Reinhard Bittner · Ferdinand Köckerling
Robert J. Fitzgibbons, Jr. · Karl A. LeBlanc
Sumeet K. Mittal · Pradeep Chowbey *Editors*

Laparo-endoscopic Hernia Surgery

Evidence Based Clinical Practice

Springer

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Preface

When asked by Dr. Bittner to join him as a coeditor of this work, I couldn't help but think "why do we need another book devoted to hernia repairs." But then he explained the unique perspective he intended as the focus of this new work. He felt there was a need for a book about hernia repair which was strictly limited to endoscopic surgery and was to incorporate guidelines indorsed by important surgical societies derived from critical analysis of appropriate literature. Certainly, traditional aspects of a surgical textbook were to be included in each chapter such as historical perspective, anatomy, incidence, operative details, perioperative care, and so on, but they are presented from an evidence-based perspective and not just the opinion of the author. I quickly came to the realization that he was right. I respectfully accepted the invitation and was honored to be asked.

Now after several years of work, the book has come to fruition. A quick perusal of the table of contents reveals an author list which can be considered a "who's who" in the field of endoscopic hernia surgery. Each chapter is well written and a pleasure to read. I believe the original goals of applying evidence-based science to the clinical practice of endoscopic hernia surgery have been met and even superseded.

Finally, it is important for the reader to recognize that the driving force behind this work was Dr. Reinhard Bittner. From the original conception to the actual production, it was he alone who kept the work going with endless letters, emails, phone calls and face-to-face conversations with authors encouraging them to complete their assignments. We all know that, in this day and age with so many other priorities, this can be a daunting task. Congratulations to Dr. Bittner because without him this work would have never been completed. I can't thank him enough for the small part he allowed me to contribute to the project.

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Preface

In the era of digital media, does it still make sense to write a surgical textbook? The digital media provide the spread of the newest results of experimental and clinical research within seconds to every interested surgeon around the world. However, when using the digital media alone in order to study and to learn the well-proven standards in diagnostics, operative techniques and aftercare, especially in the new field of surgery, the laparo-endoscopic hernia repair, it is almost impossible to get the necessary information in a timely manner. On the other hand, while writing a book takes about 2–3 years, however, for the surgeon to look for the essentials in his daily work, it requires only a very short time to be fully informed. Therefore, despite currently overwhelming digitization, the printed media are still indispensable.

But, why write another book on hernia surgery as there are already many? This book is mainly devoted to laparo-endoscopic hernia surgery, but covers some particularly noteworthy features: (1) This textbook provides not only a comprehensive, state-of-the art review of the total field of laparo-endoscopic surgery of inguinal and ventral hernia but also of hiatal hernia repair. Furthermore, recently achieved insights into the surgical anatomy of the groin and the abdominal wall, in current operative techniques and mesh technology, are described in detail. (2) The uniqueness of this book, however, is that not only the good clinical practice is described but also the scientific background of daily routine work is quoted in terms of evidence-based medicine (Oxford classification of levels of evidence). (3) This book is written by an international group (International Endohernia Society (IEHS)) of highly experienced laparo-endoscopic surgeons from three continents inclusive of former presidents and meeting presidents of the German Hernia Society (V. Schumpelick, R. Bittner, F. Köckerling, W. Reinpold, D. Weyhe, U. Dietz, A. Koch), the European Hernia Society (V. Schumpelick, R. H. Fortelny, S. Morales-Conde), the Americas Hernia Society (R. Fitzgibbons, K. A. LeBlanc, M. Arregui, B. Ramshaw), and the Asia-Pacific Hernia Society (P. Chowbey, D. Lomanto, A. Sharma).

In summary, hernia surgery affects about 20 million patients per year worldwide. Due to this huge number of patients, the quality of performances in diagnostics and treatment has an impact not only on the individual patient but also on the cost for the health care systems of the respective countries. Therefore, it is of paramount importance to find the best treatment options. This applies in particular to this new field of surgery, the laparo-endoscopic hernia repair. This book may be an indispensable aid to any surgeon in his daily decision-making process to do the best for his patient.

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Ferdinand Köckerling
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Preface

Every surgeon strives for excellence to deliver best clinical outcomes. Surgery is the field of science which is in the process of continuous evolution and has gained momentum in the past few decades. Today, when we sit in a time machine, grab the control gears in our hand, and accelerate on the road of the twenty-fisrst century, the pursuit of herniology has taken a giant leap forward towards advanced surgical techniques that constitute minimal access surgery (MAS). Laparoscopic surgery has emerged as a cost-effective and patient-friendly technique for the repair of hernias.

