Length cm	Width cm	Width		
				Yes	No			W1 <4 cm	W2 4–10 cm	W3 >10 cm
Midline	M1 subxiphoidal									
	M2 epigastric									
	M3 umbilical									
	M4 infraumbilical									
	M5 suprapubic									
Lateral	L1 subcostal									
	L2 flank									
	L3 iliac									
	L4 lumbar									

Fig. 9.3 EHS classification for incisional hernia classification (Reproduced with permission from Muysoms et al. [5])

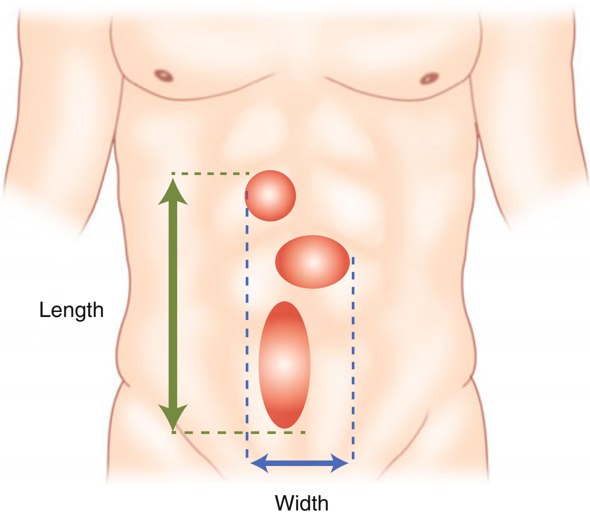

Fig. 9.4 Incisional hernias: multiple diameters (Adapted with permission from Muysoms et al. [5])

as the longest size in transversal diameter for laparoscopic repair, while others set this limit at 15 cm.

It seems to be reasonable that limits depend on the technical difficulties of handling the instruments and the mesh in the abdominal cavity [8, 9].

Some exceptions, like small hernias in an obese patient or giant ventral hernias, can benefit from a laparoscopic approach using component separation in order to reduce the transverse diameter of the hernia hole and then completing the treatment by open [10] or laparoscopic surgery [11].

Surgical Technique

Technical variability between different surgical groups is essentially based on the mesh choice and the fixation method to the abdominal wall.

The common steps in the ventral hernia repair using a laparoscopic approach are as follows: patient positioning, pneumoperitoneum procedure, port placement, adhesiolysis, hernia content replaced inside the abdomen, and fixation of the mesh overlapping the hernia hole.

Patient Positioning

The patient is placed in a supine decubitus position, usually with arms fixed to the body. In obese patients, very often both arms are separated in order to allow better maneuverability of the instruments.

Pneumoperitoneum

Pneumoperitoneum technique will depend on the previous surgery performed on the patient and the surgeon's suspicion of intraperitoneal adhesions to the abdominal wall. A Veress needle in the left hypochondrium is commonly used; previously a nasogastric tube was used in order to avoid a stomach puncture. In case of relevant adhesions, a port of vision is recommended.

Adhesiolysis and Replacing Hernia Content (Fig. 9.5)

Adhesions must be carefully managed with gentle traction maneuvers, using careful dissection whenever possible. Sharp dissection can be performed using an endoscopic scissor; avoid electric scalpels unless you are absolutely sure that there is not a hidden loop of intestine behind the adhesion.

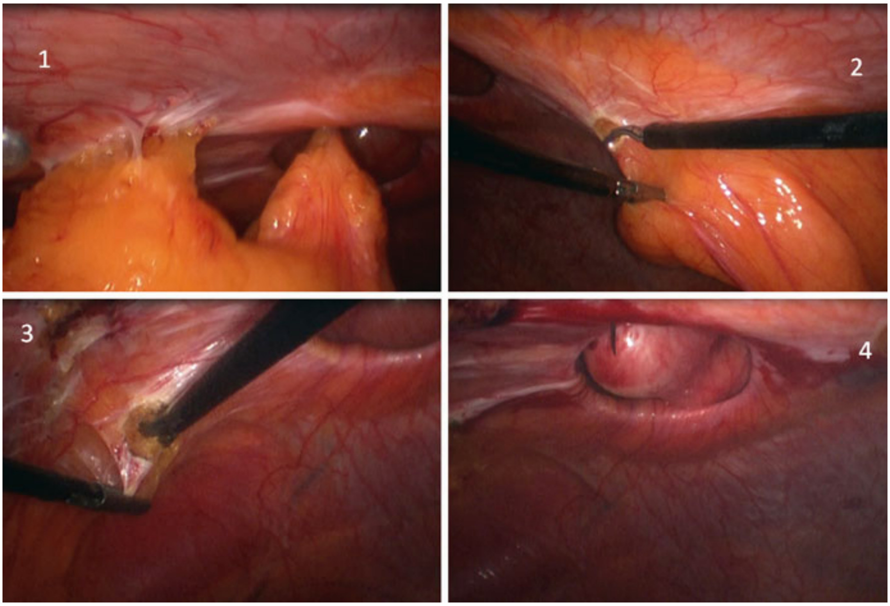

Fig. 9.5 Laparoscopic ventral hernia repair. *1* ventral hernia, *2* section of round ligament, *3* section of umbilical ligament, *4* measure of the diameter of the hernia using a needle

Replacement of the hernia content is managed in a similar way. Exceptionally, external pressure maneuvers are needed to more easily replace the content into the abdominal cavity.

Placement and Fixation of Mesh (Fig. 9.6)

A real measure of the hernia edge is needed, using an intramuscular needle inserted into the skin, in the four cardinal points of the hole. Mesh must exceed the size of the hernia hole by at least 3 cm; many authors today recommend a 5 cm mesh overlap.

In the next step, the mesh is rolled on its axis and introduced into the abdominal cavity through a 11 or 12 mm port or wrapped in sterile plastic to avoid contamination.

Double crown technique is generally used to place the mesh in the abdominal wall [12], fixed by absorbable or nonabsorbable tackers, preserving a distance of 1 cm between them, in both fixation lines, internal (edge) and external. Details and controversies will be discussed later in this chapter.

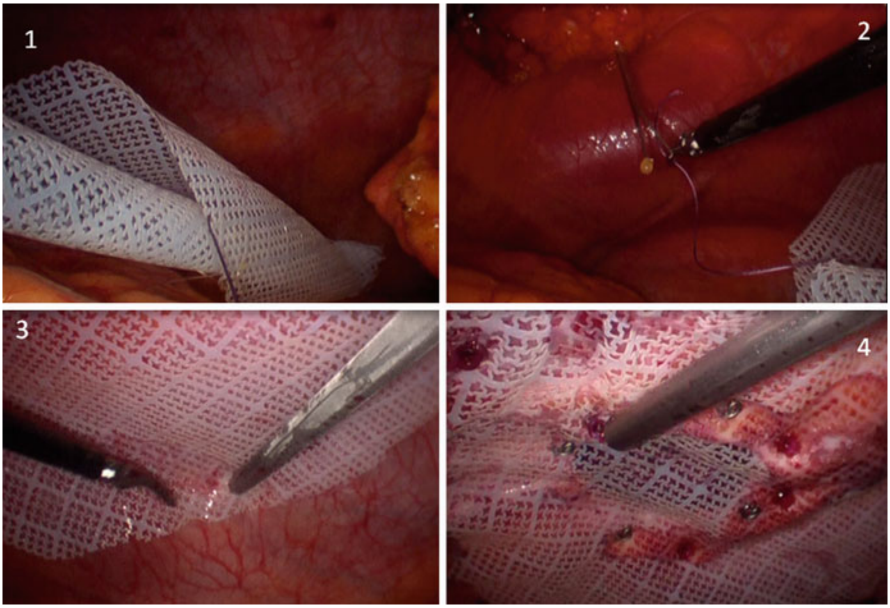

Fig. 9.6 Laparoscopic ventral hernia repair. *1* rolled PTFE-c (Omira) mesh into the abdominal cavity, *2* cardinal points using a Reverdin (proxy) needle, *3* tackers in the outer crown, *4* tackers in the inner crown (absorbable tackers and nonabsorbable tackers, aiming for a lesser rate of pain and adherences)

Complications

Complications can arise during the procedure or once it has been completed. In the sections that follow, we will describe the most common complications related to this procedure.

Intraoperative

These are usually related to the Veress needle puncture and the laparoscopic port placement. Adhesiolysis and hernia content replacement maneuvers may produce bowel perforation, hemorrhage, and visceral injuries [13].

Hemorrhage management includes, in addition to traditional methods, energy sources, sutures, clips, and hemostatic substances involving human thrombin.

Intestine perforation secondary to the treatment of ventral hernia is an added risk, both in open and laparoscopic surgery, with similar consequences [14]. One out of six of these patients will suffer this complication secondary to maneuvering

Table 9.1 Classification of seromas after laparoscopic ventral hernia repair

Type 0		No clinical seroma	No clinical seroma
	0a	Neither clinical nor radiological seroma	
	0b	No clinical seroma, but it can be detected by radiological exams	
Type I		Clinical seroma lasting less than 1 month	Incident
Type II		Clinical seroma lasting more than 1 month: seromas with excessive duration	
	IIa	Between 1 and 3 months	
	IIb	Between 3 and 6 months	
Type III		Minor seroma related-complications: symptomatic seromas that may need medical treatment	Complication
	IIIa	Clinical seroma lasting more than 6 months	
	IIIb	Esthetic complaints of the patient due to seroma	
	IIIc	Important discomfort which does not allow normal activity	
	IIId	Pain	
	IIIe	Superfitial infection with cellulitis	
Type IV		Mayor seroma related-complication: seromas that need to be treated	
	IVa	Need to puncture the seroma to decrease symptoms	
	IVb	Seroma drained spontaneously (applicable to open approach)	
	IVc	Deep infection	
	IVd	Recurrence related to seroma	
	IVe	Mesh rejection related to seroma	

Used with permission of Morales-Conde [15]

dissection of adhesions, hernia content replacement, or first port placement. It can occasionally occur during the placement of the Veress needle.

An unnoticed intestinal perforation could become a serious threat to the life of the patient.

Postoperative

Postoperative complications related to surgical technique can be divided into minor complications (wound infection, seroma, hematoma, paralytic ileus, pain) and major complications (hemorrhage, prosthesis infection, sepsis, intestinal perforation, recurrence, and mortality).

A recent meta-analysis reported that wound infection in laparoscopic repair is lower compared to open surgery.

Seroma is the most prevalent complication of this surgery, and this still presents in almost 80 % of the cases, although it usually does not cause problems or any inconvenience to the patient. Recently, a classification of five types of seromas was developed (Table 9.1), ranging from the nonobvious clinical seroma to the seroma that needs treatment [15].

Hematoma usually is limited to minimal bleeding or hemorrhagic suffusions located in wounds due to trocar placement or in the area where the mesh has been fixed. Hematomas caused by tacker placement can simulate small recurrences in imaging studies in early stages.

Postoperative abdominal pain should usually be mild and tolerated by the patient during the first 24 h of follow-up. Intense pain after laparoscopic surgery should make us suspect peritoneal inflammation and often involve a laparoscopic review to rule out any serious complication.

Chronic pain is frequently related to transfascial sutures or tacker placement. It is generally caused by nerve entrapment in the fixation area. The use of sealants of fibrin in mesh fixation could reduce the number of tackers and decrease chronic pain.

Treatment of these patients ranges from opiates and nonsteroidal analgesic to local anesthetics infiltration and even removal of tacker or transfascial sutures as the last alternative.

Mesh infection incidence has been reported in 0.7 % of the cases [13–16]. It is usually related to abscesses above or below the prosthesis, disseminated peritonitis, or adhesions between the bowel and the mesh. Patients who previously were subject to open hernia repair and suffered mesh infection reported a higher incidence of mesh infection.

An excessively thin skin above the hernia sac, postoperative seroma punctures, or abdominal wall hematomas are the most frequent causes of mesh contamination.

We must be careful to avoid contamination when we manipulate the mesh before it is introduced inside the abdominal cavity, using new gloves and instruments, wrapping the mesh, and even using skin protector devices such as OPSITE® (Smith & Nephew, London, England).

Mesh infection treatment often requires mesh removal, but exceptionally a percutaneous drainage of the abscess may be useful [16].

Leblanc et al. reported a recurrence incidence of ventral hernia in laparoscopic surgery as ranging between 1 and 16 % [17]. Tobacco and previous hernia recurrence are described as risk factors for recurrence [18]. The most recent meta-analysis [1, 4, 6] concludes that there are no differences between laparoscopic and open surgery in hernia recurrence. However, the latest reviews note that recurrence could be lower in the laparoscopic approach [19]. Multicenter studies based on randomized controlled trials with a longer follow-up are needed to obtain more conclusive and reliable results.

Mortality associated with laparoscopic hernia repair is as low as 0.05 %, but it can increase to 2.8 % in cases of bowel injuries, ranging from 1.7 to 7.7 %, depending on whether bowel injury is noticed or not during the procedure [20].

Controversies

The main controversies arising from ventral hernia repair are related to the approach technique (open or laparoscopic). Other important issues around which there is controversy are patient selection, mesh choice, fixation device, and guidelines to be followed in the case of bowel perforation.

Patient selection has already been addressed earlier in this chapter, but we would like to emphasize here that those hernias greater than 184 cm^2 would be appropriate for an open repair.

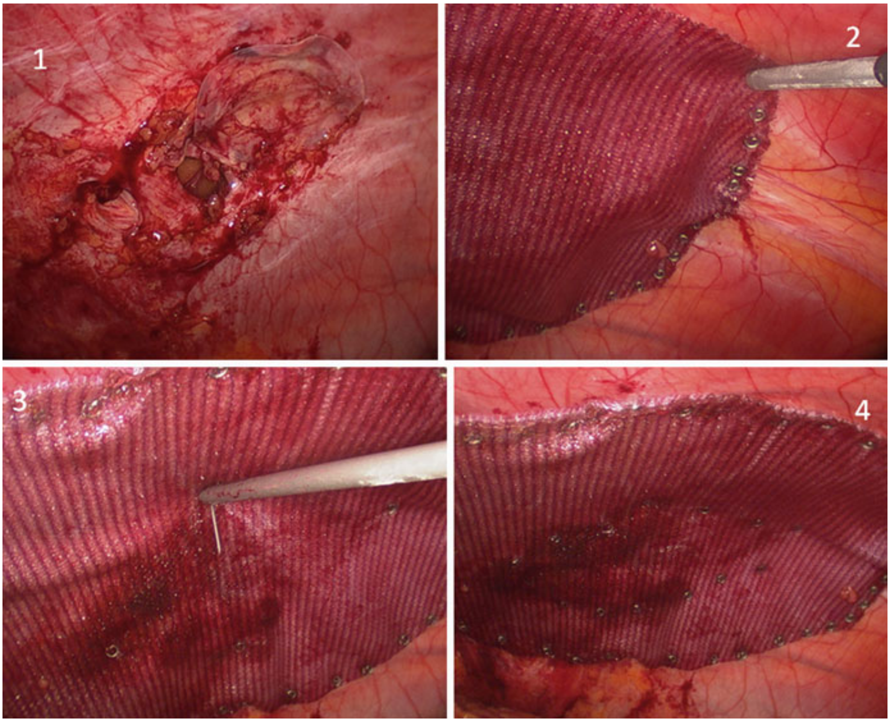

Fig. 9.7 Laparoscopic incisional hernia repair. *1* ventral hernia recurrent, with a previous hernioplasty with plug, *2* outer crown (Sepramesh mesh, tackers at 1 cm), *3* tackers in the inner crown, pointed out by needle, *4* double crown technique

The choice of mesh influences technical maneuvers and surgical results. Several years ago, hernia used to be repaired by meshes thicker than the current ones; these thicker meshes were more difficult to fix using tackers and possibly tended to increased shrinkage. More studies are needed to assert what type of mesh is better. As a general rule, one should use a mesh with a low rate of adhesions, simple or composed, and allow a flap of 5 cm. It is important that a mesh can be easily rolled and handled inside the abdominal cavity, in order to allow for a comfortable setting for today's fixating devices and for a rapid tissue integration. A low rate of infection and the strength of the mesh are very important too. An adequate drainage through the mesh can reduce the seroma incidence [21]. See Fig. 9.7.

There are no significant differences between the use of transfascial stitches and tackers [3], although stitches seem to be more cost-effective. Otherwise [22], placement of stitches is usually more complex, related to higher postoperative pain and worse cosmetic results.

Fibrin glue decreases postoperative pain [23] and contributes to an optimal integration of the mesh to soft tissues, decreasing the number of tackers or sutures needed, but it will increase significantly the cost of the procedure. Currently, absorbable tackers might be an alternative option to prevent adhesions and chronic pain. See Fig. 9.8.

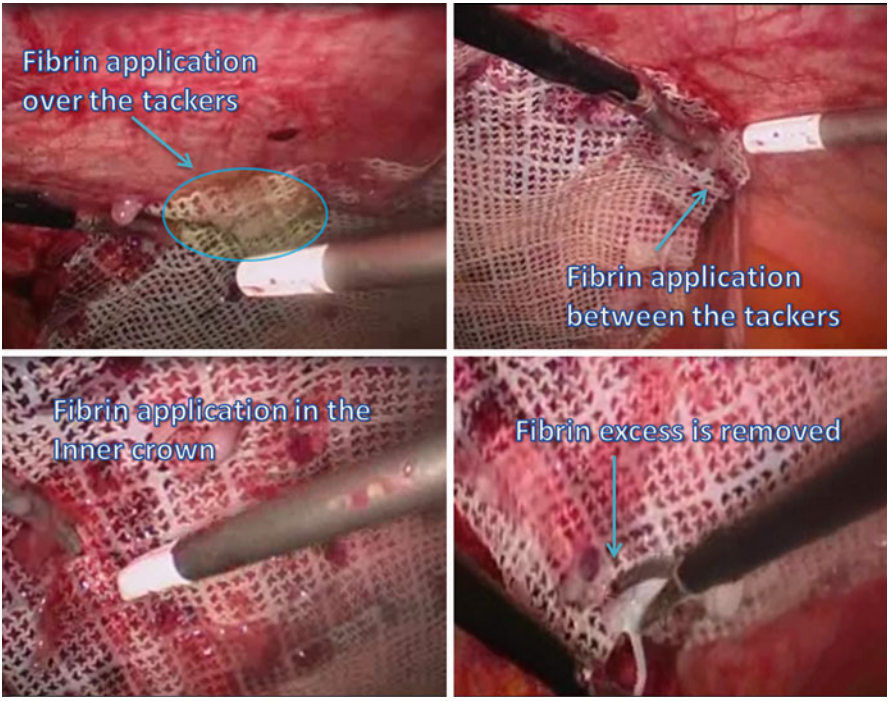

Fig. 9.8 Laparoscopic ventral hernia repair (double crown modified with fibrin glue). *1* fibrin over the tackers to avoid adherences, *2* fibrin between the tackers to minimize the number of tackers, *3* fibrin in the inner crown to reduce the seroma in the hernia sac and minimize the number of tackers, *4* the excess of fibrin must be removed

Bowel injury occurs in 1.78 % of the cases, and it is not related to the surgeon's experience; 92 % of the cases are related to the small bowel. The procedure's success will depend on the size of the intestinal injuries and the surgeon's skill [20].

Bowel repair can be performed using a laparoscopic approach or a conventional approach, depending on the surgeon's experience. A minilaparotomy may be needed.

There is no consensus as to whether a surgeon must complete the procedure once the bowel injury has been repaired. In case of significant contamination secondary to gut contents, the abdominal cavity should be washed using saline solution, intravenous antibiotics should be prescribed, and the procedure should be completed within a period of 3–7 days [20]. In those cases with small output of gut contents, it is acceptable to complete the ventral hernia repair as it was planned before the incident.

Colonic lesion is a more serious issue. Although laparoscopic ventral hernia repair using mesh has been reported in the literature at the same time of a colonic suture, most of authors prefer to perform a primary herniorrhaphy without prosthesis, and, especially in those cases, they changed to open surgery [8, 20, 24].

New Trends

We have already discussed some trends with regard to the use of new mesh and fixation using absorbable tackers or fibrin sealant. We will see the results of the studies that now are taking place in the future.

Minimal access surgery (single port) also has been reported in ventral hernia repair, but it is actually reserved for experienced surgeons in laparoscopic surgery. Benefits of this access are a lower number of surgical incisions and better cosmetic results. A lower percentage of wall hernias associated to ports' incisions has been described when single incision is done using a surgical wound size similar to the conventional port wound [25]. Some critics argue that there are an increase of hernias in access sites, more surgical difficulties, and longer surgery times.

Recently, it has been reported that the hernia default closure before the mesh placement could reduce the seroma incidence and the size of the mesh needed and contribute to a lower recurrence rate. Surgical duration, stitch tension, and postoperative pain, especially in case of a similar rate of recurrences, should be examined.