The surgical doctrine of conventional hernia surgeries using large incisions, inconvenience of adjusting lights in the operation theaters, using magnifying loupes has revolutionized into small ports, magnified vision through laparoscopes, increased dexterity, easy access, shorter hospital stay, and faster recovery for the patients with minimal access surgeries.

Encountering the challenging situations on the operation table has increased the surgical expertise in laparoscopic hernia repairs. These academic records and literature are a medium to equip the young and upcoming surgeons to face and deal with the complex situations and to cater the needs of patients.

It gives me immense pleasure and honor to be a part of this academic venture. This book is an amalgamation of dynamic experiences and insights to laparoscopic hernia repairs. The team approach for the management of hernias with evidence-based clinical practice has been thoroughly discussed. The landmark of this published work is its comprehensive chapters which have been compiled in a precise way for each type of hernia for easy understanding and clarity. Clinical tips and surgical experience contributed by eminent herniologists across the globe are highly commendable. I would like to once again compliment the authors and the team for taking the opportunity under one platform to share their experiences and opening the new gateways for future laparoscopic surgeons.

Tracking the wheels of surgical journey from old standard approaches to modern and current approaches, the change is never ending. These changes have the potential to unfold newer understanding, newer approaches, and implementation of new prosthetic materials in the field of herniology.

I would just like to conclude that safety is never enough in the ever-evolving world. This manuscript is an attempt to increase the level of safety for the present generation of surgeons engaged in laparoscopic hernia repairs.

Pradeep Chowbey
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Inguinal Hernia

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Clinical Anatomy of the Groin: Posterior Laparoscopic Approach

Reinhard Bittner, David Chen and Wolfgang Reinpold

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In-depth knowledge of groin anatomy is essential for a successful inguinal hernia operation. Sir Astley Paston Cooper postulated in 1804, "No disease of the human body, belonging to the province of the surgeon, requires in its treatment, a better combination of accurate, anatomical knowledge with surgical skill than hernia in all its varieties" [1]. While Bassini helped to elucidate the anatomy of the anterior inguinal canal in 1884 [2] ushering in the modern era of safe and effective hernia repair, understanding of the posterior canal remained limited. W.J. Lytle reported in1945, "The operating surgeon knows little of the posterior wall of the inguinal canal, so well is it hidden from his view" [3]. In the early 1990s, laparoscopic approaches to the inguinal canal emerged. However, the posterior anatomy of the groin remained poorly understood and the laparoendoscopic view of this region was virtually unknown to most surgeons [4]. The adoption of this novel and exciting technique without a firm anatomic understanding resulted in several intra- and postoperative complications including vascular, visceral, and nerve injuries as well as high recurrence rates. Detailed study of the posterior anatomy, continuous technical refinements into well-standardized modern laparoscopic techniques, and unparalleled in vivo visualization of this region have transformed laparoscopic inguinal hernia repair into a safe, reproducible, and successful operation providing an ideal repair for all variants of groin hernias.

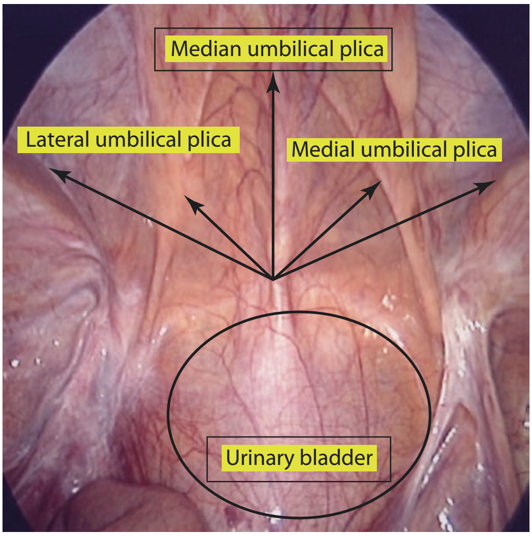
The basic anatomical principles of laparoscopic herniorrhaphy were first described by Spaw in 1991 based on human cadaveric dissections [4]. He coined the term "triangle of doom" delineating the region between the vas deferens and the spermatic vessels. In this triangle, the external iliac artery and vein are hidden under the peritoneum and transversalis fascia, and major vascular injury is possible with improper dissection. In his description, Spaw did not specifically consider the neuroanatomy of the preperitoneal space [4]. He described that "suturing or stapling of synthetic materials should be performed lateral to the spermatic vessels along the abdominal wall" leading to serious neuropathic consequences for many patients. Rossner was the first to describe the inguinal neuroanatomy as it pertains to posterior inguinal hernia repair in 1994 roughly delineating the anatomical course of the inguinal nerves [5]. Seid and Amos provided a more precise description of the nerves [6] postulating that the "triangle of doom" should be extended further laterally to the anterior superior iliac spine. The authors introduced the term "trapezoid of disaster" describing that in addition to potential injury to the major vessels within the triangle of doom, nerves (n. femoralis, n. genitofemoralis, n. cutaneous femoris lateralis, n. ilioinguinalis, and n. iliohypogastricus) located lateral to the testicular vessels within the "triangle of pain" were also at risk [7, 8]. The most comprehensive analysis of the posterior inguinal anatomy was given by Annibali [7, 8] including the fascial structures, vessels, and nerves. Recently very detailed descriptions of the course of the nerves and their variations have been published by Rosenberger [9], Loeweneck [10], and Reinpold [11] adding to our understanding of this anatomy.

The aim of the following chapter on groin anatomy is to translate this detailed knowledge of cadaveric anatomy and extensive clinical experience into relevant surgical anatomy that will optimize operative technique and outcomes of inguinal hernia repair:

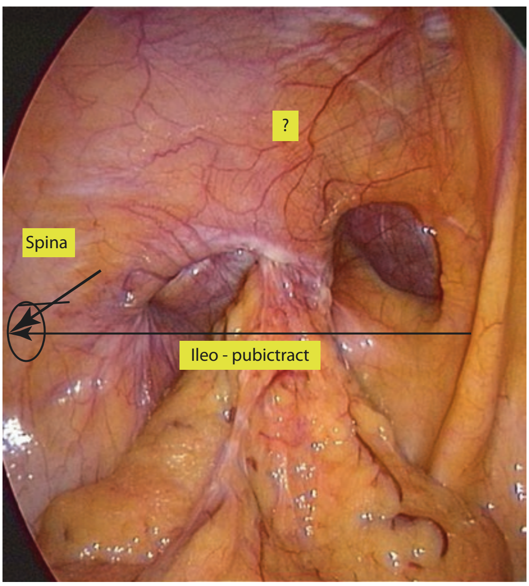
1.1 The First View to the Groin After Introducing the Laparoscope: Peritoneal Landmarks

The initial laparoscopic view of the groin will identify five peritoneal folds (plicae) (◘ Fig. 1.1) which serve as guiding landmarks when opening the peritoneum. The plica umbilicalis mediana (median umbilical ligament) found in the midline contains the obliterated urachus. It is less distinct but fortunately less clinically relevant to inguinal hernia repair. The medial umbilical plica (medial umbilical ligament) is the most prominent landmark seen on initial transabdominal inspection. This plica is easily recognized and contains the remnant umbilical vessels. The medial umbilical plica should not be routinely cut because the umbilical vessels may still be patent causing bleeding. If extension of the peritoneal incision is necessary, the cut should be continued cranially and parallel to the plica avoiding this problem.

The lateral umbilical ligament may be difficult to identify from this view, but its recognition is the most important of the plicae. This ligament contains the inferior epigastric vessels which divide

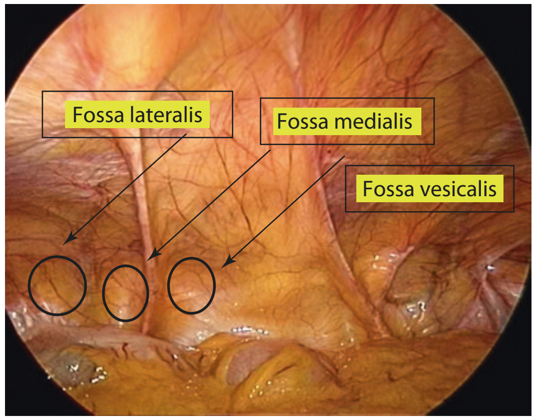


■ **Fig. 1.1** Five peritoneal folds (plica)



■ **Fig. 1.2** Recurrent hernia. Lateral plica is difficult to identify (?)