Laparoscopic separation of components is a technique used to provide myofascial flaps and a tension-free closure of the hernia hole. The aim of this technique seems to be a reduction of complications secondary to large myocutaneous flap dissection in the conventional procedure [10]. The first step in this technique is to perform an incision as lateral as possible, one centimeter below the eleventh rib, and identify the external oblique muscle fibers, then perform a rome dissection to expose the internal oblique muscle. A space is created between these two muscles, initially using a digital dissection and later setting a balloon port. A 30° or 45° angle optic is needed, and 12 mmHg insufflation pressure is required. This maneuver allows you to create enough virtual space under endoscopic supervision from the eleventh rib to the inguinal ligament. Two 5 mm ports are needed, one placed in the posterior axillary line at the level of the umbilicus and another just above the inguinal ligament beside the rectus abdominis muscle. Electrocoagulation with scissors or hook is useful to separate the external oblique muscle fibers, 2 cm to the semilunar line, from the rib to the inguinal ligament. Leaving drainage in this space is optional. The same technique is performed on the opposite side [10, 26]. It is up to the surgeon to decide whether or not to use an open or a laparoscopic ventral hernia repair.

EuraHS (http://www.eurahs.eu) was created to record the measurements of outcomes in reparation of abdominal wall hernias. Analysis of this data may lead in the future to the creation of clinical guides based on the evidence and classified according to patients, types of hernias, types of materials, and available techniques [27].

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Chapter 10
Prostheses in Laparoscopic Ventral Hernia Repair

Juan Manuel Suárez Grau, Carolina Rubio Chaves, Fernando Docobo Durantez, and Manuel Bustos Jiménez

Abstract Current development of meshes has made possible the introduction and widespread use of laparoscopic techniques. Currently, we have multiple material combinations of meshes. It is important to make the correct choice of materials depending upon the type of hernia. We describe the classification of biomaterials of Amid with the latest variations by Bellón and Coda. The type of material and the pore diameter are subjects of intense study. Complications such as seroma and infection decrease with the correct selection of mesh for each surgery.

Keywords Prosthesis • Mesh • Hernia • Surgery • Laparoscopy • ePTFE • Polypropylene • Polyester • Biological • Abdominal wall • Seroma • Infection

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Prosthetics and Biomaterials: Concept and Classification

Biomaterial Concept

The Biomaterial Consensus Conference in 1983 reached an agreement on the definition of biomaterial as follows: a substance or combination of substances, except for drugs of natural or synthetic origin, that can be used alone or in combination for a variable time period to treat, augment, or replace the function of the organism [1].

These can be defined as all locatable biomaterials on the market such as metals and alloys, ceramics, carbon derivatives, polymers, and biological tissues, which have been used and are still used in surgical treatments. Only some of these components are used today as prostheses in hernia surgery [2].

Prosthetic materials used in hernia surgery for the abdominal wall consist of the following categories [1–4]:

- Biologics
  Skin: auto-/allo-/xenograft
  Aponeurosis: auto-/allo-/xenograft
  Muscle: muscle pedicles

- Synthetics
  Titanium metals and alloys: steel, cobalt
  Polyethylene:
  - Polypropylene
  - Polytetrafluoroethylene
  - Polyacid

  Polymers:
  - Polyacetal
  - Polyamide
  - Polyglycolic acid
  - Polylactic acid
  - Polyglactin

The classification proposed in 1997 by Amid provides four categories of synthetic prostheses in response to the diameter of the pores (Table 10.1). This classification has become somewhat dated, with the emergence of next-generation prostheses [5].

A new classification of the meshes for hernia surgery takes into account integration and peritoneum formation (Table 10.2) [6]:

- The reticular prostheses are useful for placement in a tissue interface.
- The laminates are optimal prostheses for placement in direct contact with the visceral peritoneum.
- The composite prostheses can be placed on all interfaces, but their design is devised in order to be placed in a tissue and a visceral peritoneum interface.

Table 10.1 Classification of synthetic prosthesis

Type I	Macroporous prosthesis pores >75 μ	Monofilament polypropylene mesh
Type II	Macroporous prosthesis (at least one of three directions) Pores <10 μ	ePTFE mesh
Type III	Macroporous prosthesis with multifilament component or microporous	Polyester mesh ePTFE perforated mesh Monofilament polypropylene mesh
Type IV	Prosthesis with submicron pores	

Data from Amid [3]

Table 10.2 Classification of prostheses used in the repair of abdominal wall hernial defects

Reticular prosthesis	
Nonabsorbables	Polypropylene (high or low density), polyester
Partially absorbables	Polypropylene/polyglactin 910, polypropylene/poliglecaprone
Absorbables	Polylactic, polyglactin 910
Laminar prosthesis	
Nonabsorbables	ePTFE, silicone, polyurethane
Absorbables	Porcine intestinal submucosa, bovine pericardium, human acellular dermal matrix, other biological meshes
Composite prosthesis	
Nonabsorbable components	Polypropylene/ePTFE, polypropylene/polyurethane
Absorbable components	Polypropylene/polyethylene glycol, polyester/polyethylene glycol, polypropylene/hyaluronic acid, polypropylene/polydioxanone/cellulose

Data from Bellon [6]

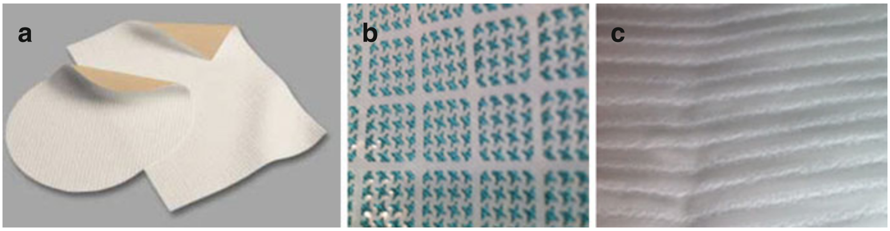

Fig. 10.1 (**a**–**c**) Laminar meshes. (**a**) Dual Mesh™ (L. Gore & Associates, Newark, DE, USA). (**b**) Omyra™ Mesh (Braun, Tuttlingen, Germany). (**c**) Mycromesh™ (L. Gore & Associates, Newark, DE, USA)

***Laminar Prostheses** (Fig. 10.1a–c)*

These meshes provoke low formation of new peritoneum but high integration with the receptor tissues:

- *Nonabsorbable*: PTFE, silicone, polyurethane
- *Absorbable*: biological material (dermis or submucosa of swine, bovine, or human tissue)

A new version of the last Categorization of Coda is used today, its author is Klinge. This classification indicates that the most important is the pore meshes [7].

Coda's classification

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

Klinge's classification

Class I: Large pore meshes (characterised by a textile porosity of >60 % or an effective porosity of >0 %)

Though the relevance was not clear yet, we further subgrouped for

(a) Monofilament
(b) Multifilament
(c) Mixed structure or polymer (e.g. absorbable + non-absorbable, or different non-absorbable)

Class II: Small pore meshes (characterised by a textile porosity of <60 % and without any effective porosity)

(a) Monofilament
(b) Multifilament
(c) Mixed structure or polymer

Class III: Meshes with special features

Class IV: Meshes with films

Class V: 3D meshes

Class VI: Biologicals

(a) Non-cross-linked
(b) Cross-linked
(c) Special features

***Reticular Prostheses** (Fig. 10.2a, b)*

These meshes provoke high formation of new peritoneum and normal integration:

- *Nonabsorbable*: polyester, polypropylene.
- *Absorbable*: polyglactin, polyglycolic acid.
- *Lightweight prostheses*: these meshes have big pores and low density; can be one single material or mixed materials such as nonabsorbable and absorbable material together.

***Composite Prostheses** (Fig. 10.3a–c)*

These prostheses provoke high formation of peritoneum and high integration. They consist of two different material layers: the first (superior layer) prosthesis is a reticular type, designed to increase the fibroblastic reaction (usually polypropylene or polyester). The second component (inferior layer) is a laminar type, and it can be of absorbable or scarcely reactive material such as the PTFE.

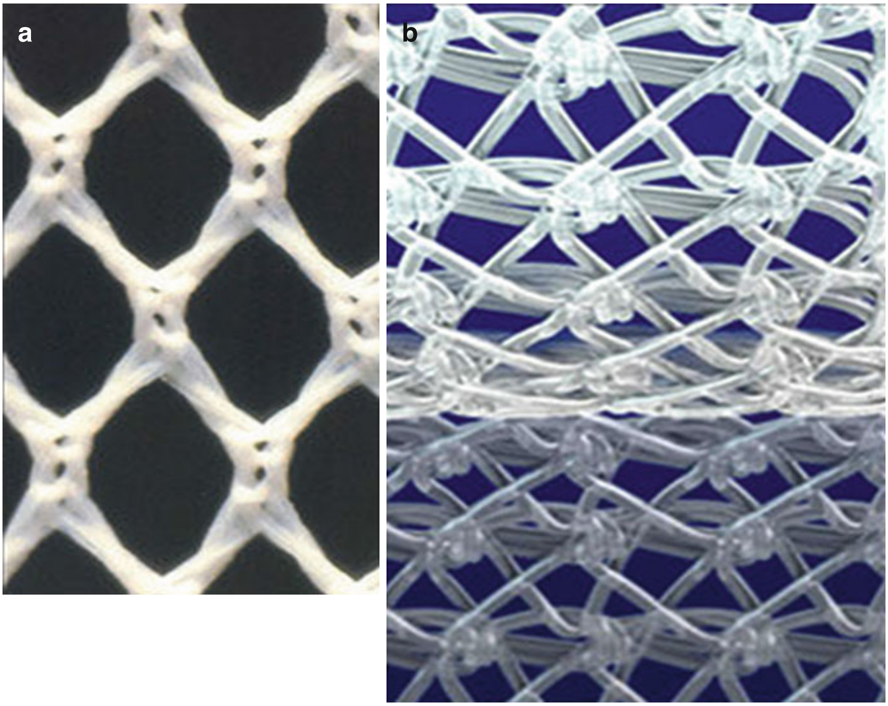

Fig. 10.2 (**a**, **b**) Reticular meshes. (**a**) Polyester. (**b**) Polypropylene

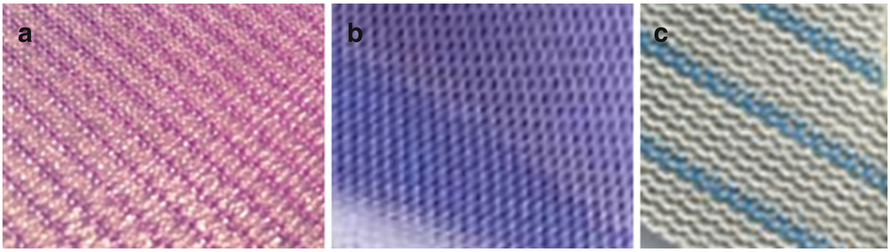

Fig. 10.3 (**a**–**c**) Composite meshes. (**a**) SEPRAMESH™ (Davol, Warwick, RI, USA). (**b**) Parietex™ mesh (Covidien, Dublin, Ireland). (**c**) Proceed™ (Ethicon Endo-Surgery, Blue Ash, OH, USA)

Laminar and composite prostheses are the main meshes used in laparoscopic ventral hernia repair, where the biomaterial is in contact with the visceral peritoneum and the mesh is in contact with the intra-abdominal organs (small bowel, omentum, etc.).

In ventral hernia or primary hernia surgery, these prostheses (laminar and composites) currently have these positive properties: inducing good tissue integration and preventing the formation of adhesions when placed in contact with the viscera [6, 8].

Nonabsorbable Prosthesis [1–6, 8, 9]

Polyester (Dacron)

This is derived from terephthalic acid and ethylene glicol. It was first used in the USA in 1954 as a prosthesis in vascular surgery and subsequently introduced in 1967 in Europe (in France by Rives) for surgery to repair abdominal wall defects. Dacron prostheses (Type III, according to Amid) used for hernia surgery consist of very fine braided polyester filaments. These filaments are light, soft, flexible, slightly elastic, and endowed with high tensile strength.

Their plasticity makes them adaptable to different anatomical situations and suitable for retromuscular or preperitoneal placement during hernioplasty (Rives-Stoppa-Wantz method). Macroporous structure stimulates fibroblast reaction and vivid and rapid formation of a periprosthetic capsule and offers excellent biological tolerance; it does not allow contact with viscera, which would result in high risk of erosions, fistulae, and adhesions.

Dacron prostheses have a lower resistance to infection due to their status as multifilaments, but the fact is that, in case of infection, it is usually necessary to consider timely appropriate antibiotic treatment if a decision is made to remove these types of meshes.

Polypropylene

This is a synthetic polymer derived from polyethylene. It presents certain advantages such as high tensile strength, the ability to sterilize, tolerance to infections and many chemicals, and ease of use. This versatility allows it to adapt to different situations for a tension-free hernioplasty. This biomaterial is hypoallergenic, hardly induces tissue reaction, and generally is well tolerated by patients. This is a Type II and a Type III prosthesis according to Amid.

Since the start of its use in 1958 (by Usher), polypropylene has become the material used in the repair of abdominal wall defects, especially for the treatment of herniated inguinal.

In ventral hernia repair, it is used only in transabdominal preperitoneal hernioplasty.

All polypropylene meshes (Type I according to Amid) have in common a high tensile strength, encouraging rapid intra- and periprosthetic fibroblastic reaction and resistance to infections. Some examples are meshes (PHS®, PAD®, Ethicon Endo-Surgery, Blue Ash, OH, USA) and prefabricated blocks (plugs) (PERFIX®, Davol, Warwick, RI, USA; Hernia Plug Mate System, USSC; Premilene Mesh Plug ®, Braun-Dexon, Tuttlingen, Germany; Self-Forming Plug, Atrium Med Corp, Hudson, NH, USA). Due to the polypropylene forming dense scar tissue and inducing a fibroblastic reaction, it is recommended that these meshes do not have contact with

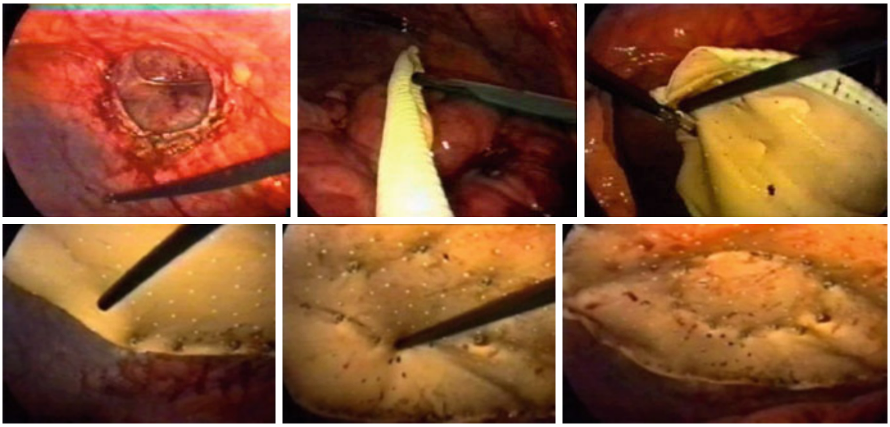

Fig. 10.4 Double-crown technique with Dual Mesh™ (L. Gore & Associates, Newark, DE, USA)

intraperitoneal structures; there is high risk of adhesion formation with possible evolution to erosion and intestinal fistulae.

Polytetrafluoroethylene (PTFE) and Compressed or Expanded PTFE (ePTFE, cPTFE) (Fig. 10.4)

Expanded polytetrafluoroethylene (ePTFE) is a synthetic polymer derived in 1963 in Japan from Teflon and subsequently redefined by Gore in 1970 in the USA. PTFE-e was initially used in surgical prostheses for vascular surgery. In 1983, it began to be used to repair abdominal wall defects as Gore-Tex® Soft Tissue Patch (STP) (L. Gore & Associates, Newark, DE, USA).

The ePTFE (GORE DUALMESH™, L. Gore & Associates, Newark, DE, USA; DULEZ™ BARD Mesh, Davol, Warwick, RI, USA) is one of the most inert and biocompatible biomaterials currently available. It has many advantages: it is not absorbed, does not cause allergies, has a minimal inflammatory response, is not altered by the action of enzymes, and is not subject to modification by the presence of infections, although these are poorly tolerated.

The behavior of PTFE-e against bacterial contamination and infection is controversial. Due to its hydrophobicity, ePTFE has the ability to slow down bacterial penetration, but there are several articles that challenge this theoretical and clinical result. These articles confirm the low possibility of penetration of neutrophil granulocytes, with subsequent infection and possibility of chronic infection in the mesh.

This is the mesh that began the revolution in laparoscopic ventral hernia. Today, it is used widely throughout the world. The natural evolution has led to the creation of new prototypes with larger pore diameter and lower density. The next step is cPTFE, which seems to show a greater biocompatibility with the tissues.

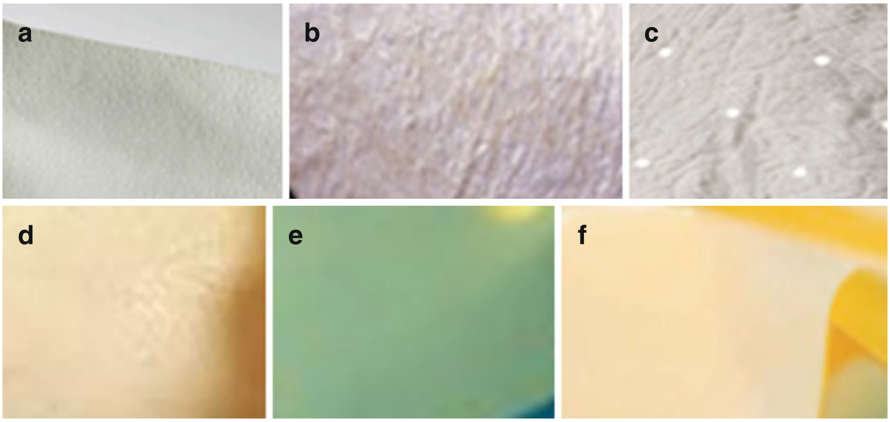

Fig. 10.5 (**a**–**f**) Absorbable meshes. (**a**) Permacol® (Covidien, Dublin, Ireland). (**b**) Surgisis® (Cook Biotech, West Lafayette, IN, USA). (**c**) Tutomesh® (Tutogen Medical, Neunkirchen am Brand, Germany). (**d**) AlloDerm® (LifeCell, Bridgewater, NJ, USA. (**e**) Veritas® (Synovis Surgical, Deerfield, IL, USA). (**f**) Peri-Guard (Synovis Surgical, Deerfield, IL, USA)

Composite Mesh

The composites were designed to functionally join the properties of two types of prostheses. The objective of these prostheses is (a) to improve the peritoneal interface and (b) to have the properties of both materials as regards integration and biomechanical strength.

These prostheses are manufactured using different types of biomaterials.

Most common are (1) polypropylene and PTFE (COMPOSIX™, Davol, Warwick, RI, USA), (2) polypropylene and a sheet of hyaluronic acid (SEPRAMESH™, Davol, Warwick, RI, USA), and (3) polyester and polylactic (Parietex™ Composite, Covidien, Dublin, Ireland).

The composites demonstrate good integration behavior, modulated by the reticular prosthesis (polypropylene or polyester), and an excellent ability to generate mesothelial cells, due to the laminar component of the prosthesis.

They are especially useful in large hernia defect repair, where it is necessary to reconstruct the abdominal wall and in cases in which resistant tissue upon which to fix the mesh properly does not exist. In laparoscopic surgery of abdominal hernia, it is useful for the biomaterial to be in contact with the visceral peritoneum.

Absorbable Prosthesis (Fig. 10.5a–f) [6, 8–11]

The creation of these prostheses was undertaken to counteract the weaknesses of the nonabsorbable prostheses. At the research level, in vitro and animal models demonstrate that this has succeeded. These prostheses have exhibited a decrease in the rate of adhesions when placed in contact with viscera and a lower rate of infection, so much so that their current indication is primarily focused on use in infected or high-risk infection cases, despite not having their own antimicrobial properties.

In the literature, the biological meshes used in laparoscopy in cases involving the ventral hernia only have demonstrated efficacy in uncommon hernias (perineal, Littré, hiatal hernia) and infected fields close to the hernia or in the hernia itself.

Absorbable Synthetic Prostheses (Polymer of Glycolic Acid Esters or with Lactic Acid (Polyglactin 910), PGA-TMC)

Synthetic absorbable meshes are usually textured, braided multifilament. Most prostheses are soft, flexible, extensible, moldable, and biodegradable. They are gradually reabsorbed by hydrolysis between 90 days and 6 months, with a gradual reduction in mass and resistance to stress.

Biological Absorbable Meshes

Xenograft Acellular Collagen Type I (Surgisis®, Cook Biotech, West Lafayette, IN, USA) from Porcine Submucosa, Alloprostheses Human Acellular Dermal Matrix (AlloDerm®, LifeCell, Bridgewater, NJ, USA), Xenograft Derived from Bovine Pericardium (Peri-Guard and Veritas® Collagen® Matrix, Synovis Surgical Innovations, St. Paul, MN, USA), and Xenograft Acellular Collagen Matrix Subdermal Swine (Permacol®, Covidien, Dublin, Ireland).