the groin in a medial (space of Retzius) and a lateral (space of Bogros) compartment. Depending on the patient's body habitus and fat distribution, the lateral ligament may not be readily visualized laparoscopically (■ Fig. 1.2). However, the epigastric vessels should always be preserved, and careful assessment of the anatomy prior to dissection of the peritoneal flap is an essential operative step. External palpation of the surface anatomy allows for precise localization of the anterior superior



■ **Fig. 1.3** Three flat fossae

iliac spine and pubic tubercle, thereby delineating the ileo-pubic tract that divides the groin into an upper and a most critical lower part (■ Fig. 1.2). The ileo-pubic tract which corresponds to the inguinal ligament seen in open surgery is therefore one of the most important landmarks and should always be identified. The inferior epigastric vessels are found approximately at the midpoint of the tract, and careful dissection in this region will prevent injury.

In addition to the five plicae, three flat fossae are recognizable on each side, corresponding with possible hernia defects (■ Fig. 1.3). The lateral fossa, located in the triangle between the lateral umbilical ligament and the ileo-pubic tract, corresponds to the location of the internal ring from which a lateral (indirect) inguinal hernia originates. The medial fossa is located between the lateral and the medial umbilical ligament and is inferiorly limited by the ileo-pubic tract (■ Fig. 1.4a). A direct hernia will be found in this region passing through Hesselbach's triangle. The third fossa (vesicalis) is located medial to the medial umbilical ligament and cranial to the ileo-pubic tract, pubic bone, and urinary bladder. Rare defects in this point of weakness may be the origin of a so-called supravesical hernia (■ Fig. 1.4b, c). A fourth location where a hernia may develop is within the region of the femoral canal, the triangle below the ileo-pubic tract, medial to the femoral vein and superior to the pubic bone and Cooper's ligament. A hernia present in this region can be more easily diagnosed by laparoscopy (■ Fig. 1.4d) compared to the totally extraperitoneal technique or open surgery.