These are the biological meshes with more impact as shown in the literature in open ventral hernia repair.

The advantage of cross-linked mesh versus non-cross-linked mesh remains a controversial area. Early investigation showed increased stiffness for two cross-linked biological mesh products (porcine dermis and bovine pericardium) compared to the non-cross-linked bovine pericardium mesh. Greater cell infiltration was seen in the non-cross-linked mesh. Future investigation is warranted as to whether or not these characteristics are clinically important or if the cross-linked mesh poses an increased risk for infection by preventing collagen breakdown and macrophage migration. Chemical cross-linking of collagen is performed not only in hernia prosthetics but also in bone, cartilage, and vascular implants and in degrees from low to high density.

The cross-linking density is greater, and so is fibroblast encapsulation and implant resistance to enzymatic degradation. However, the rate of cellular infiltration decreases.

The optimum balance of cross-linking pattern and density to balance, graft strength, and durability with cellular ingrowth and remodelling remains unclear. A lack of quality long-term clinical experience and data makes it difficult to decide which product has the optimal balance.

In conclusion, as the placement of any synthetic material in the presence of intra-abdominal infection has a high risk of complications (regardless of whether the graft is absorbable (polyglactin) or nonabsorbable (polypropylene or polyester)), biological mesh could be an alternative in the presence of infection.

Recommendations for the Meshes We Use in Laparoscopic Surgery for Ventral Hernia

We describe our preferences regarding the use of bioprosthesis by type of hernia:

- In midline ventral hernias (periumbilical, suprapubic, subxiphoid): cPTFE (Omyra™ Mesh, Braun, Tuttlingen, Germany)/Parietex™ (Covidien, Dublin, Ireland)/SEPRAMESH™ light (Davol, Warwick, RI, USA)
- In lateral hernias (lumbar/subcostal hernia): SEPRAMESH™/ePTFE (Gore DUALMESH™, L. Gore & Associates, Newark, DE, USA)
- In large-diameter hernias, very weak or tissues: ePTFE (Gore DUALMESH™)
- In parastomal hernias: Sugarbaker technique with Parietex™ Parastomal/cPTFE (Omyra™)/SEPRAMESH™/ePTFE (Gore DUALMESH™)
- In hernias with suspected abdominal wall-associated infection: ePTFE/cPTFE/biological meshes (Permacol® (Covidien, Dublin, Ireland), Surgisis® (Cook Biotech, West Lafayette, IN, USA), Tutomesh® (Tutogen Medical, Neunkirchen am Brand, Germany))

New Mechanisms for Mesh Fixation in Ventral Hernia (Incorporated in the Mesh) (Fig. 10.6a, b)

Positioning Systems

The Echo PS Bard Positioning System keeps the mesh open and up against the abdominal wall with no additional graspers or spreading devices, allowing for complete visibility during fixation. This mechanism saves time, making it very useful for surgeons who are not experts in laparoscopy.

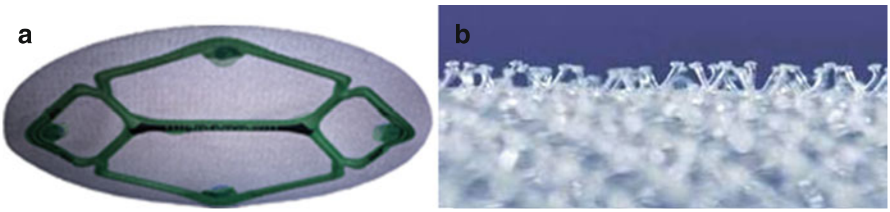

Fig. 10.6 (**a**, **b**) New fixation system incorporated in the mesh. (**a**) Echo PS™ Positioning System (Courtesy of Davol, Warwick, RI, USA). (**b**) ProGrip™ self-adhesion system (Courtesy of Covidien, Dublin, Ireland)

Self-Adhesion

The advanced technology of ProGrip™ and PARIETEX™ (Covidien, Dublin, Ireland) provides immediate microgrip by the fixation of mesh surface for a secure repair. The resorbable polylactic acid (PLA) microgrips enable surgeons to position and place the mesh quickly. In ventral hernias, this system is designed for preperitoneal repair (transabdominal laparoscopic or open) or open techniques. This reparation is only recommended for advanced laparoscopic surgeons.

Complications in Prostheses in Ventral Hernia Repair

All the recurrence rates decreased drastically thanks to these prostheses: in open surgery, 10–40 %, and, in laparoscopy, the range today could be less than 2 % (8 % per Sanders in 1999, 2.8 % per Morales in 2002). However, other new problems have arisen in hernioplasty: infection, seromas, adherences, and intolerance.

We have engaged in surgical interventions and experimentations to study these problems, and a discussion of the best solutions is presented in the sections that follow.

Recurrence

The correct selection of the prosthesis is essential in this type of surgery. The mesh must be a large mesh. The overlap recommended is over 5 cm. The shrinkage of the mesh (especially PTFE) should be a factor to consider because it can be a cause of recurrence. Informed selection of the mesh, according to the hernia characteristics, reduces recurrence [11].

Seroma [12–18]

Seroma formation has been documented as one of the most common complications, although most of the time it remains asymptomatic and it can be considered incidental. The incidence of seroma after laparoscopic ventral hernia repair has not been properly documented and analyzed since the definition used by different authors is not the same from one series to another.

Classification of the seroma is as follows:

Type I: clinical seroma lasting less than 1 month
Type II (seroma with excessive duration): clinical seroma lasting more than 1 month (IIa: between 1 and 3 months; IIb: between 3 and 6 months)
Type III (symptomatic seromas that may need medical treatment): minor seroma-related complications (seroma lasting more than 6 months, esthetic complaints

of the patient due to seroma, discomfort related to the seroma that does not allow normal activity for the patient, causes pain, demonstrates superficial infection with cellulites)

Type IV (seroma that needs to be treated): major seroma-related complications (need to puncture the seroma, seroma drained spontaneously, applicable to open approach, deep infection, recurrence, and mesh rejection)

It is important to differentiate between a complication and an incident. A seroma is an incident if it is classified as seroma Type I or Type II and a complication if it is a Type III or Type IV. The highest classification is the one that should be used in order to describe the type of seroma.

Seroma is observed in almost all cases by radiological examinations, but this does not determine if it must be considered an incident or a complication.

Type I and Type II can be managed with conservative treatment (girdle, compression bandage, relative rest). Type III and Type IV may need some kind of medical intervention to treat. Type III may benefit from conservative measures: puncture and durable compression. Type IV may also require puncture and some type of intervention (drainage, talc application, application of adhesives).

To prevent seroma, the following are essential: determining the type of hernia, choosing the proper mesh to correct it (minor seroma relates to higher porosity of the mesh), and applying preventative measures (drainage, fibrin glue application to decrease the interface between the mesh and hernia sac, or closure of the hernia defect to decrease the size of the mesh).

Infection [18–21]

First of all, the antiseptic methods (changing gloves) and the correct technique could be combined with antibiotic prophylaxis in all cases that require mesh. When prostheses are infected, several actions could be attempted: removal of the laminar mesh, curing the reticular meshes, and, finally, using absorbable (biological, essentially) mesh to repair the defect in infected tissue or after removal of infected mesh. The use of antimicrobial drugs at the infection site is a new concept that can be useful in this complication.

In the Case of Reticular Mesh: If the infection is not in the entire mesh (only in a portion because of necrosis of the hernia sac), it is possible to remove only the infected area of the mesh and wash it several times to decrease the growth rate of the bacteria. If the mesh is completely infected, the best choice is to remove the entire mesh and undertake a new surgical procedure: place a new biological mesh, use vacuum therapy, or perform an anatomical reconstruction such as herniorrhaphy or separation of components. Vacuum therapy is a good method to use in order to avoid the removal of the mesh, and there is minimal aggression to the patient. VAC therapy allows salvage of infected, exposed mesh by promoting granulation through the mesh. Judicious use of VAC therapy may prevent the need of mesh excision and its wound-related complications.

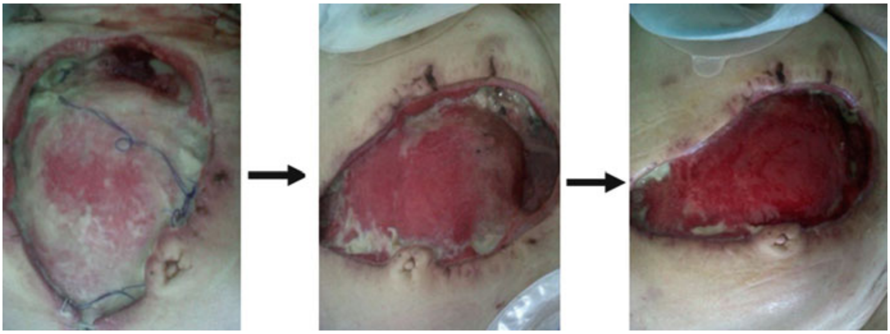

Fig. 10.7 Vacuum therapy in infection after necrosis of the skin in a ventral hernia with mesh

In the Case of Laminar Mesh: Although the infection may affect only a small portion of the mesh, the most often used treatment removes all the mesh and uses the anterior surgical procedures. A new generation of mesh has an antibiotic impregnation (vancomycin), and this can be used for infections in hernia repair.

Vacuum therapy is a good method to use even in laminar meshes in order to avoid the removal of the mesh, and there is minimal aggression to the patient. VAC therapy allows salvage of infected, exposed mesh by promoting granulation through the mesh. Judicious use of VAC therapy may prevent the need of mesh excision and its wound-related complications. See Fig. 10.7.

On the other hand, infected mesh after laparoscopic ventral herniorrhaphy without systemic sepsis may be amenable to nonoperative treatment. A conservative approach that includes percutaneous drainage followed by antibiotic irrigation is a potential alternative to prosthetic removal in carefully selected patients.

Adhesions [16–18]

The reticular prosthesis only has indications in composites. The laminar and composite meshes have low rates of adhesion to the intraperitoneal organs. We can apply nonstick substances such as fibrin glue or hyaluronidase cream, which decreases the risk of future adhesions.

Adhesions in intraperitoneal organs when using a reticular mesh must be repaired with a redo in order to remove the mesh and look for any perforation or erosion of bowels and in other intra-abdominal organs. A novel alternative is to coat the exposed area of the reticular mesh with an absorbable substance capable of causing a nonstick effect. Products like Coseal® (Baxter Healthcare, Deerfield, IL, USA) or TachoSil® (Takeda Pharmaceuticals, Zurich, Switzerland) have been proposed. Our group has experimented with TachoSil® in rats, obtaining good results regarding the reduction of adhesions with the coated polypropylene mesh TachoSil.

Occurrence of adhesions when using a laminar mesh is not frequent. The best option is a composite mesh to avoid adhesion when the mesh is or could be in contact with viscera.

Intolerance [20, 21]

This is a very uncommon problem. Intolerance could be a chronic infection of the mesh. The existence of infection must be investigated (blood test, cultures, imaging tests). If, despite all this, the intolerance is confirmed, the best option is to replace the mesh with another kind of mesh (depending on the location of the anterior mesh and the contact with viscera).

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Chapter 11
Fixation of Prostheses in Laparoscopic Ventral Hernia Repair

Beatriz Marenco de la Cuadra, Javier Valdes Hernandez, and Juan Manuel Suárez Grau

Abstract Mesh fixation in laparoscopic ventral hernia benefits from a wide range of devices and materials that can be used, according to the location and characteristics of both the hernia and mesh. At our disposal are sutures (metal, traumatic, plastic, absorbable) and adhesives. The advantages of fibrin have been incorporated into traditional metal sutures (tackers), offering potential improvements in terms of integration and the decrease of possible complications (seroma, hematoma, etc.).

Keywords Fixation • Hernia • Laparoscopy • Tackers • Fibrin • Glue • Cyanoacrylate • Mesh • Prostheses

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Introduction

Laparoscopic ventral hernia repair (LVHR) was first described in 1993 by LeBlanc and Booth [1, 2]. Since then, a number of articles have been published on this technique showing that it is a therapeutic and safe alternative, as well as being feasible and effective.

Numerous articles deal with this surgical technique; there is a meta-analysis, published in 2009 in *British Journal of Surgery* by Forbes, comparing laparoscopic with open ventral hernia repair. The laparoscopic repair was found to be more effective than the open approach, LVHR had a shorter hospital stay, and it was associated with fewer wound infections, although there was no difference in recurrence rates [3]. Recently, a systematic review published in the Cochrane by Sauerland et al. shows, in terms of success rate, mortality, morbidity, and recurrence, the superiority of laparoscopic repair when compared with the open approach for ventral hernia [4].

However, one of the most controversial issues today remains the method of fixation of the prosthesis to the abdominal wall in the repair of ventral hernia defects. There are many methods for this, such as traumatic methods (sutures, tackers) or nontraumatic (glues), but the literature has not demonstrated the superiority of one technique of mesh fixation over another in terms of recurrence [5].

Traumatic Fixation

When mentioning traumatic attachment methods, we should take into account that in the current market, there are different mechanisms, the most prominent being tackers: reabsorbable or non-reabsorbable. There are other traumatic non-helical attachment methods: Salute® (Davol, Warwick, RI, USA) (coil type), SecuresTrap® (Ethicon Endo-Surgery, Blue Ash, OH, USA) (absorbable stapler), EndoAnchors (Ethicon Endo-Surgery, Blue Ash, OH, USA), and Endo Universal™ Staplers (Covidien, Dublin, Ireland).

The fixation capacity of the staple type is significantly lower than the helical type and coil type. See Table 11.1.

We are going to focus on the fixation type that is most commonly used today. See Fig. 11.1a–d for devices for mechanical fixation [6–8].

Nonabsorbable Tackers

Nonabsorbable tackers are suture materials made of titanium, allowing the attachment of the prosthetic material and the approximation of tissues in laparoscopic repair of the hernia defect. The closure can be either omega shaped or helical (Fig. 11.2). The omega shaped are the most frequently used today because they generate a single point of entry, thereby minimizing the risk of nerve entrapment.

Table 11.1 Different types of tackers

	Protack	Absorbatack	Permasorb	Sorbafix/Permafix	Ethicon Securestrap™
Company	Covidien	Covidien	Bard/Davol	Bard Davol	Ethicon
Construct					
Total length	3.3 mm	5.1 mm	6.08 mm	6.7 mm	7.2 mm
Profile	~.4 mm	1 mm	~.3 mm	~.85 mm	.5 mm
Material	Titanium	PGLA	PDLLA	PDLLA	PLG blend
Delivery	5 mm	5 mm	5 mm	5 mm	5 mm
Method of delivery	Spiral	Spiral	Needle introducer	Spiral needle introducer	Expulsion
# of tacks	30	10, 20	5, 12	15, 30	25

Used with permission from Nebinger et al. and Covidien [21]. Study sponsored and performed by Covidien. Images courtesy of Covidien, Dublin, Ireland (ProTack®, AbsorbaTack®); Davol, Warwick, RI, USA (Permasorb®, SorbaFix®, Permafix®); Ethicon Endo-Surgery, Blue Ash, OH, USA (SecuresTrap®)

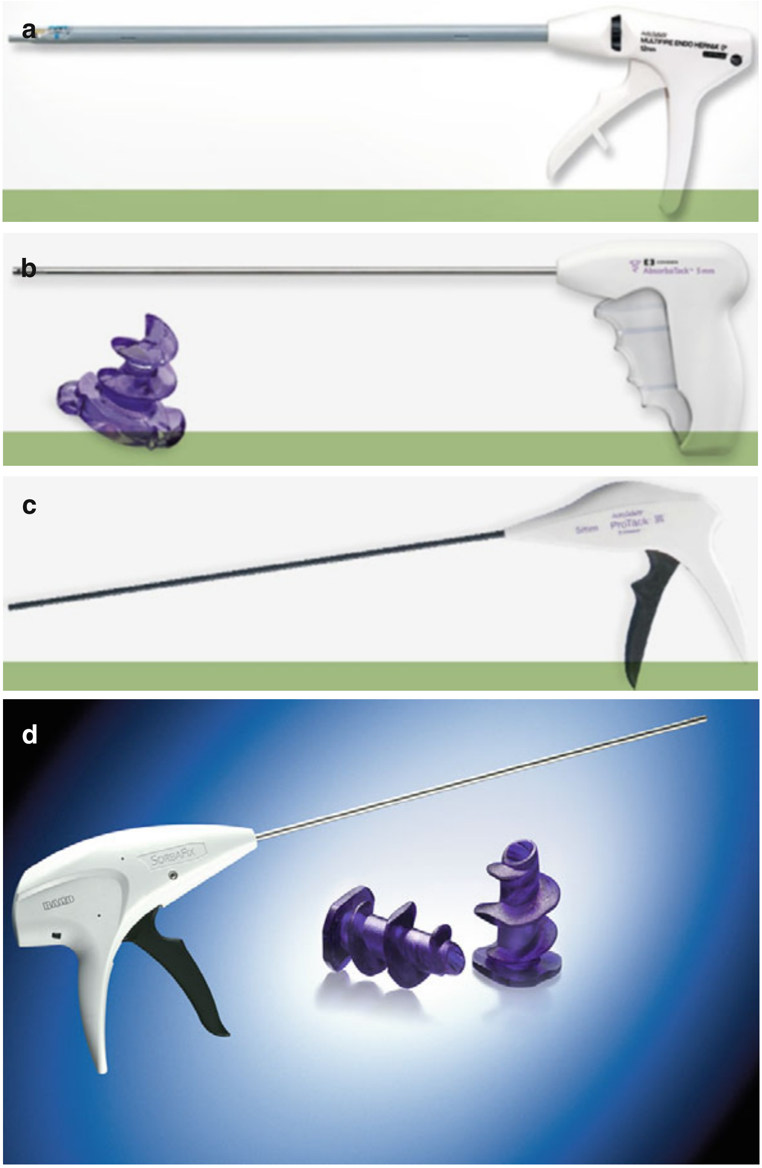

Fig. 11.1 (**a**–**d**) Devices for mechanical fixation. (**a**) Multi Fire Endo Hernia™ Stapler; (**b**) AbsorbaTack™; (**c**) ProTack™; (**d**) SorbaFix™ (a–c: Courtesy of Covidien, Dublin, Ireland; d: Courtesy of Davol, Warwick, RI, USA)

Absorbable Tackers

Absorbable tackers are composed of polyglycolic acid-polylactic acid, a polymer that is reabsorbed through hydrolysis 3–5 months after surgery, with complete reabsorption in a year, thereby allowing safe and temporary fixation without any foreign

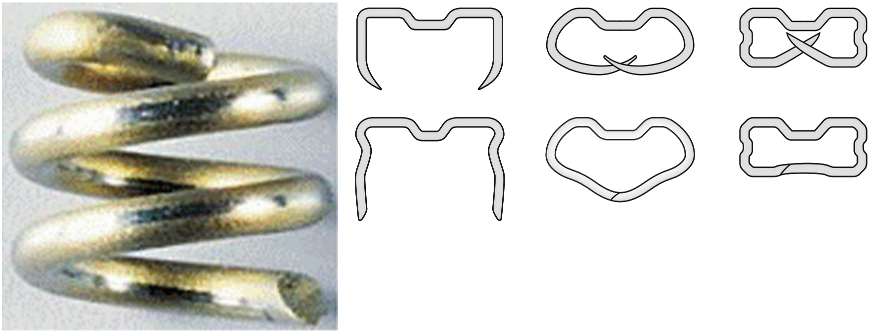

Fig. 11.2 Tacker and staples (Courtesy of Covidien, Dublin, Ireland)

body over time. This material penetrates all types of meshes and seems to be related to a reduction in chronic pain as well as a reduced risk of adhesions [1, 9].

It is vital that the fixation generated by any of the methods used is strong enough to withstand abdominal forces and friction until the mesh has been completely integrated. For many years, the permanent titanium tack was the only available option for tack fixation and therefore the gold standard [10]. However, at both short- and long-term evaluation, significant problems have been reported, such as postoperative pain, erosion, intestinal fistula, adhesion formation, and even tack hernias [11]. Due to this, in an attempt to minimize these problems, absorbable fixation methods have been developed [8]. Both Hollinsky and Gőbl [12] and Duffy et al. [13] highlighted that tensile strength was comparable to nonabsorbable fixation devices, a factor related to the possibility of recurrence [14]. Hollinksy and Gőbl [12] showed significantly higher adhesion scores with titanium tacks compared to reabsorbable devices because the tip of the permanent helical tack often does not completely penetrate the abdominal wall and small parts remain uncovered by the peritoneum; small foreign materials which are in direct contact with viscera result in adhesions to both the omentum and small bowel, and the sharp point is more harmful to the peritoneum, with local ischemia and local tissue injury resulting in more intense adhesion formation [15–17].

Transmural Sutures

Another type of traumatic attachment that should be mentioned is transmural sutures, either with reabsorbable suture material or not. However, the use of these alone has failed to become a standard technique as it requires longer operative time and requires great technical ability without providing any superior results compared to the rest [10].

After this, we can say that there are different techniques of fixation, either with single-use tackers (double crown or a crown), transfascial sutures, or a combination of both. Currently, the two most widely accepted techniques are, first, double crown

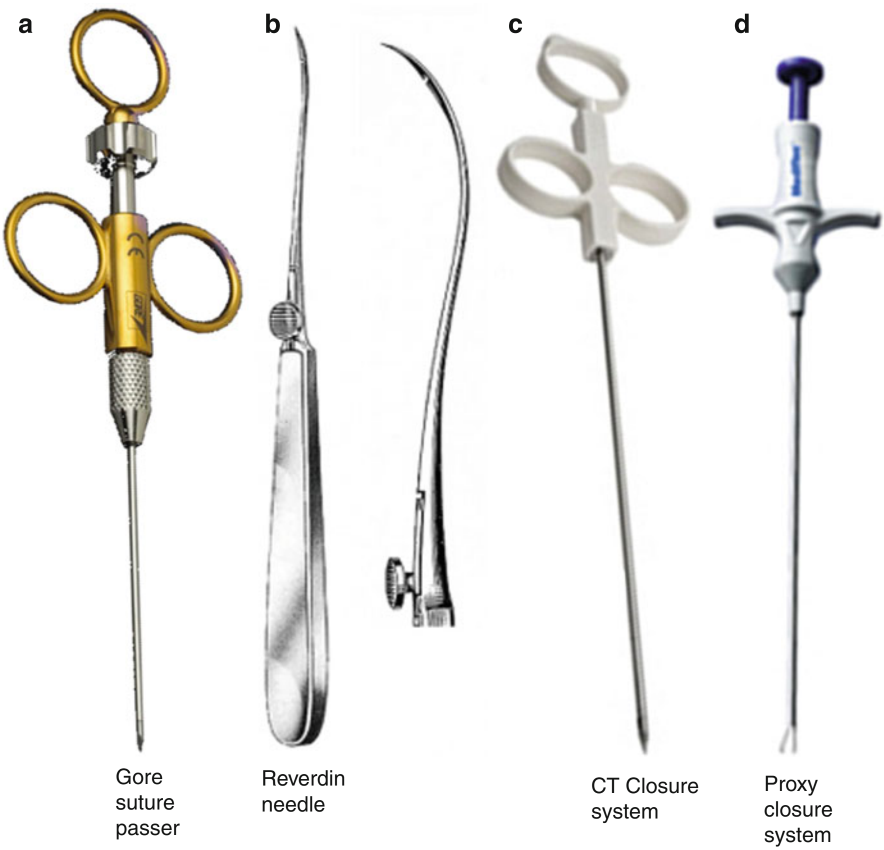

Fig. 11.3 (**a**–**d**) Devices for transmural sutures. (**a**) GORE™ suture passer (Courtesy of L. Gore and Associates, Newark, DE, USA); (**b**) Reverdin needle. (**c**) CT Closure System® (Courtesy of Cooper Surgical, Trumbull, CT, USA). (**d**) Proxy closure system (Courtesy of Ranfac Corp, Avon, MA, USA)

of tackers (this prevents dead spaces, allowing a reduction of seroma between the mesh and the hernia sac, ensuring adequate fixation of the mesh when placing a crown of internal fixation at the level of the fibrotic ring, and preventing recurrence by default enlargement [7]) and, second, a combination of tackers and transfascial sutures [1]. See Fig. 11.3a–d for devices for transmural sutures.

One of the most controversial issues in the majority of existing literature, even given greater consideration than that of recurrence, is postoperative pain in this type of patient. Traditionally, most authors thought that the pain was caused by the transmural sutures, because pain after LVHR is frequently associated with movement and a pulling sensation at the site of transmural sutures placement [11]. However, more and more published work finds that there is no difference and that both transfascial sutures and the use of tackers are responsible for prolonged postoperative pain. Carbajo et al. [18] reported a 7.4 % rate of persistent postoperative pain using

Table 11.2 Different types of adhesives

Natural	Fibrin (autologous)	Vivostat, Cryoseal
	Fibrin (heterologous)	Tissucol or Tisseel
Semisynthetic	Bovine albumin glutaraldehyde	BioGlue
Synthetic	Cyanoacrylate	Histoacryl, Glubran, Dermabond, Indermind

the double crown technique. Bageacu et al. [19] observed the persistence of severe pain in patients who only had tackers. Recently, a randomized study comparing commonly used fixation techniques (double crown, tackers and nonabsorbable sutures, and tackers and absorbable sutures) with respect to postoperative pain and quality of life has been published. In this study, they also included a group of patients in whom absorbable transmural sutures were employed to affix the mesh, speculating that if postoperative pain is due to the presence of a permanent mesh-fixation device, the potential for such pain might decrease over time in patients in whom an absorbable material is used instead. However, after obtaining their results, the authors concluded that there are no differences in terms of postoperative pain and quality of life with respect to any of the three techniques [8], and they suggest that none of the techniques is superior to another in terms of pain reduction. Therefore, it is necessary to develop new methods of fixing mesh to treat postoperative pain.

Atraumatic Fixation (Tissue Adhesives)

In spite of the good results obtained with traumatic repair, these methods are associated with up to a 21 % rate of local pain and discomfort that may persist beyond 6 months postoperation [6]. For this reason, there is a tendency to search for methods which minimize the morbidity associated with traditional techniques. Among atraumatic fixation techniques, we can distinguish different types of adhesives which are classified into three groups (Table 11.2).

Synthetic: Cyanoacrylate

These have experienced an increase in use since the 1950s. These adhesives are especially inert when dry; they are bacteriostatic and can be applied without causing pain. Cyanoacrylate prevents the exchange between the internal environment and the external one, which helps to reduce wound infection. It has also been shown that these products have an antimicrobial effect against gram-positive bacteria, both in vitro and in vivo. This means that they can be used as sealants, hemostats, or as fastening in hernioplasty, the latter being its main use for pediatric wounds. See Fig. 11.4 for cyanoacrylates and the system to apply in laparoscopy.

Fig. 11.4 Cyanoacrylates and system to apply in laparoscopy

Semisynthetic Adhesives (BioGlue)

This is a surgical adhesive and sealant composed of bovine serum albumin and glutaraldehyde in use since 1998. It is a chemical-fixing tissue through glutaraldehyde cross-link, hardening after implantation, forming a clot with a rigid high tensile strength; its absorption takes up to 2 years.

Fibrin Sealants

Fibrin sealants are a hemostatic compound and adhesive, derived principally from plasma products such as fibrinogen, fibronectin, Factor XIII, and growth factors such as VEGF, TGF-B, EGF, and FGF. Therefore, having incorporated these growth factors, fibroblast proliferation occurs after mesh placement, which leads to a correct integration and an optimal result.

There are two types of fibrin glues: the autologous nature (Vivostat®, Vivostat, Alleroed, Denmark) fibrin glue which is obtained from the patient's blood and the heterologous nature (Tissucol®, Baxter Healthcare, Deerfield, IL, USA) which has proven to be successful in various fields, such as nonstick barrier formation (to prevent occurrence of intraperitoneal adhesions) or for fixing an atraumatic mesh.

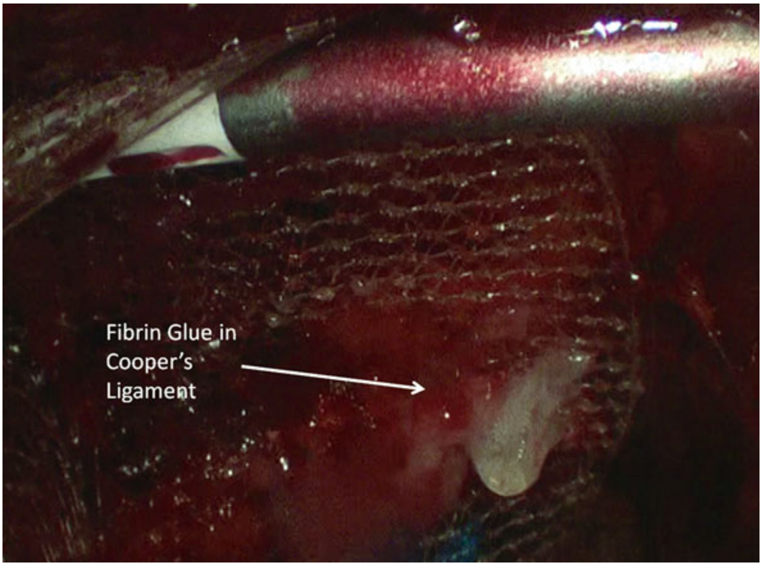

Fig. 11.5 Fibrin glue in laparoscopic hernia repair

Fibrin glues have shown stabilization of hernia repair at an early stage, until being completely reabsorbed, and in vivo studies have shown a decrease in pain after hernia repair when compared with traumatic fixation.

In addition, recent research has focused on pain induction. Olmi et al. [14] observed a low rate of postoperative pain (VAS scale) in 40 patients in which fibrin glue was used to fix the mesh in laparoscopic hernia repair in cases of hernias of medium fault and of a small size. Eriksen et al. [15, 16] demonstrated that intraperitoneal fixing fibrin glue was safe, effective, and feasible, with reduced postoperative pain. However, results on recurrence require a greater number of studies.

See Figs. 11.5 and 11.6 for fibrin glue in inguinal hernia repair and a system for autologous fibrin glue.

Fixing Method: Traumatic vs. Nontraumatic

Acute and Chronic Pain

Acute pain is pain that remains within the first 3 months postoperation, and chronic pain is that which persists beyond the third month.

Postoperative pain in laparoscopic ventral hernia repair has always been related to traumatic fixing material because of the possibility of nerve entrapment or muscle damage. Although there is little literature regarding this, there appears to be an improvement in acute postoperative pain, as regards discomfort and recovery time in LVHR with nontraumatic fixing [14].

Fig. 11.6 System for autologous fibrin glue

Recurrence

Although for inguinal hernias there are many studies regarding their effectiveness from a biomechanical point (tensile strength, swelling with increased intra-abdominal pressure, and displacement of the mesh) and recurrence, there are currently no data to recommend the replacement of traumatic fixing for biological glue in repair of ventral hernia [15].

Adhesions

Atraumatic attachment has a lower rate of adhesion compared to non-reabsorbable traumatic material [20].

Recent studies recommended the possibility of adding to the usual technique of fixation with tackers (absorbable or nonabsorbable): fixation with fibrin glue, tackers to cover and avoid adhesions, and to save on the number of tackers, distancing the tackers between each other by adding glue around the edge of the mesh.

Surgical Time

At present there is no evidence to suggest the influence of atraumatic fixation on surgical time [20].

Costs and Hospital Stay

The impact of fibrin as a hemostatic glue in open ventral hernia repair reduces overall costs. However, at present there is no available literature on the results in laparoscopic ventral hernia repair.

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Chapter 12
Laparoscopic Approach in Other Hernias: Subcostal, Xiphoid, Lumbar, Suprapubic, Parastomal, and Spigelian

Javier Valdes Hernandez and Enrique Navarrete de Carcer

Abstract Laparoscopic ventral hernia surgery in the midline is an easily reproducible technique and does not require a long learning curve. Technical complications can arise from abdominal wall hernias that are not placed in the midline. Lumbar, subcostal, epigastric, subxiphoid, suprapubic, spigelian, xiphoid, and parastomal hernias require a customized approach and a better understanding of the surgical techniques in order to provide favorable results.

Keywords Hernia • Laparoscopy • Subcostal • Xiphoid • Lumbar • Suprapubic • Parastomal • Spigelian • Atypical localization

Introduction

Hernia disease is one of the most frequent benign problems. Abdominal wall hernias have accompanied mankind since its origins, considering that it is a tribute to the standing position. We understand an incisional hernia as a defect in the abdominal wall, closely related to a postoperative scar. Most of the patients who will develop this type of problem will present it the first year after the surgical intervention. Incidence rates varied from 0.5 to 6 % after a laparoscopic approach to up to 32 % with an open approach. Higher prevalence is observed in female patients (3/1).

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Attention must be paid to special types of hernias due to the fact that they require difficult repairs and have a high recurrence rate and low bibliographic references. These could be classified as incisional hernias close to bony margins or hernias in the abdominal border, such as xiphoid or subxiphoid hernias and subcostal and suprapubic hernias. Special attention should be paid to lumbar and parastomal hernias, especially regarding diagnosis and surgical repair.

Incisional hernias are a prevalent social and sanitary problem, with high social and economic costs. Traditionally, surgical treatment was performed by direct suture of the defect, with or without relaxing incisions. All these techniques are associated with an unacceptable recurrence rate, which was the reason why tension-free techniques with synthetic prostheses were introduced. This was a revolution in the surgical management of these patients, mainly improving recurrence rates and postoperative comfort, but still presenting important incision-related morbidity and high consumption of hospital resources.

A minimally invasive approach, such as laparoscopy for the surgical treatment of these patients described by LeBlanc [1], helped to improve these adverse results in the last 15 years.

The surgical community still debates what the best surgical solution is for this problem, especially regarding the best approach, the best treatment of the hernia defect, and the best mesh type and where to place it, as well as the fixating method. There is profuse scientific literature regarding these matters, especially when inguinal and midline incisional hernias are discussed, but this literature dries up when it comes to these special types of hernias.

If we review the literature of the last 15 years, we find no meta-analysis comparing results after surgical repair of these hernias. We can usually only find small series with heterogeneous results. As a consequence, there is not enough evidence to enforce any approach, and we should consider these conclusions as expert recommendations.

Nowadays, surgical concepts in the laparoscopic approach for these incisional hernias are the same for all types: tension-free technique, intraperitoneal placement of the mesh (IPOM), adequate overlap of the prosthesis to the hernia margin (most accepted, 5 cm), and good fixation, either by transfascial sutures, helical sutures, tissue adhesives, or a combination of these.

The use of laminar or bilaminar prosthesis with an antiadherent surface for the visceral side with an evidence grade 1 hernia is universally accepted when a laparoscopic repair is performed. The use of transfascial vs. helical sutures does not relate to the recurrence rate, and there is no significant evidence demonstrated by meta-analysis favoring one or the other. It seems that transfascial sutures are associated with longer operative time and more postoperative pain, while the use of metallic helical sutures could be related to higher visceral adherences. Tissue adhesives such us fibrin glue are not recommended as the only method of fixation, due to the high risk of early disruption of the mesh, and their use should be in tandem with helical or transfascial sutures, and thus a fewer number of these sutures could be used.

We can find some similarities among the special types of incisional hernias that will be discussed in the chapter. First, they present some special characteristics which make them different from midline incisional hernias and that make the surgical repair more difficult, whether open or laparoscopic approach is chosen. Second, there is a lack of specific literature about these hernias. During the literature review prior to the writing of this chapter, few publications were found and those were not very significant. Some of the longest series that have been published are those by Moreno-Egea and Carrillo-Alcaraz [2] in 2012 ($n = 53$) and Ferrari et al. in 2009 [3], ($n = 39$).

Classification of Hernias Close to Abdominal Wall Margins

Defects located close to abdominal wall margins would include those placed in the subxiphoid area, those located right below the last costal arches in both sides (subcostal), and those just above the symphysis pubis. We should also include the lumbar hernias since they are usually close to the costal margin and the iliac crest, but in the posterolateral region.

There is no absolute consensus regarding the classification for this type of hernia. We believe it is crucial to follow some type of classification for comprehensive and homogenization purposes. Chevrel suggested a classification which is not very well followed in the surgical community [4, 5]. We use the one proposed by the European Hernia Society (EHS), which defines localization, size, and recurrence. This classification can be found in the EHS web site and was published in *Hernia* in 2009 (Fig. 12.1) [6].

Indications and contraindications for this surgery are the same as for any laparoscopic approach and for midline hernias. Obesity and cardiovascular diseases, as well as respiratory problems, are considered risk factors for postoperative morbidity. The hernia defect must be taken into account, since it is related directly to the conversion and recurrence rate, this last one being much higher for defects larger than 10 cm in diameter.

Common Surgical Management

Preoperative management is common for all of these hernias. Preoperative imaging (CT scan preferred) is recommended in order to correctly localize the defect, measure it, and confirm the diagnosis in some cases. Informed consent must be collected; preanesthetic evaluation and ASA classification are mandatory.

Surgical repair will start with the patient in the supine position, securely attached to the operating table, which facilitates the different movements and positions. General anesthesia is used in all patients. The placement of the nasogastric catheter is not necessary except when important distension of the stomach is observed. Prior to surgery, and with the patient in a standing position and also in a supine position, the edges of the defect as well as most significant anatomical marks (including bone reliefs and the size of the hernia sac or sacs in case of multiplicity) should be drawn

Fig. 12.1 EHS Classification (Reprinted with permission from Muysoms et al. [6])

EHS Incisional hernia classification			
Midline	Subxiphoidal	M1	
	Epigastric	M1	
	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 <4 cm O	W2 ≥4–10 cm O	W3 ≥10 cm O

on the abdominal wall with a dermographic marker. We believe that the real measurement of the defect is an important consideration during the visceral dissection and also for the choice and size of the prosthesis and the orientation of the mesh.

Pneumoperitoneum is systematically performed by the insertion of a Veress needle at the left point of Palmer except in cases of subcostal hernia on that side, in which case this will be made periumbilical. We have not had further complications regarding this maneuver. The working pressure is initially set on 14 mmHg.

Subxiphoid Hernia

It was not until the beginning of the twenty-first century (after the publication by Muysoms et al. [6]) that subxiphoid hernias were considered an independent pathology. It has different characteristics from other incisional hernias. The hernia sac is very close to bony margins, increasing the tension, and close to neurovascular structures. These hernias usually develop in patients that might have important comorbidities and surgical interventions, such as cardiac surgery (especially transplant) and bilio-pancreatic and esophagogastric surgeries, which may need bilateral subcostal incisions, high midline incisions, or a combination of them.

As this type of hernia is not very well defined and has a low report rate in scientific literature, its incidence varies from 2 to 4.2 %, especially after a sternotomy, although this incidence might be underestimated, because in up to 89 % of the cases, no incarceration is present, so the patient could have experienced the hernia much earlier with no further symptoms but cosmesis. Risk factors for the development of these hernias are left cardiac failure, male patients, obesity, immunotherapy, and wound infection.

Indications for surgery must include all symptomatic hernias (but this is uncommon as less than 2 % present pain), but also cosmetic and preventive purposes.

Conventional surgery is difficult, and high rates of recurrence have been described; this is the reason why many different approaches have been described, without a formal recommendation.

Early publications mention simple closure of the defect, with recurrence rates from 43 to 80 %. This is the main reason, together with the anatomical difficulties and proximity to bony margins, why the surgical community shifted to the use of prosthetic materials, with lower recurrence rates of 0–32 %. Some authors like Carbonell et al. [7] propose the use of a double mesh. It is accepted, with no clear evidence, that the best repair would include the implantation of a parietal prosthesis, submuscular, with a minimum 5 cm overlap surrounding the perimeter of the defect. In this anatomical region, attention to the retro-xiphoid-sternal dissection as well as perixiphoid space, mainly cranially and towards the costal insertions, must be especially paid, in order to achieve enough overlap. Some publications present the use of fixation with sutures or prosthetic loops fixed to the costal arch. This use is contraindicated nowadays, due to the high rate of postoperative chronic pain caused by the damage of this fixation to the periosteum.

During the last decade, the open approach with the insertion of a retromuscular mesh (sublay) has been used, with recurrence rates higher than 50 % in some series; this has led to controversies in the approach. Laparoscopy is the main option for treatment in referral centers. This approach does not diminish recurrence rates significantly but results in less postoperative pain, better cosmetic results, shorter postoperative stays, and faster recovery times, as the start of normal activities has been seen earlier, which proves the benefits of minimally invasive surgery for this repair.

First publications about this laparoscopic approach date from 2000 and 2001. Still, up to this point in time, few references can be found, with short and heterogeneous series and limited follow-up. Most authors recommend the laparoscopic approach with the use of laminar or bilaminar meshes, ePTFE, or polypropylene/polyester with an antiadherent side and partial fixation of the prosthesis.

In summary, in the case of a subxiphoid hernia, we recommend the laparoscopic approach with the use of a prosthetic material placed intraperitoneally (IPOM).