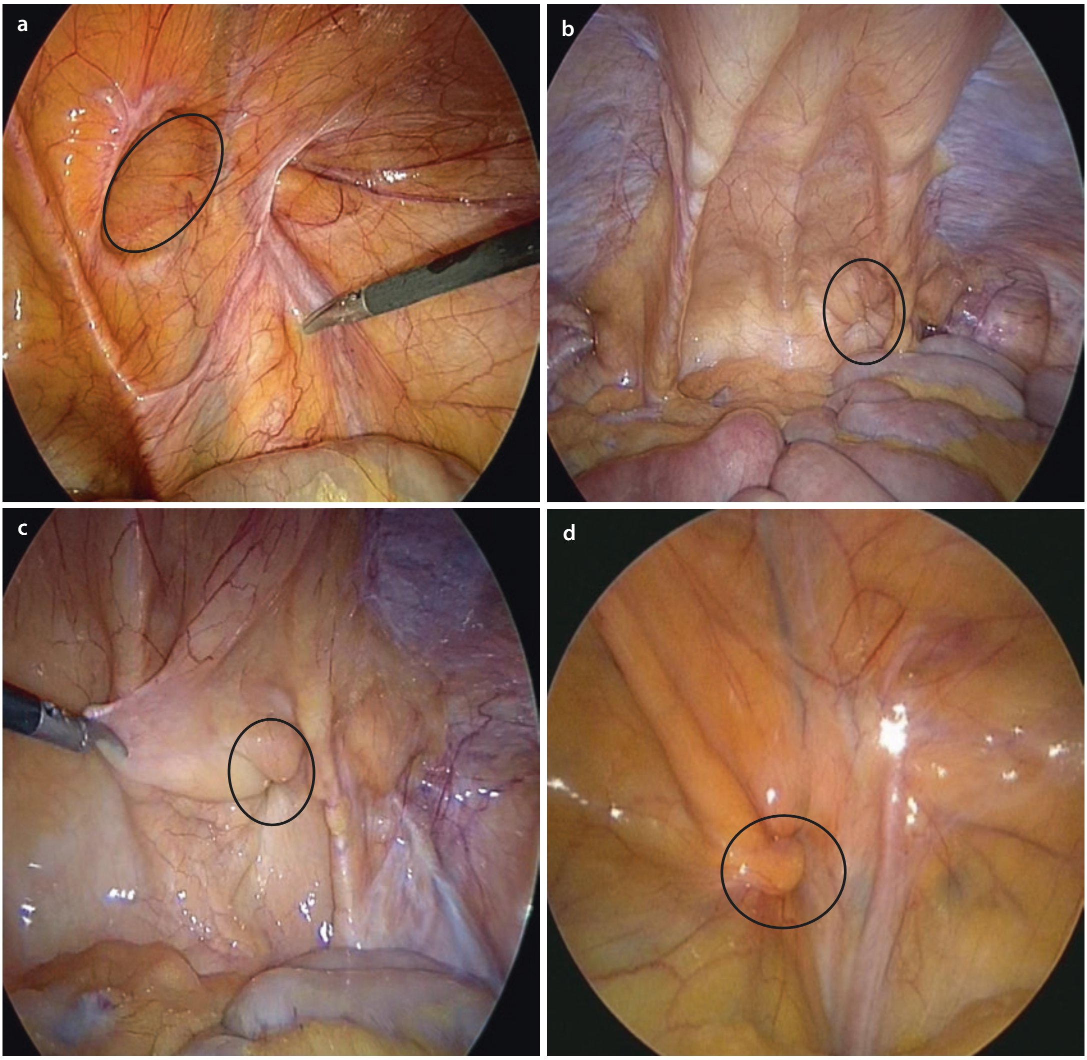


Fig. 1.4 Hernia localizations. **a** Medial and lateral hernia. **b** Supravesical hernia. **c** Supravesical hernia, partially reduced. **d** Femoral hernia

1.2 Anatomic Structures of the Preperitoneal Space: View After Creation of the Peritoneal Flap in TAPP or Total Extraperitoneal (TEP) Dissection Plane

1.2.1 Transversalis Fascia and Preperitoneal Space

Initial laparoscopic inguinal repairs utilized intraperitoneal onlay mesh (IPOM) techniques to cover inguinal hernia defects. This led to high recurrence rates and complications because of the inability to safely and securely fixate the mesh in this location rendering it "a boat in a rough sea." To address this limitation, mesh was placed within the preperitoneal space in direct apposition to the muscular, tendinous, and bony structures of the posterior abdominal wall and pelvis. The preperitoneal space lies between the peritoneum internally and the transversalis fascia externally. Within the preperitoneal space is a variable quantity of adipose tissue, loose areolar connective tissue, and membranous tissue [12]. The transversalis fascia is perhaps the most important fascial structure in the groin as it is involved in both the development of a hernia as well as its treatment.

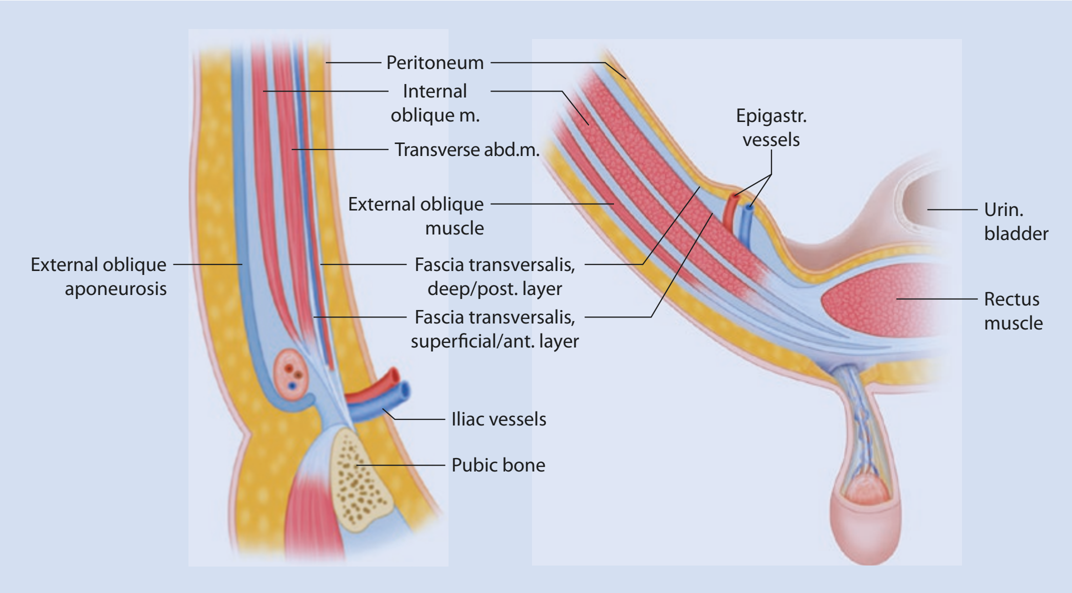


Fig. 1.5 **a**, **b** Schematic representation of the planes of the abdominal wall in the inguinal region (Modified according Colborn and Skandalakis [15])