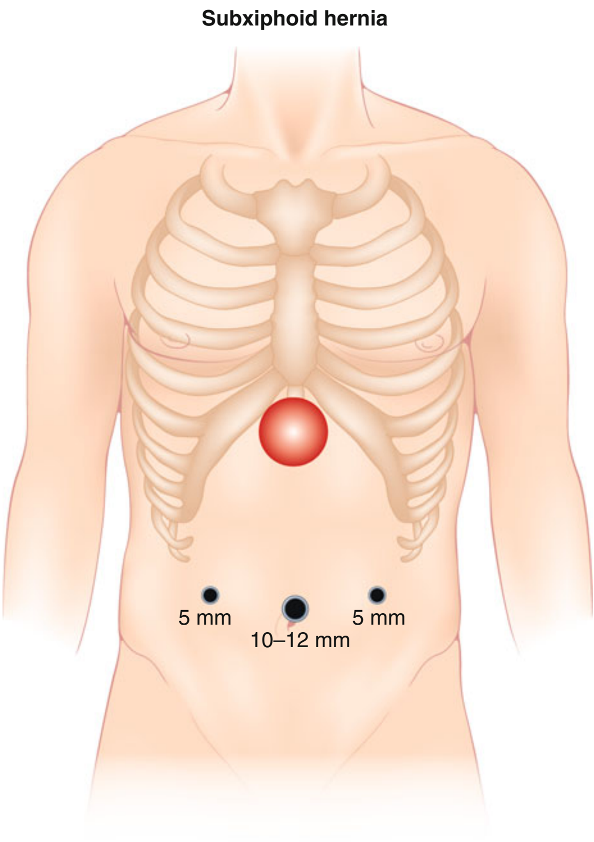

Fig. 12.2 Trocar placement in subxiphoid hernia

This approach allows for an excellent view of the hernia margin, as well as the subfascial space, and also any associated unsuspected defects, and is considered as a safe and minimally invasive alternative.

Surgical Technique

Trocar placement is described in Fig. 12.2. The success of the repair depends upon ensuring an overlap >5 cm of the defect margin. Fixation can be made with helical metallic or resorbable sutures, as well as a combination of both, depending on the experience of the group and availability. Transfascial nonabsorbable sutures may also be used, alternatively. The fastening of the mesh in this region is especially difficult, especially in the cephalic portion, due to the proximity of the ribs, diaphragm, and the pericardium. Diaphragmatic injuries, pericardial tamponade, and even cases

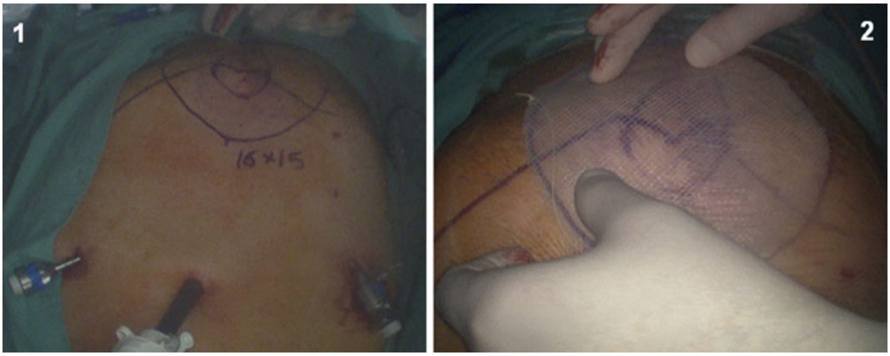

Fig. 12.3 *1* Measure of the defect. *2* Mesh with two strands for the transmural sutures

of cardiac tamponade (because of the use of helical sutures) formally discourage their use. A vast majority of authors, such as Eisenberg [8], recommend no fixation of the cephalic portion of the prosthesis and fixing only the caudal portion, leaving the intra-abdominal pressure, the liver, and the stomach to help protect the upper area. The development of effective biological adhesives, in the future, to help us solve this key problem will be necessary to achieve a safe repair of these hernias.

Our group performs the fixation following the double crown technique with metallic and absorbable tacks, in a proportion of 1:3. The limits for this are the costal arch and the diaphragm, where we use tissue adhesives (Tissucol Inmuno®, Baxter Healthcare, Deerfield, IL, USA) and absorbable sutures anchoring the mesh to the peritoneum/diaphragm with extracorporeal knotting. See Fig. 12.3.

Major complications associated with this laparoscopic repair are visceral lesions during the adhesiolysis (often unknowingly), which cause high morbidity and mortality (which can be avoided following careful dissection without thermal energy), and the appearance of seroma, common to the abdominal wall prosthetic repair, which can be handled in the same manner as after hernia repair in other locations.

Subcostal Hernias

An incidence rate of 6–17 % for subcostal hernias can be found in literature, although it might be higher. Moreno-Egea and Carrillo-Alcaraz [2] describe rates as high as 25 % (including other lateral hernias such as lumbar and iliac hernias). Among their characteristics, very similar to subxiphoid defects, are having the costal arch as one of the limits on one side or the other and also presenting more diffuse hernia margins, compared to midline defects. This is the reason why published incidence rates are higher.

Standard treatment includes open repair, with mesh placement in the retromuscular space, with at least 3 cm overlap, which sometimes cannot be achieved due to the presence of the 10th or 11th rib as a limit. That is the reason why the laparoscopic approach is becoming more used lately, with intraperitoneal technique (IPOM) and transfascial or helical sutures.

A recent study published by Wassenaar et al. in 2009 [9] on 509 patients shows that the recurrence rate after laparoscopic incisional hernia repair occurs only when the principle of repairing the whole incision and prior hernia defect is omitted, regardless of the type of fixation used. This becomes of capital importance in the case of subcostal hernias since, as we have seen, subcostal defects are more diffuse and less fibrous edged. Therefore, we recommend the laparoscopic approach, which allows you to clearly identify the margins of the hernia, hidden defects, and areas of muscle weakness in the vicinity, which must necessarily be covered by the intraperitoneal prosthesis. Recurrence rates of 1.7 % as published by Wassenaar are described when applying these principles.

It is crucial to measure the whole defect, and the prosthesis size must include a total 5 cm defect overlap in all cases. Anchoring can be made as in subxiphoid hernias through transfascial sutures, helical sutures, or both. Fixing to the proximity of the ribs or intercostal spaces, which inevitably will result in postoperative pain, is not recommended. Fixing limit is set on the lower costal edge, so the cephalic segment of the prosthesis may be fixed by tissue adhesives, or sutures from the prosthesis to the peritoneum and the diaphragm. Our group employs a combination of tissue adhesives such as Tissucol® and, sometimes, depending on the size and type of implant used, employs the use of two or three stitches of absorbable material between the prosthesis and the peritoneum, which maintain, along with the abdominal pressure and the liver, the mesh in place.

Surgical Technique

The technique is similar to that described for subxiphoid hernias. Placement of trocars is almost identical (Fig. 12.4) (mirror image in the case of a left subcostal hernia). The technique is always IPOM, and prostheses are used according to the surgeon's preferences: PTFE (Dual Mesh™ Plus, W.L Gore & Associates, Newark, DE, USA) or Parietex™ composite (Covidien, Dublin, Ireland). Frequent complications are seromas (which can usually be treated conservatively), hematoma, and persistent postoperative pain. Visceral lesions are rare, if the technique is successful, but if they go unnoticed, they can produce high mortality and usually involve reoperation and explant of the prosthesis. In the case performing a wide adhesiolysis, we systematically leave an aspirating drainage (Blake No. 19) through one of the 5 mm trocars, in the event of visceral perforations, which will facilitate the decision for early reoperation if needed. The drainage is removed after 24 h, if discharge is less than 60 cc.

All patients leave the operating room with an elastic corset, continuously worn for 10 days. We have seen that postoperative pain and the incidence of symptomatic seromas have diminished significantly due to this. Average postoperative stay is 1–3 days. See Fig. 12.5.

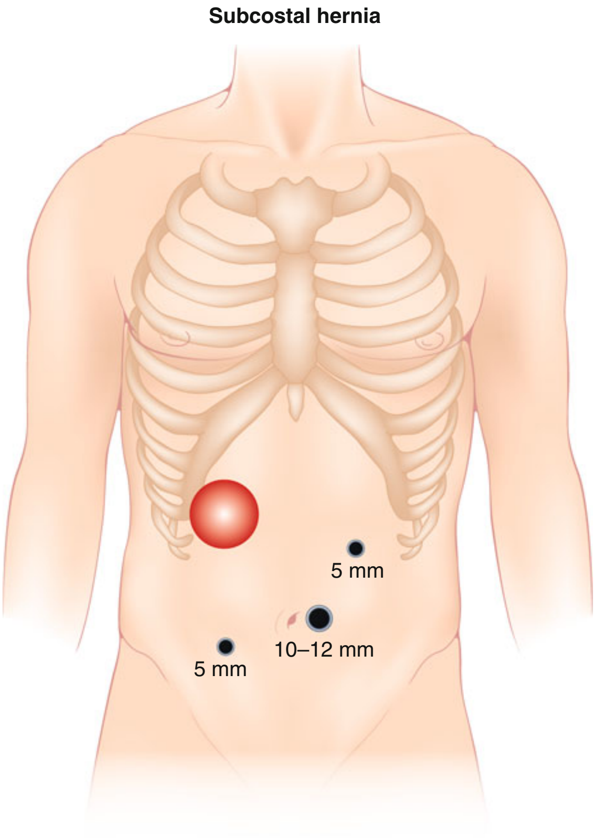

Fig. 12.4 Trocar placement in subcostal hernia

Suprapubic Hernias

Suprapubic incisional hernias are defined as parietal defects located less than 4 cm from the symphysis pubis. The concept was first introduced by El Mairy [10]. This type of hernia usually appears after lower midline laparotomies during gynecological and urological or rectal surgical interventions, and less frequently after Pfannenstiel's or Maylard incisions.

As a result of their low and mostly unknown incidence, very little has been published about them. The key to a proper repair is perfect knowledge of the local anatomy and all the osteomuscular and neurovascular structures. Before the development of laparoscopic techniques, the standard for this type of hernia repair was popularized by Stoppa: implantation through an open approach, prosthesis in the Retzius space, anchored to Cooper's ligament on one or both sides. Hirasa et al. in 2001 [11] published his results of laparoscopic treatment of these defects in 7 patients using a composite prosthesis anchored with metallic helical sutures. He

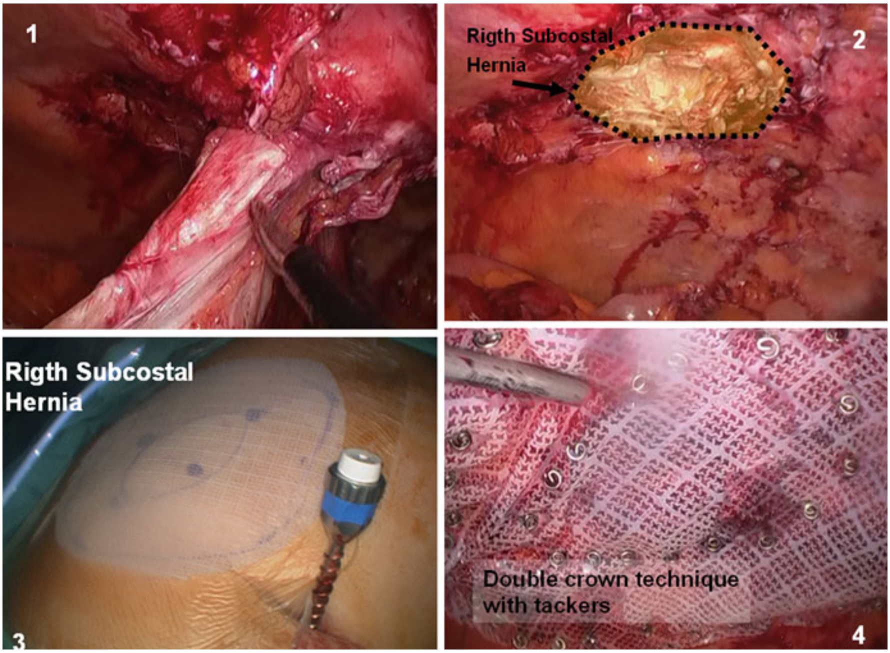

Fig. 12.5 Steps in subcostal hernia. *1* Adhesiolysis to discover the defect. *2* Subcostal hernia. *3* Measure of the limits of the hernia and the mesh (overlapping 5 cm). *4* Double crown technique with tackers

described an initial 14.3 % recurrence rate. Other important series published to date are those of Carbonell et al. in 2005 ($n = 36$) [7], with laparoscopic approach and fixation with transparietal sutures and helical sutures to the Cooper's ligament (recurrence rate of 5.5 %), and the recent series by Sharma et al. in 2011 ($n = 72$), the largest published to date with a recurrence rate of 0 % [12]. Essential surgical principles for the laparoscopic repair of suprapubic hernias are the same as for the rest of incisional hernia repair: proper fixation to the abdominal wall and 5 cm or more overlap. The problem in this case is that the inferior limit of the defect tends to be very close to the pubis and therefore does not allow for a proper fixation or overlap below the pubis. In order to achieve this, it is essential to carry out an opening of the supravesical peritoneum as in the TAPP technique for the laparoscopic treatment of inguinal hernia. The peritoneal flap must be pulled back to expose all the anatomical structures of the region: the symphysis pubis, Cooper's ligaments, and epigastric vessels on both sides, retracting the bladder down and dissecting the Retzius space widely. Only by this often difficult and potentially dangerous dissection is it possible to achieve a proper overlap of the prosthesis in the caudal edge of the hernia defect. Once the prosthesis is placed in this position and at least a 5 cm overlap is guaranteed, the mesh should be fixed as described by Carbonell [7], using transfascial or helical sutures to the abdominal wall and using helical sutures to the pubis bone between both Cooper's ligaments.

Surgical Technique

The position of the patient on the operating table is similar to other hernias, and the location of the trocar is shown in Fig. 12.6, but in the case of suprapubic hernias, a bladder catheter will be inserted for bladder filling/identification during the dissection of prevesical space. Our group has changed the position, exchanging the trocar for the optic, placing it almost at the midline, and raising the left-working trocar to an almost subcostal situation.

This type of repair is usually accompanied by a higher incidence of bruising and bleeding because of a greater dissection and the presence of higher vascularization. Dissection and hemostasis must be carefully done. We should be aware that the use of transfascial sutures in the vicinity of the inguinal regions may cause prolonged, severe, chronic pain, the main reason why some authors recommend only 2–3 transfascial stitches on the superior edge of the prosthesis. The balance of the fixation is made by helical sutures, which may be absorbable.

Some authors recommend removing the hernia sac, which is related to fewer incidence of postoperative seroma. The prostheses used must be the same as in the

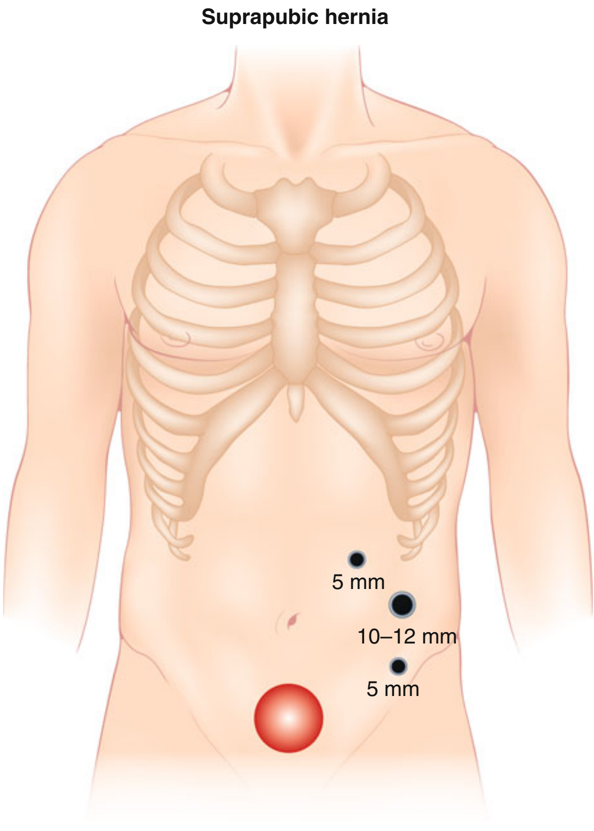

Fig. 12.6 Typical disposition of trocars in suprapubic hernia

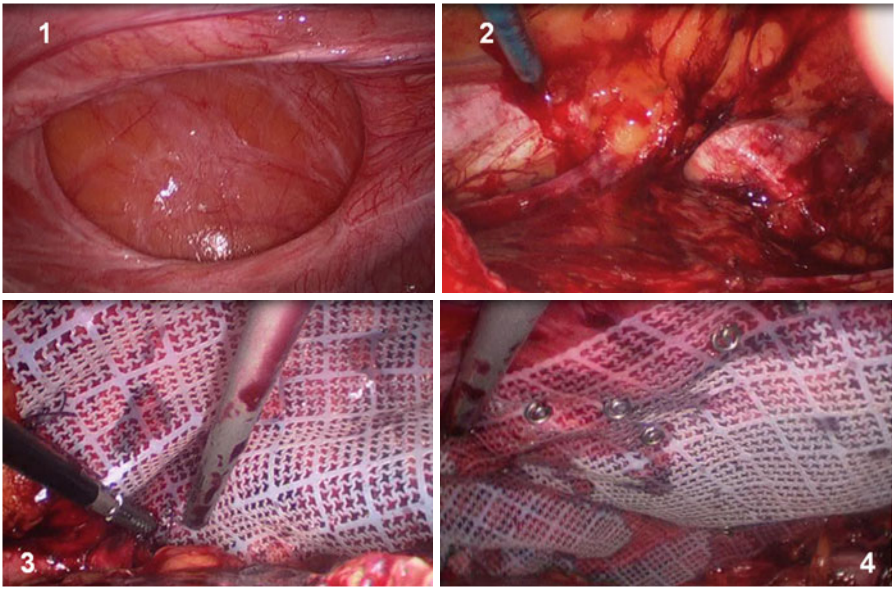

Fig. 12.7 Steps in superpubic hernia approach. *1* Suprapubic hernia. *2* Cooper's ligament bilateral exposed. *3* Fixation in the Cooper's ligament. *4* Double crown technique

case of an IPOM repair: laminar non-adherent or bilaminar, due to the partially intraperitoneal position, and therefore visceral contact [13]. See Fig. 12.7.

The use of intraperitoneal drains is discretionary, and these are not used on a regular basis, although the use of aspirative drainages, in the case of procedures that are long, bloody, and potentially harmful to the viscera, is recommended. It will be brought out through one of the 5 mm trocars and will be removed within 24 h in case of low discharge. The use of abdominal banding (strip) is mandatory in all cases. Food intake and mobility are introduced 24 h postoperative, and discharge is usually done after 24–48 h.

Lumbar Hernias

Lumbar hernias are defined by the protrusion of intraperitoneal or extraperitoneal content through a defect of the posterolateral abdominal wall. Incidence of this type of hernia is difficult to assess and can often be underestimated, but it would include up to 1.5 % of all abdominal hernias.

They can be divided into either congenital or acquired hernias. Congenital hernias involve close to 20 % of the cases. Acquired hernias also can be divided into primary or secondary. Primary hernias are usually associated with an increased abdominal wall pressure and settle mainly through the Grynfeltt triangle in the inferior margin and the Petit triangle in the superior one. Secondary hernias occur after surgical interventions (urology, retroperitoneal approaches to the aorta, etc.) or after trauma [14].

It is crucial to distinguish these hernias from abdominal wall muscular atrophy related to denervation after a flank surgical incision, where no "real" hernia defect is present, so there is no need to perform a surgical repair.

Clinical presentation is commonly represented as a bulge in the lumbar region. Usually asymptomatic, pain or discomfort may be present. Incarceration and even strangulation are uncommon but can occur depending on the content of the hernia sac.

Even though clinical presentation may determine the diagnosis, CT scan or MRI is usually needed to confirm the presence of the hernia and also to assess its relationships to the surrounding osteomuscular structures as well as the nature of the hernia content.

Surgical Management

It is located between the 12th rib and the iliac crest. Surgical management still remains unclear, mainly due to the low incidence of this type of hernia and difficulties localizing the correct limits and the presence of bony margins, which make it hard to perform a proper surgical repair.

Despite this fact, most authors recommend repairing these lumbar hernias upon presentation, if there is no formal contraindication, in order to avoid possible complications [15].

Many different techniques have been described for the repair of lumbar hernias.

Open repair with mesh placement can be difficult to perform in some cases, as it can be hard to identify the margin of the defect and can be especially difficult to achieve good fixation of the prosthesis to the osteomuscular surrounding structures. This can lead to a larger incision and extensive dissection in order to place the mesh, which might be related to wound complications and longer hospital stay.

The laparoscopic approach for incisional hernias is widely accepted, and it can also be applied in the treatment of these special hernias.

The potential advantages of this approach include those related to minimal invasive surgery, such as less pain and shorter postoperative stay. Other advantages include better visualization of the hernia defect and its margins, contributing to a more definitive diagnosis; more accurate measure of the actual hernia size; and more accurate tailoring of the mesh [16].

Surgical Technique

The patient is placed in a lateral decubitus position, and three or four trocars are placed around the midline (Fig. 12.8).

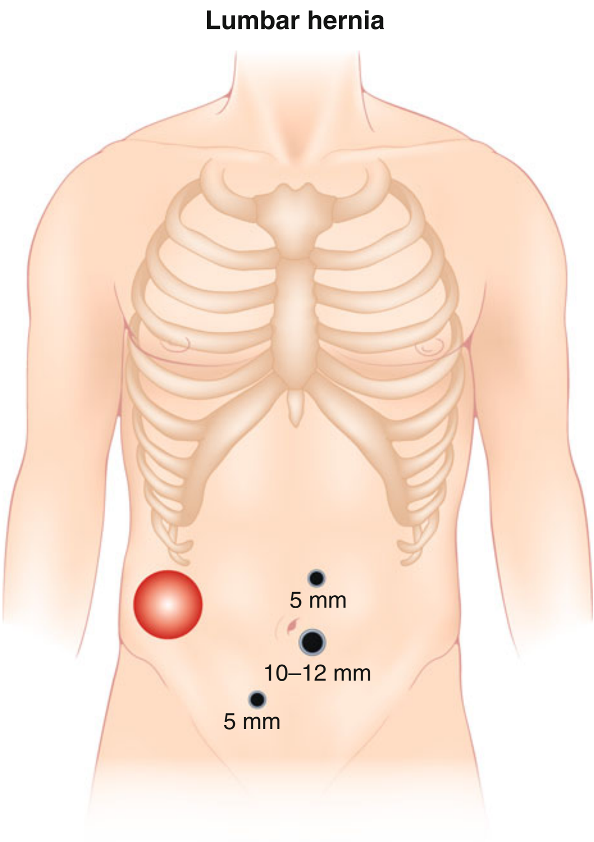

Fig. 12.8 Trocar placement in lumbar hernia

Adhesiolysis must be carefully performed. It is usually mandatory to mobilize the colon medially, to expose the iliopsoas and lumbar muscles.

Retroperitoneal fat should be cleared when necessary in order to assure good fixation to the abdominal wall.

Once the mesh is introduced, transfascial sutures can be helpful in order to correctly hold it into place, but also to assure good overlap on the superior margin when it is closed to the costal edge. This can be achieved by passing the suture through the intercostal spaces. Always be aware to do so just over the margin of the immediate inferior rib, in order to avoid lesions of the intercostal neurovascular trunk.

There is not enough evidence regarding the type of prosthesis that should be used in these cases, although the majority of authors use either polypropylene or ePTFE meshes. It seems important regarding this special type of hernia to use a prosthesis that assures a good tensile strength, so low weight meshes might not be the best option for these cases. See Fig. 12.9a, b.

Parastomal Hernias

Parastomal hernias are the most frequent complication appearing after a stoma- formation surgery. It can be described as an incisional hernia developed in the proximity of a stoma (ileostomy, colostomy, ureterostomy, etc.). Incidence of this type of hernia is not easy to establish, as this is an often underestimated problem for the patient and even the physician, and incidence rates from 2.8 to 50 % have been reported. Incidence is directly related to the time of follow-up.

Many risk factors have been described in the development of parastomal hernias, but only waist circumference, age, and the size of the stoma have shown to be independent risk factors for the appearance of a parastomal hernia after permanent colostomy.

Diagnosis is done by clinical examination, although imaging tests may be useful (usually CT scan) [17].

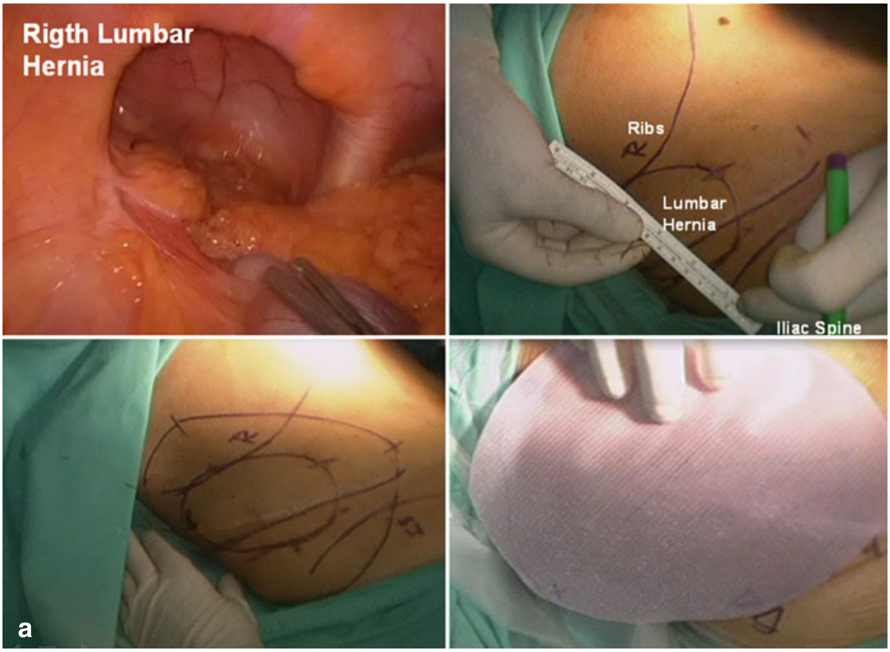

Fig. 12.9 (**a**, **b**) Steps in lumbar hernia laparoscopic approach. (**a**) *1* Identify the lumbar hernia and adhesiolysis. *2* Measure of the hernia. *3*, *4* Measure of the mesh and the marks on the skin with the limits. (**b**) *5* Rolling the mesh, marked. *6* Introduction of the mesh into the abdominal cavity. *7*, *8* Extension of the mesh and fixation in the two main cardinal points (cranial and caudal). *9* Tackers in the inner crown. *10* Final view of the double crown in lumbar hernia

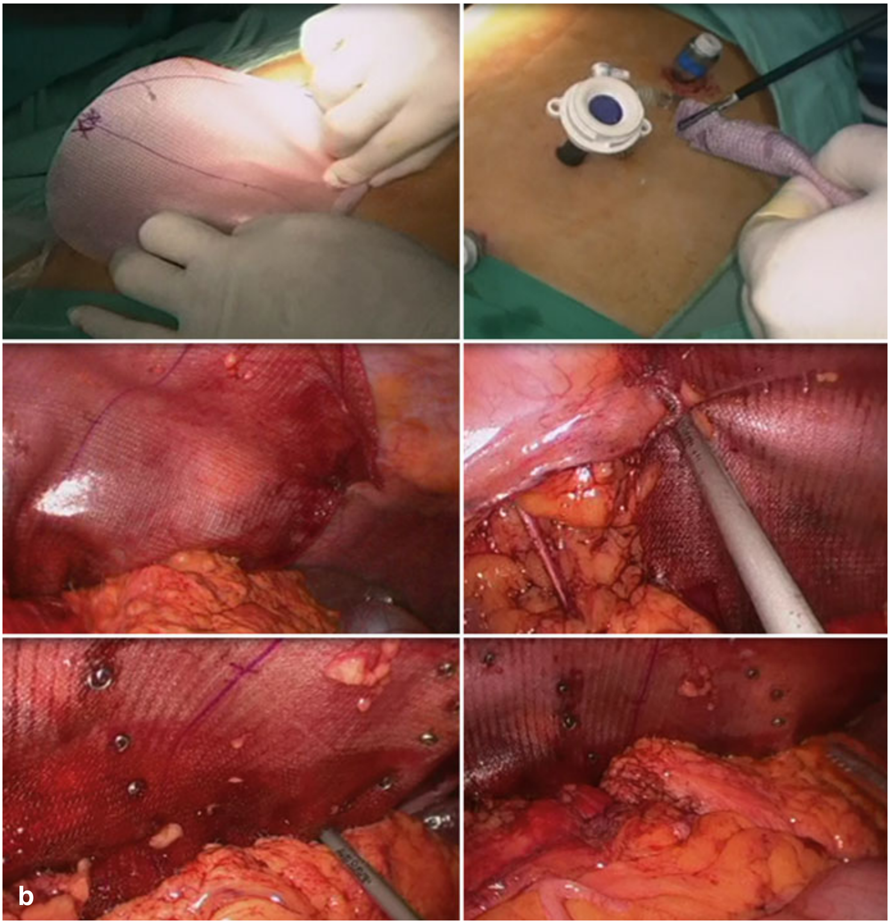

Fig. 12.9 (continued)

Surgical Management

When it comes to surgical repair of parastomal hernias, the preferred option is not so clear [18]. Many different techniques have been described for the treatment of parastomal hernias.

Non-mesh techniques are related to a high recurrence rate (46–100 %) and therefore should not be performed [19].

Mesh techniques have better results. Local repairs, whether the position is onlay or sublay, are related to a high incidence of wound infection of up to 30 %.

The underlay or IPOM (intraperitoneal onlay mesh) position has better results in terms of wound infection and presents the opportunity to repair a concomitant incisional hernia if present

The laparoscopic approach for the treatment of parastomal hernias was first introduced by Porcheron et al. in 1998 [20], and this attempts to bring the advantages of the minimally invasive approach to this type of surgery.

Since then, many authors have reported this approach for the treatment of these hernias [21, 22]. Two main techniques have been described.

The laparoscopic keyhole technique was first described by Hansson et al. in 2003 [23]. Different meshes have been used in this procedure, whether pre-shaped or tailored with a central hole. First results by the Hansson group were promising after a follow-up of 6 weeks, but after a 36-month follow-up, the recurrence rate grew as high as 37 % [24]. Other authors published their results with the keyhole technique with recurrence rates that were up to 73 % (8–73 %), as well as complication and reintervention rates up to 22 and 13 %, respectively [25]. This recurrence rate is the main reason why many surgeons switched to other techniques for the treatment of parastomal hernias.

The laparoscopic Sugarbaker technique was first described by Voitk in 2000 [26]. Some authors published promising results with this new approach. Mancini et al. [27] reported good results with the Sugarbaker technique in 25 patients after a 19-month follow-up with a recurrence rate of 4 % and a postoperative morbidity rate of 23 %. Recently, Hansson et al. [28] presented very good results with the Sugarbaker technique with a recurrence rate of 7 % after a follow-up of 26 months.

Surgical Technique

We use the laparoscopic Sugarbaker technique as the preferred option for the treatment of parastomal hernias.

The patient is placed in a supine position, and three trocars are placed opposite to the stoma site. See Fig. 12.10.

Careful adhesiolysis must be performed, and the use of electrocautery should be done with caution in order to avoid any intestinal lesion.

The intestinal segment going into the stoma (usually colon) must be freed, with the main goal of creating a tunnel for the colon through the prosthesis.

The mesh is then introduced and fixed to the abdominal wall, usually with spiral tacks, even though transfascial sutures can also be placed.

The mesh must be gradually unrolled, creating a tunnel over the colon as it enters the stoma site, and a double crown of tackers is placed (Figs. 12.11 and 12.12).

Whether the gap between the mesh, colon, and the parietal peritoneum should be closed can be debated.

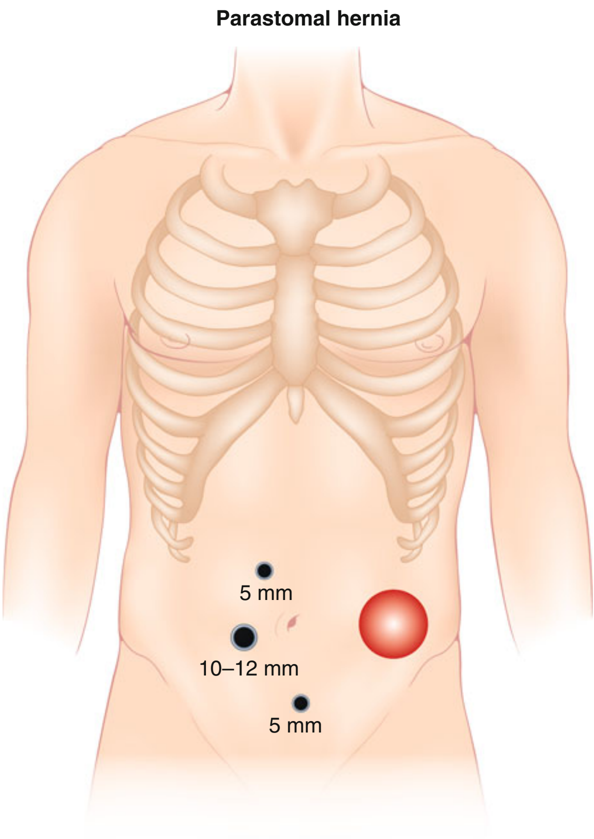

Fig. 12.10 Trocars placement in parastomal hernia

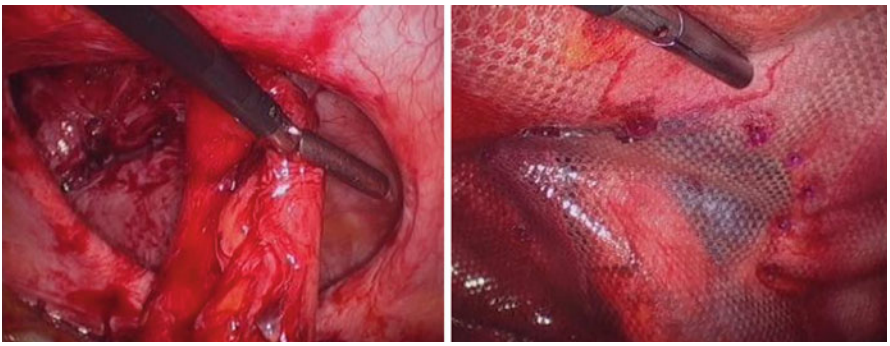

Fig. 12.11 Parastomal hernia and Sugarbaker technique

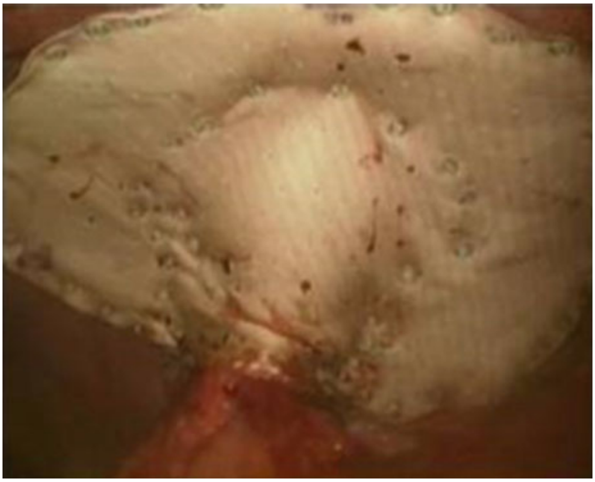

Fig. 12.12 Sugarbaker technique with ePTFE mesh (L. Gore & Associates, Newark, DE, USA)

Spiegel Hernia

A spigelian hernia (or lateral ventral hernia) is a hernia through the spigelian fascia, which is the aponeurotic layer between the rectus abdominis muscle medially and the semilunar line laterally. These hernias almost always develop at or below the linea arcuata, probably because of the lack of posterior rectus sheath. Its incidence varies from 0.12 to 2 % of abdominal wall hernias, and it presents usually between the ages of 50 and 60.

Spigelian hernias are usually interstitial sacs covered by oblique fascia externally, and this helps to make the diagnosis. Furthermore, these hernias can be confused with inguinal hernias if the spigelian hernia is lower.

CT and ultrasound can help considerably with diagnosis, the more definitive diagnosis being CT. Laparoscopy has an important role as a means diagnosis, with the added advantage of being able to complete treatment by this approach.

Laparoscopy for repair of this type of hernia was first performed in 1992, and there are three main variations: totally extraperitoneal repair, the transabdominal preperitoneal approach, and the intraperitoneal type “onlay” method. These techniques have shown recurrence rate reported as 0 %.

Intraperitoneal techniques allow assessment of the abdominal viscera, which may be useful in checking the viability intestinally if there is doubt in the diagnosis or for performing other simultaneous procedures.

Surgical treatment combines conducting a unilateral TAPP (Cooper’s ligament exposing of the hernia side) and, after fixing the mesh in this ligament, extends upwardly and proceeds as in the case of a ventral hernia, with a double crown mesh technique around the defect. See Figs. 12.13 and 12.14.

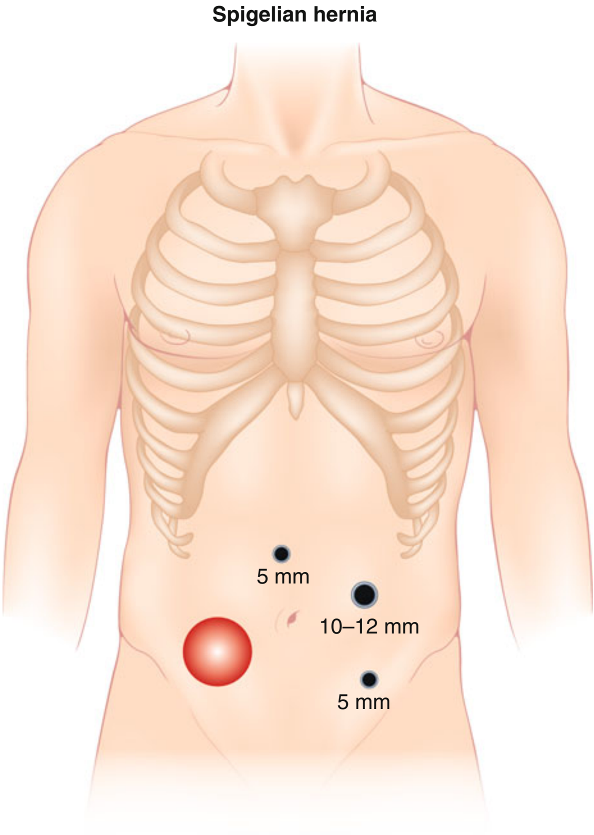

Fig. 12.13 Trocars placement

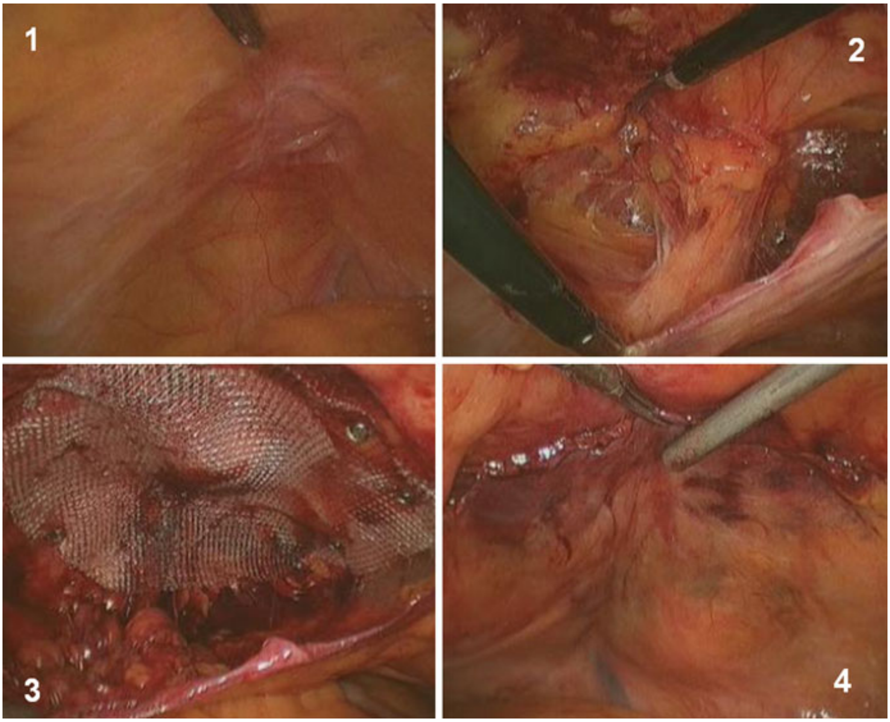

Fig. 12.14 Spigelian hernia and intra-abdominal hernioplasty. *1* Spigelian right hernia. *2* Opening the preperitoneal space (Retzius and Bogros). *3* Hernioplasty with tacker fixation (Cooper's ligament). *4* Closure of the peritoneum

Conclusion

Surgical treatment of these special incisional hernias still remains controversial, due to their low incidence and difficult management. The open approach had been the standard of care until the introduction of laparoscopy as an option for surgical treatment.

The laparoscopic approach presents the opportunity to achieve a better diagnosis, as we are able to explore the abdominal cavity and the real borders of the hernia defect, which can help to assure proper placement as well as enough overlap of the mesh. This approach also has the advantages of a minimally invasive approach and can be the preferred option when performed by an experienced team.

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Chapter 13
Emergency Laparoscopic Surgery of the Abdominal Wall

Juan Antonio Bellido Luque and Juan Manuel Suárez Grau

Abstract One of the most controversial situations in laparoscopic abdominal wall hernia surgery is an incarcerated or strangulated hernia. Currently, there are few groups that perform laparoscopic surgery for these complicated hernias with a high probability of conversion to laparotomy. We describe in this chapter the concepts of hernia incarceration and hernia strangulation and the surgical techniques and resources that can be used in this emergency situation.

Keywords Hernia • Surgery • Laparoscopy • Incarcerated • Strangled • Emergency • Ventral • Inguinal • Hernioscope

Introduction

In abdominal wall surgery, there are several very common emergencies in daily practice, namely, the incarceration and strangulation of inguinal and ventral hernias.

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Inguinal Hernia in Urgent Situations

Incarcerated Hernia

Nonreducible hernia with compromised intestinal transit usually generates a subocclusion or complete occlusion. The patient will have pain and present with a hard lump in the groin or femoral, abdominal distention (to a greater or lesser extent depending on the degree of occlusion present), and nausea and vomiting. Vomiting initially will be food before moving on to be bilious or fecaloid.

In abdominal radiography, one will observe dilated bowel loops fundamentally. Although the abdominal CT scan may be useful, thoroughly scanning all regions for hernia is sufficient to confirm the diagnosis.

Initial treatment of this entity is the attempt at hernia reduction. To this end, the hernia sac compression works on the superficial inguinal hernia hole, gradually and without exerting too much pressure. The use of painkillers and muscle relaxants as well as placing the patient in Trendelenburg position facilitates this maneuver. If you obtain a complete reduction, it is advisable to keep the patient under observation for a few hours to confirm the absence of complications from the reduced hernial contents.

If unable to perform hernia reduction, the only option is surgery. Subsequently, detailed surgical alternatives and the role of laparoscopy are discussed.

Strangulated Hernia

The vascular compromise differentiates the strangulated herniated loop from the incarcerated hernia. This complication appears in 8–11 % of patients with inguinal hernia, being more frequent in indirect hernias than direct. The content is usually omentum or bowel.

Hernia content constriction at the neck of the sac produces, on the one hand, lymphatic and venous occlusion and, secondly, an occlusion of the lumen. Venous occlusion leads to an *ischemia phase* of the intestinal loop, called congestion phase. If constriction is maintained, arterial occlusion occurs, followed by the *infarct phase* and subsequently *gangrene*. The latter two phases signal the need for bowel resection.

Surgical Treatment of Urgent Inguinal Hernia

Surgical treatment can be divided into several phases, all discussed in this section.

Access

The most accepted surgical approach for the treatment of complicated inguinal hernia (incarcerated or strangulated) is laparotomy. An incision about 5–6 cm above the lump is made, dissecting the subcutaneous tissue until the hernia sac and the constriction ring are reached.

An alternative to the conventional approach is to access laparoscopically, with two main advantages:

- Less postoperative pain and therefore an improvement in comfort after intervention [1]
- Decreased rate of wound infection, to access the abdomen distant from the hernia [2]

Although there have been reports that confirm the feasibility of totally extraperitoneal approach (TEP), the transabdominal preperitoneal (TAPP) provides more benefits and involves less technical difficulty.

We use three trocars: 10 mm in one location for introducing periumbilical optics 30° and two 5 mm placed so we get adequate triangulation to facilitate maneuvering. See Fig. 13.1.

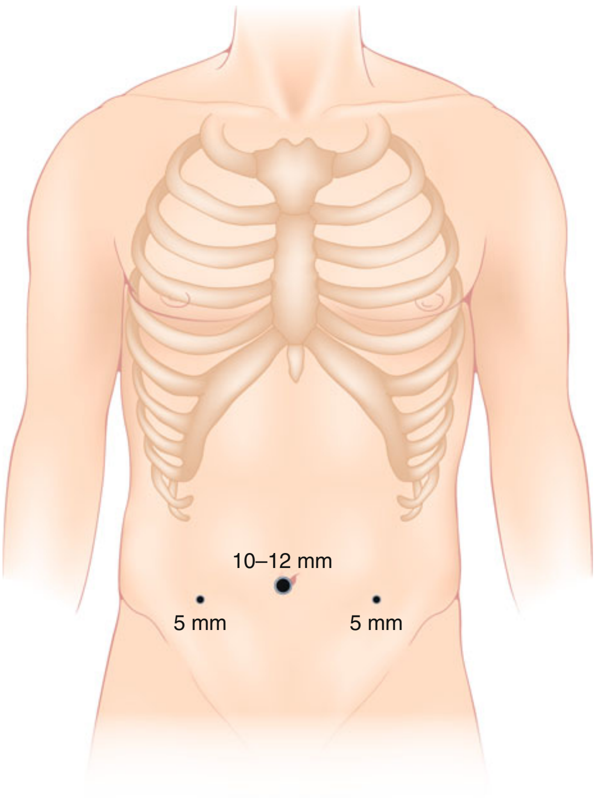

Fig. 13.1 Trocar placement

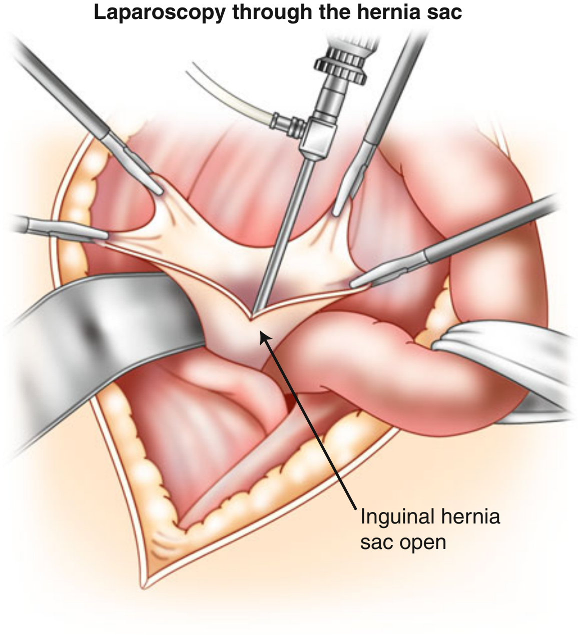

Fig. 13.2 Hernioscopy

Reduction of the Hernia Contents

In open surgery, it is important not to try to reduce the hernia contents during induction of anesthesia, since it is possible to introduce a viable ischemic bowel into the intra-abdominal compartment, with the risk of perforation during the immediate postoperative period. It is important to keep the hernia contents in the bag until opened and subsequent assessment of viability is made.

If the bowel is reduced spontaneously, its location through the hernia ring is difficult and ineffective. For identification, it is feasible to use the laparoscope introduced through the hernia ring and then to evaluate whether or not bowel viability exists. This technique is called *hernioscopy* [3].

Hernioscopy is laparoscopy traversing a hernia sac used in the course of traditional treatment for groin hernia, and it may be both diagnostic and therapeutic. See Fig. 13.2.

In laparoscopic surgery, we are able to assess the vitality of the bowel even before the induction of anesthesia, because we can view it directly. The establishment of pneumoperitoneum facilitates spontaneous reduction.

In the case of nonreduction, there are several techniques for reintroducing the abdomen [4] (Fig. 13.3):

- Traction control, avoiding handling it directly. First try to reduce omentum and get more space so as to facilitate the reduction of the bowel loop.
- Opening the hernial orifice in its medial part, avoiding damage to epigastric vessels. This maneuver sections ring constriction and facilitates the complete reduction of the content.

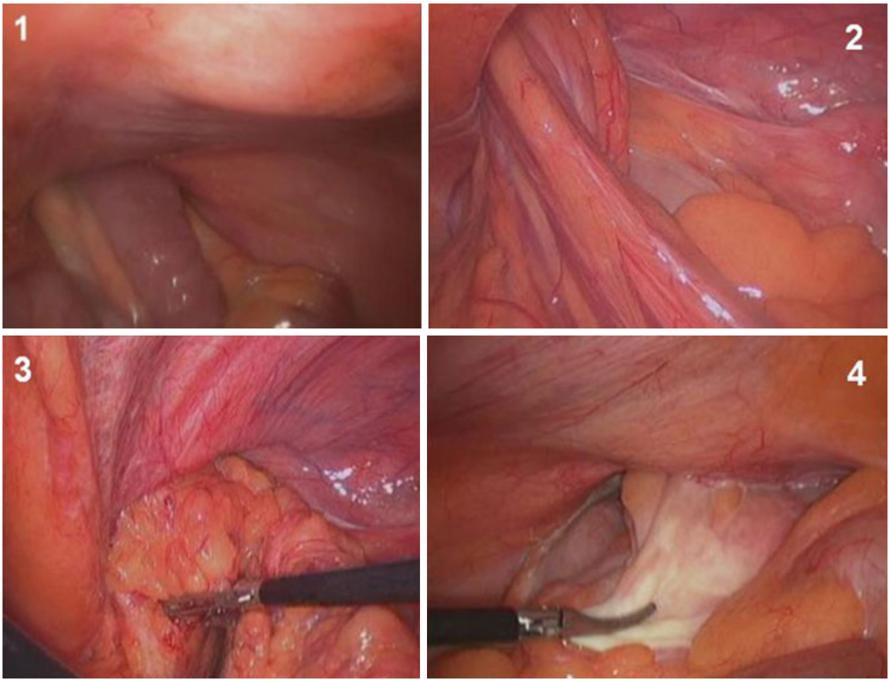

Fig. 13.3 TAPP in inguinal hernia, incarcerated. *1* Small bowel incarcerated in right inguinal hernia. *2* Reduction of the hernia with traction control. *3* Incarcerated epiplon in right inguinal hernia. *4* Colon incarcerated in left inguinal hernia

Treatment of Content

Once the hernia content is reduced, the bowel integrity is evaluated based on its coloration and peristalsis. If it is necessary to do loop resection when you are doing an open inguinal access, you may do so through the inguinal or by midline laparotomy depending on the difficulty.

During the laparoscopic approach, intestinal resection can be performed laparoscopically or by minilaparotomy assistance, which later will be used to extract the surgical specimen. This surgical approach decreases pain and postoperative recovery time for patients when compared with conventional open surgery [5].

Treatment of Hernia Defect

Until recently, all surgeries that required a bowel resection contraindicated the use of mesh because of the probability of infection by this prosthetic. However, according to scientific evidence, there is currently no reason not to use mesh for the treatment of urgent hernia defect surgery in the abdominal wall. Wisocky et al. objectified only two prosthetic infections in 56 patients treated for emergency inguinal hernias by the Lichtenstein technique [6].

Leibl confirmed only one case of infection of the prosthesis placed in 194 TAPP laparoscopic approaches [7].

Therefore, for treatment of hernia defect associated with intestinal resection, the use of mesh is recommended, since the probability of secondary infection of the mesh is very low.

Ventral Hernia in Urgent Situations

Ventral hernia, either primary or incisional, may be urgent, as it can be both incarcerated and strangulated, as in an inguinal hernia. Open access laparotomy and laparoscopy are feasible as surgical options.

If we focus on the laparoscopic approach, it has a number of advantages and disadvantages when compared with open surgery [8, 9]:

Advantages

- Less postoperative pain
- Low wound infection rate
- Quick recovery after surgery
- Reduced hospital stay
- Ability to identify and correct other hernia defects simultaneously

Disadvantages

- Most patients have a secondary subocclusive disease, avoiding the correct visualization of the hernia.
- Difficulty in reducing the hernia contents, due to relation to accessibility with laparoscopic trocars. The opening of the hernia defect is a complexity added by proximity of the loop.
- High probability of intestinal resection. Over 50 % of patients with a ventral hernia have a strangulated bowel and require resection, increasing the complexity of laparoscopy.
- Operating time: minimally invasive access requires longer operative time than laparotomy.
- The total cost of the laparoscopic procedure is greater than the access laparotomy.

Surgical Treatment of Urgent Ventral Hernia

Emergency surgical treatment of ventral hernia is similar to treatment of urgent inguinal hernia, with the same surgical steps. Although cases have been published in which placement of the prosthesis in the preperitoneal space is done laparoscopically, most surgical teams do this intraperitoneally, using a technique similar to that used in uncomplicated laparoscopic ventral hernia. See Fig. 13.4.

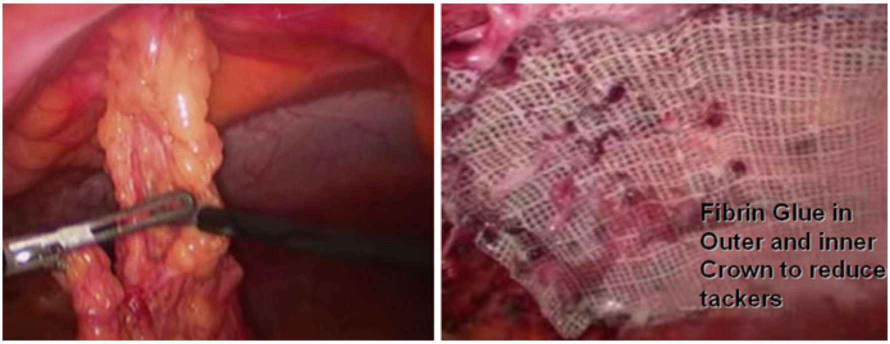

Fig. 13.4 Incarcerated ventral hernia and double crown technique modified with fibrin glue

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Chapter 14
Current Advances and New Frontiers in Laparoscopic Hernia Repair

Juan Manuel Suárez Grau and Juan Antonio Bellido Luque

Abstract The current relentless advances of surgery continuously bring forth new techniques, new devices, and new materials. Currently, the single-port ventral hernia surgery is in practice and is being increasingly used. Robotic surgery has started tackling hernias, though at great cost, permitting procedures performed by a single surgeon. Other techniques are gaining importance: laparoscopic surgery of diastasis recti, especially in women after childbirth; transabdominal repair with preperitoneal mesh placement; and closure of the defect before placement of the mesh, which seems to favor the recovery and dynamics of the abdominal wall muscles.

Keywords Hernia • Abdominal wall • Laparoscopy • Surgery • e-TEP • Defect closure • Robotics • Single port • Diastasis recti • Transabdominal preperitoneal repair • Advances

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Introduction

In this chapter, we present the current advances in laparoscopic hernia repair of the abdominal wall, along with new techniques with new devices, single-port surgery, and laparoscopic robotic surgery.

Extended Totally Laparoscopic Inguinal Hernioplasty Extraperitoneal (e-TEP)

In the past 2 years, a new laparoscopic inguinal hernioplasty technique has been developed which has advantages over conventional TEP. The e-TEP provides a wider field of vision and better access. As a result of having better access to the preperitoneal space, we can resolve larger hernia defects without accessing the intraperitoneal space, with the advantages of the preperitoneal inguinal reparation [1].

Indications

- The characteristic of laparoscopic TEP inguinal hernia repair.
- Inguinoscrotal hernia: extended TEP provides greater access to preperitoneal space, which facilitates the reduction of the hernia sac, treatment, and mesh placement.

Contraindications

Contraindications to this technique are the same as for TEP hernioplasty. They are not absolute, but relative.

Surgical Technique

The placement of the access trocars differs from conventional TEP. An incision is made on right flank if we are treating a left inguinal hernia and in left flank if the hernia is on the right. After pulling back the subcutaneous tissue, we open the superficial fascia of the rectus muscles to expose the posterior fascia. See Fig. 14.1.

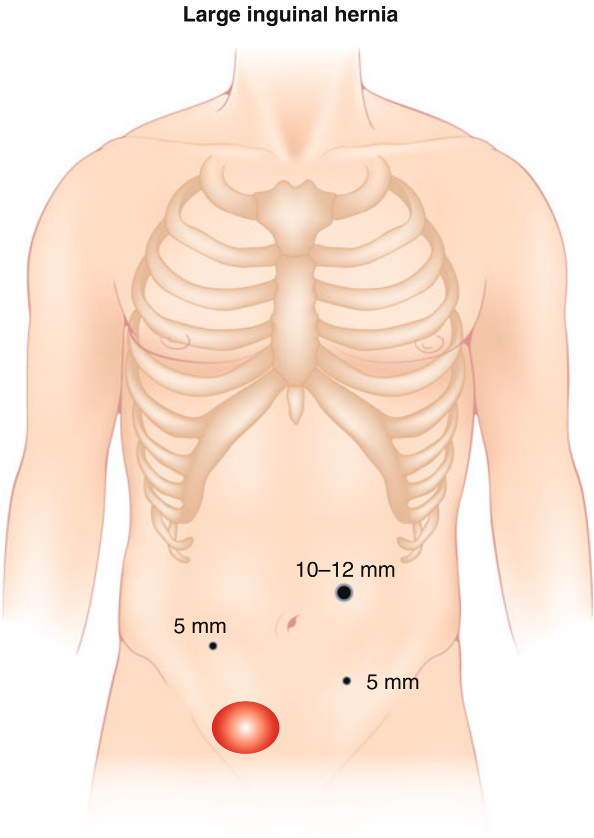

Fig. 14.1 e-TEP trocar placement

The next step is to introduce the trocar PDB balloon, sliding on the posterior fascia to reach Cooper's ligament. We begin inflating the balloon, and with zigzag movements, the preperitoneal Retzius and lateral Bogros spaces are opened, identifying the inferior epigastric vessels. PDB trocar is exchanged for a BTT trocar, and the 10 mm 30° optic is introduced.

Under direct vision, two 5 mm trocars are placed—one in the left paraumbilical region and one in the right iliac fosa—when a left inguinal hernia is corrected.

The steps that follow are no different from those taken in conventional TEP: enlargement/opening of the Bogros and Retzius spaces, reduction of the hernia sac, and mesh placement. However, if necessary, there is further opening of the preperitoneal space, and the semilunar ligament is sectioned, thereby extending the preperitoneal space that facilitates the successful completion of the surgical steps, particularly with large inguinoscrotal hernias. See Fig. 14.2.

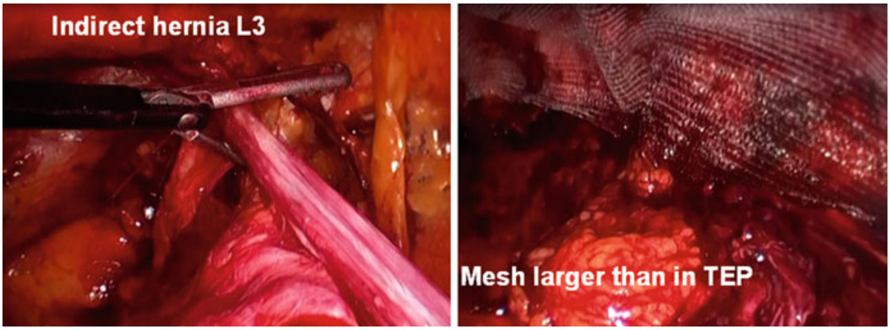

Fig. 14.2 e-TEP in right inguinal large hernia

Complications

The complications do not differ from TEP laparoscopic hernioplasty, previously explained in another chapter in this text.

Closure of the Defect in Ventral Hernia Laparoscopic Repair

Laparoscopic ventral hernia repair has been reported to have lower recurrence rates, fewer surgical site infections, and shorter hospital stays compared to open repair. The seroma formation, eventration (or bulging of mesh or tissue), and hernia recurrence remain common complications. In order to avoid or minimize these problems, primary closure of the defect by laparoscopy has gained popularity because this intervention restores the muscle continuity. It decreases the dead space, but if the defect is large, the closure could result in excessive pain and reduce the respiratory capacity [2, 3].

Indications are defects in the midline no more than 6–10 cm in diameter and no multisacular hernias with sacs not in the midline.

With this technique, the mesh necessary to cover the defect decreases. The dynamics of the abdominal wall muscle are restored more optimally and more quickly.

The incidences of seroma, mesh, tissue eventration, and hernia recurrence are significantly lower. Subjective improvement in overall patient satisfaction, cosmetic satisfaction, and functional status was reported with closing the central defect.

This technique could be superior for treating ventral hernias due to lower complication rates and higher patient satisfaction and functional status [4].

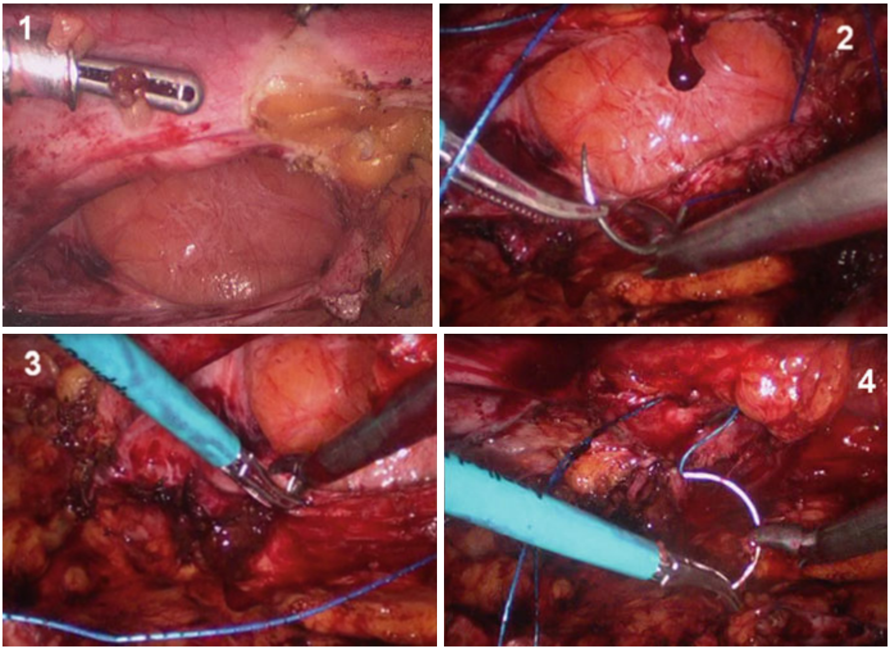

Fig. 14.3 Closure with V-Loc™ (Covidien, Dublin, Ireland) suture. *1* Incisional hernia exposed. *2* Closure of the defect with a continuous knotless (barbed) surgical suture. *3* Closure with V-Loc™ (Covidien, Dublin, Ireland) suture. *4* After the closure, the next step is the laparoscopic hernioplasty

Surgical Technique [2, 3]

- Transfascial sutures: from the outside, defect closure is done with transmural sutures.
- Laparoscopy suture:
  - Closure of the defect with a continuous suture with needle. See Fig. 14.3.
  - Closure of the defect with the Endo-Stitch™ system (Covidien, Dublin, Ireland). See Fig. 14.4.

We use the new self-gripping sutures on both sides of the laparoscopic suture of the defect. They provide better tension and do not require an extra trocar to provide constant tension on the suture (V-Loc™, Covidien, Dublin, Ireland).

After the closure of the defect, a new measure of the hernia must be taken. The mesh is lower than if the defect had not been closed. This technique reduces the numbers of tackers significantly.

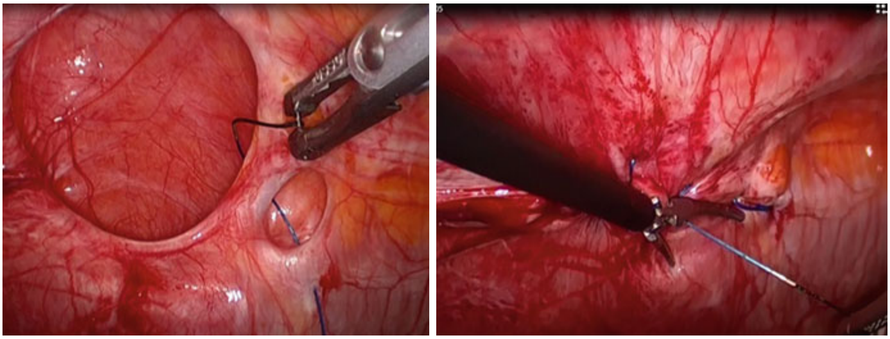

Fig. 14.4 Closure of the hernia defect with Endo-Stitch™ system (Covidien, Dublin, Ireland) with V-Loc™ (Covidien, Dublin, Ireland) suture

Laparoscopic Transabdominal Preperitoneal Repair of Ventral Hernia

The laparoscopic ventral hernia repair with preperitoneal placement of mesh minimizes the complications related to the intraperitoneal position of mesh and fixating devices. It allows safe use of conventional and less expensive polypropylene mesh.

Laparoscopically, ventral hernia repair is done by placing the mesh in either the preperitoneal (retromuscular) space or in the intraperitoneal onlay position. The placement of a large mesh in the preperitoneal space allows an even distribution of forces along the surface area of the mesh, which may account for the strength of repair and the decreased recurrence rates associated with it.

In intraperitoneal mesh placement, the direct contact of mesh with the abdominal contents cannot be avoided. The mesh behaves as a foreign material in relation to the abdominal contents and incites inflammatory reaction and adhesion formation [5, 6].

Following proper interface measures may not be possible. Severity of mesh-related complications depends on the position of the mesh in relation to the abdominal wall.

Diaz-Pizarro Graf and Chowbey demonstrated that preperitoneal placement of a polypropylene mesh is technically feasible and appears to have an advantage over laparoscopic intraperitoneal mesh placement for incisional hernia in selected patients [5, 6].

The fixation of the mesh can be done using tackers, fibrin glue, and new self-gripping meshes or with no fixation if the mesh is placed properly in the preperitoneal space. See Fig. 14.5.

The technique is feasible and safe when performed by experts. The preperitoneal placement of the mesh not only avoids the direct contact of the prosthesis with viscera but also provides additional security of fixation and can minimize complications. It allows safe use of conventional and less expensive meshes such as polypropylene mesh, which has high intrinsic tensile strength and good memory [7].

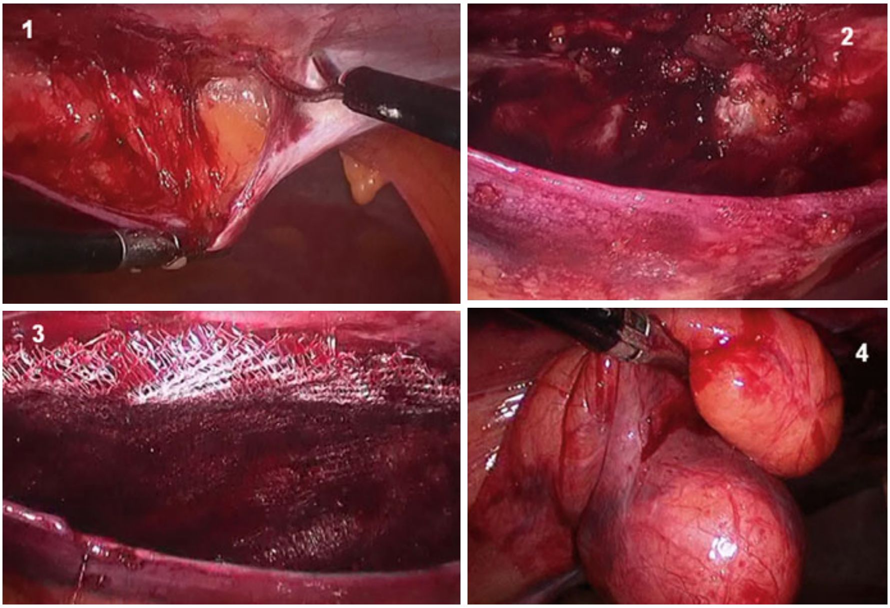

Fig. 14.5 Laparoscopic transabdominal preperitoneal repair of ventral hernia. *1* The peritoneum is opened it away from the ventral hernia. *2* The preperitoneal space is exposed and the hernia content is reduced. *3* Mesh extension along the preperitoneal space. This is a self-gripping mesh. *4* The hernia is reduced into the abdominal cavity and the peritoneum is closed

Laparoscopic Repair of the Diastasis Recti

Endoscopic Approach in Diastasis Recti and Associated Umbilical Hernia

Currently, there are no published studies on minimally invasive surgical treatment of diastasis recti with an umbilical hernia associated [8].

The problem arises in those patients with a symptomatic umbilical hernia and diastasis recti above or below the navel. If only the hernia is surgically corrected, the defect will be closed on weak anatomical tissue which is damaged. As a result, the probability of hernia recurrence is increased with poor aesthetic outcome. Therefore, in the case of the coexistence of diastasis recti with a symptomatic umbilical hernia, it is advisable to do simultaneous correction of both pathologies.

For this, conventional surgery involves making an incision along the entire length of the fracture gap (supra-infraumbilical incision), with the probability of wound infection increased and with aesthetic deterioration involved. After this, the surgeon corrects the diastasis by plication, with or without reinforcement mesh, depending on the technique used. The umbilical hernia is corrected using mesh according to the principles of “no tension.”

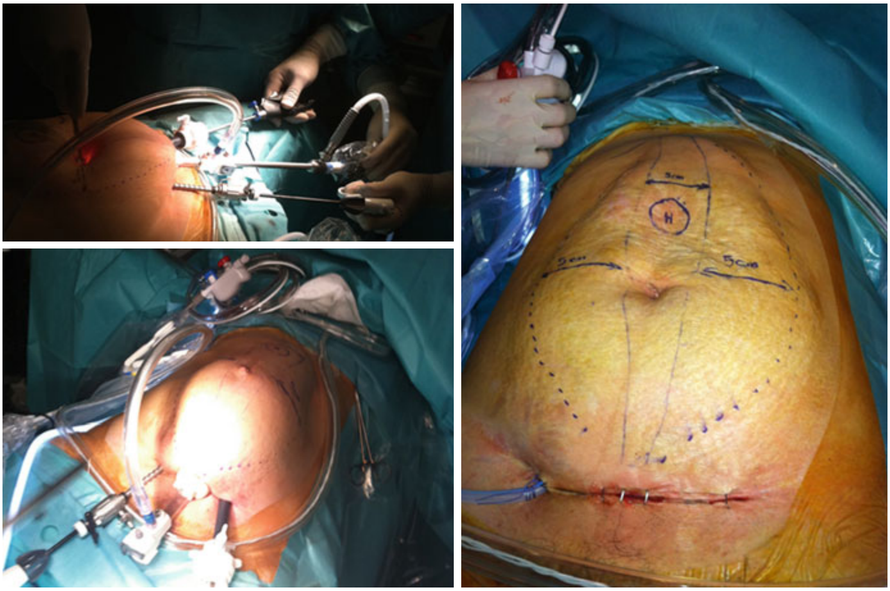

Fig. 14.6 Trocar placement. Skin marks of the diastasis recti and the umbilical hernia

The second option is the one used by plastic surgeons: abdominoplasty.

They use the suprapubic approach for correction of diastasis recti in patients with excess skin and abdominal subcutaneous tissue in the context of abdominoplasty. Using retractors, the subxiphoid region is reached from the incision made in the suprapubic region, and the superficial fascia is plicated, ending the intervention with excision of extra skin and subcutaneous tissue.

The third option, which solves both problems, is the minimally invasive approach through one 10 mm and two 5 mm incisions just above the pubis.

Technique

Incision is made midline, 10 mm suprapubic, drawing up the space between subcutaneous tissue and superficial fascia of the linea alba. A BTT trocar is introduced, and a 10 mm optic is used. Under direct vision, two 5 mm trocars are placed, one on each side of the BTT trocar, separated by about 5 cm. See Fig. 14.6.

The space work is made by exposing the both sides of the anterior rectus fascia, down to the umbilical region. The navel and the umbilical sac are detached. The sac is reintroduced to the intra-abdominal compartment. It is important not to dissect too lateral to the flange of rectus muscles to minimize the likelihood of skin ischemia and postoperative seroma.

Once the linea alba is dissected, we introduce composite prosthesis covering the preperitoneal defect.

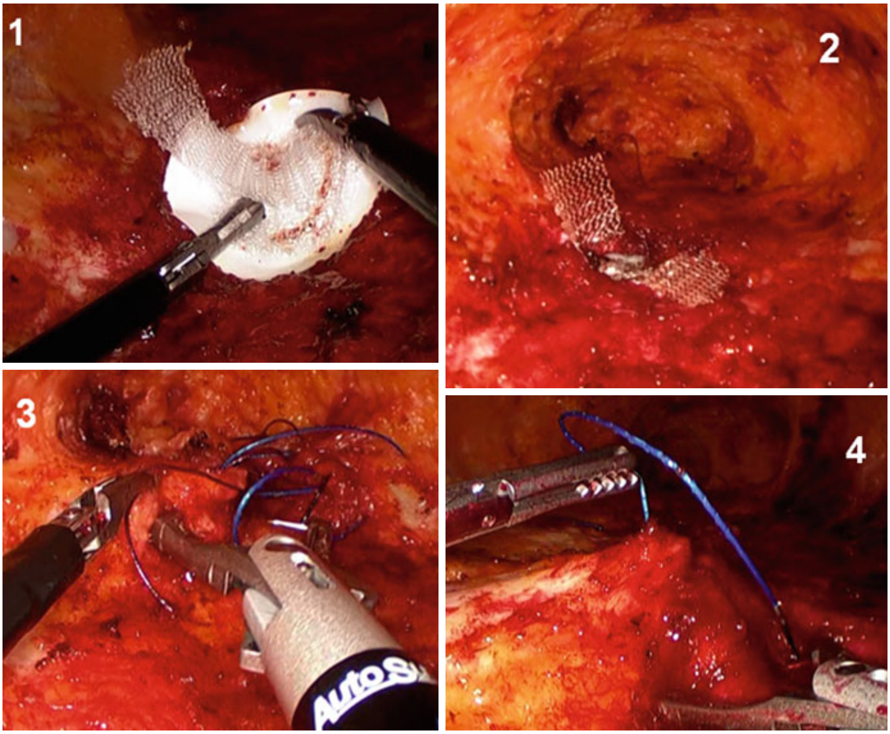

Fig. 14.7 Prefascial endoscopic umbilical hernioplasty and plicature of the diastasis recti. *1* Mesh for umbilical hernia repair. *2* Umbilical hernioplasty. *3* The plicature of the diastasis recti beginning in subxiphoid margin. *4* End of the plicature close to the pubis

The plicature of the both sides of the superficial fascia. is achieved using nonabsorbable barbed continuous suture, which greatly facilitates this step. Plication is made from the subxiphoid to the suprapubic area, if diastasis also affects the infraumbilical linea alba. See Fig. 14.7.

After this step, a subcutaneous suction drain is placed through one of the 5 mm trocars to prevent the occurrence of postoperative seroma (Fig. 14.6).

Single Incision in Abdominal Wall Surgery

Recently, a new minimally invasive surgical approach that could improve the results of conventional laparoscopy in abdominal wall surgery started being used. It attempts to combine the trocars used in the laparoscopic approach into a single device with multiple access to the necessary instruments. This is called *Single Incision Laparoscopic Surgery* [9].

The main advantage of this is minimization of abdominal wall invasion from several orifices; the trocars are assembled together in one device, which is inserted

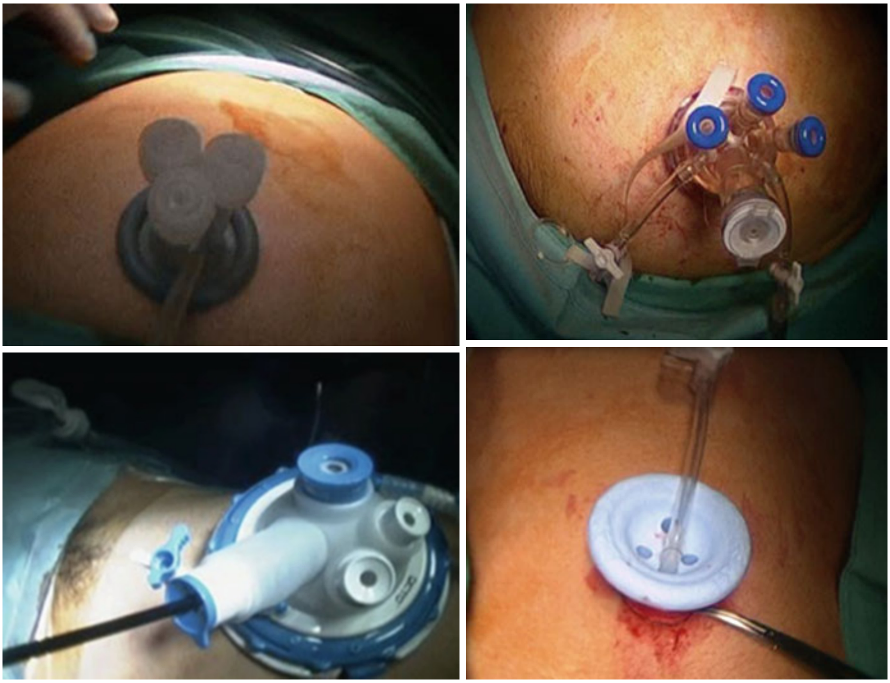

Fig. 14.8 Different kinds of single-port devices

into a single small incision. Different companies have introduced several devices to the market with access ports for this purpose [10, 11]. See Fig. 14.8.

Technique

Once the incision is made and the single-port device is placed, the main problem we face is the lack of triangulation between instruments. The introduction of the different endograsper through the same location causes the loss of the entry angle between them; therefore, there exists a conflict of mobility. Due to this, the surgeon employs a preformed curved instrument that significantly improves triangulation.

Most surgeons use one of these graspers in the nondominant hand and another straight grasper in the dominant hand to perform the different surgical steps.

Main Advantages of Using a Single Port in Abdominal Wall Surgery

Currently, the only advantage of single-port surgery for inguinal hernia is the aesthetic benefit involved, since it performs a single incision at the transumbilical level,

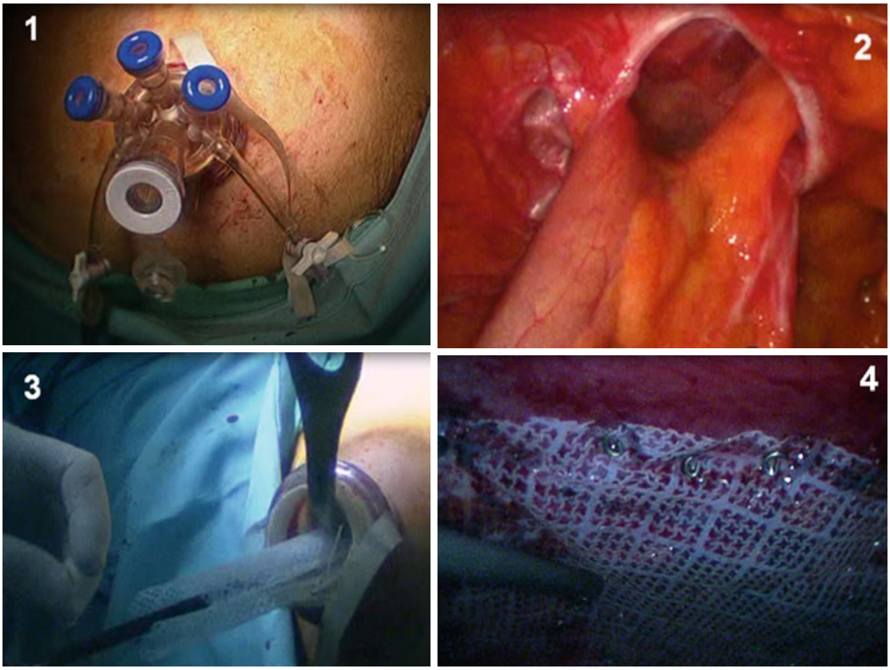

Fig. 14.9 Single-port ventral hernia repair. *1* Single-port device in left flank. *2* Ventral hernia with small bowel incarcerated. *3* Introduction of the mesh through the single-port device. *4* Double crown with tackers in single-port laparoscopic surgery

2 cm horizontally along the Langer line of the skin, into which the device is placed. Once the procedure is finished and the device is removed, the scar is invaginated deep in the navel and is almost imperceptible 2 or 3 months after the surgery. Different published series comparing the conventional single-port laparoscopic approach to multi-port approach do not demonstrate better results in terms of pain and postoperative comfort [11].

In single-port ventral hernia surgery, the incision is made on the left flank at the midclavicular. See Fig. 14.9.

Robotic Surgery

Robotic-assisted surgery has opened up a new frontier in laparoscopy. Robotic-assisted surgery enhances laparoscopy in two major ways. It allows for better visualization of the patient's tissues, and it allows for improved dexterity and finer surgical precision at the surgical site.

With robotic-assisted surgery, the surgeon sits at a special console and sees the image through a viewer that is connected to a specially designed 3-D camera. The surgeon therefore has a full 3-D view that allows for high-definition visualization of the operative field and an ability to see the relationship of structures in

Fig. 14.10 da Vinci® robot (Courtesy of Intuitive Surgical, Inc., Sunnyvale, CA, USA)

three-dimensional space. Furthermore, a stable robotic arm under the surgeon's control holds the camera. The camera is therefore always directed exactly where the surgeon wants to see, and any shaking or unsteadiness of the image is eliminated. This enables the surgeon to see in far greater detail the patient's anatomy, allowing him or her to perform the operation more effectively [12, 13].

The da Vinci® (Intuitive Surgical, Sunnyvale, CA, USA) robotic laparoscopic incisional hernia repair, with intracorporeal closure of the fascial defect and circumferential suturing of the mesh, may offer an alternative to current fascial closure and transabdominal sutures and tackers. See Fig. 14.10.

The first report of robot-assisted laparoscopic incisional hernia repair with exclusive intracorporeal suturing for mesh fixation in humans was in 2007 (Tayar) in 11 patients. The findings show that this technique is feasible and may not be associated with chronic postoperative pain [13, 14].

The da Vinci® robot for laparoscopic surgery has been used to correct inguinal hernia associated with prostatectomy. For inguinal or ventral hernia repair, the robotic surgery could be very expensive in contrast with conventional laparoscopy.

Other kinds of robotic instruments designed to help conduct surgery without a cameraman or assistant have reported good results in inguinal hernia repair with regard to a reduction of the surgery time. These devices can focus the camera to the place the surgeon directs his vision.

Since the introduction of single-incision laparoscopic surgery in 2009, an increasing number of surgical procedures, including hernia repair, are being performed using this technique. However, its large-scale adoption awaits results of prospective randomized controlled studies confirming its potential benefits. Parallel with single-port surgery development, the issue of the chronic lack of experienced camera assistants is being addressed by the robotic FreeHand® camera controller, which has the potential to replace camera assistants in a large percentage of routine laparoscopic surgery [12–14].

Robotic inguinal and ventral hernia repair is feasible and efficient. This represents a further milestone in laparoscopic surgery.

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