Cooper originally described the transversalis fascia as a bilaminar structure with a strong anterior layer and a membranous deep layer [1] with the epigastric vessels lying between. However, the question whether the transversalis fascia is bilaminar or whether the "deep/posterior lamina" is simply a significant regional condensation of extraperitoneal connective tissue ("extraperitoneal fascia") [13, 14] is still unresolved [15]. Both structures appear strong and difficult to break through especially in the young patient with an indirect hernia. The deep membranous layer (extraperitoneal fascia) divides the preperitoneal space into a visceral and a parietal compartment. Mirilas and Skandalakis [16] describe this membranous septum as creating a second internal ring and separating the planes (Fig. 1.5a, b).

The parietal compartment contains the epigastric vessels and numerous small tributaries and may be associated with troublesome bleeding during dissection. The genitofemoral and lateral femoral cutaneous nerves also travel within this compartment, and over-dissection resulting in "naked" nerves should be avoided to prevent perineural scarring and direct contact with mesh. The visceral compartment is avascular and dissection should proceed in this plane. Understanding this anatomic distinction will greatly facilitate proper dissection, ease of developing the correct preperitoneal plane, and help to prevent vascular, nerve, and mesh complications [17]. Despite numerous cadaveric studies, the nature of the transversalis fascia is still a source of controversy for surgeons and anatomists [17, 18]. According to our clinical experience with more than 16,000 laparoscopic hernia repairs, two reasons may be responsible for the continuing uncertainties: (1) There is great individual variability in its topographic occurrence and strength, and (2) whereas medial to the epigastric vessels the bilaminar structure is recognizable in most patients (Fig. 1.6a, b), medially, its identification may be difficult. In some patients, especially with obesity, adipose tissue and small vessels may occupy the preperitoneal space making it difficult to clearly delineate the compartments medially. Lateral to the epigastric vessels, the deep layer is less discrete and closely related to the anterior lamina. In contrast to the medial compartment, the dissection plane is immediately in front of the deep lamina. Therefore, because it is easier to find and separate the correct plane in this region, it is recommended to start with the dissection of the groin at the lateral aspect at the level of the anterior superior iliac spine (Fig. 1.7a, b). After making a generous peritoneal incision, most of the preperitoneal dissection can be safely and efficiently performed by bluntly sweeping away the peritoneum and fatty tissue from the

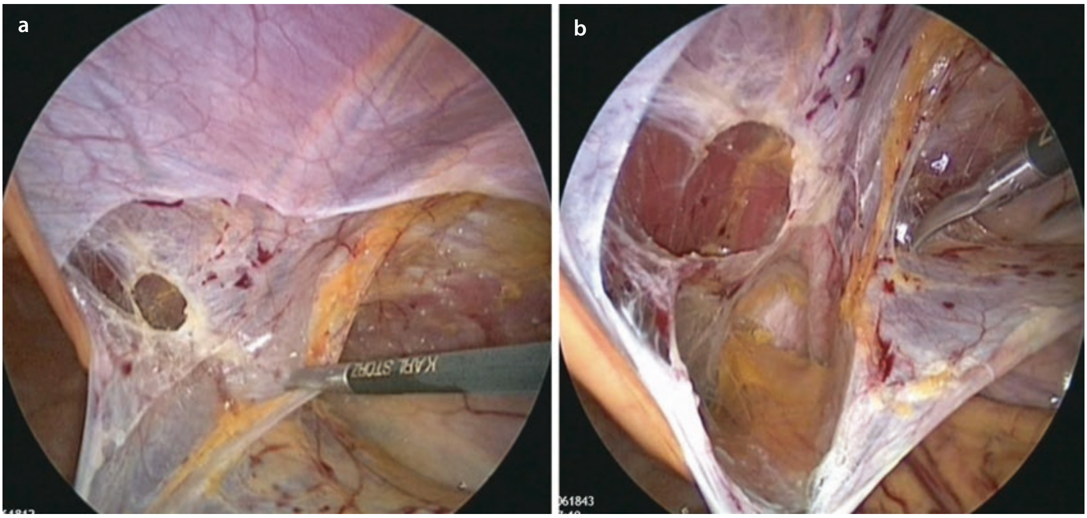


Fig. 1.6 **a** Superficial and deep layer of transversalis fascia medially. **b** Superficial layer of transversalis fascia after breaking through the deep layer

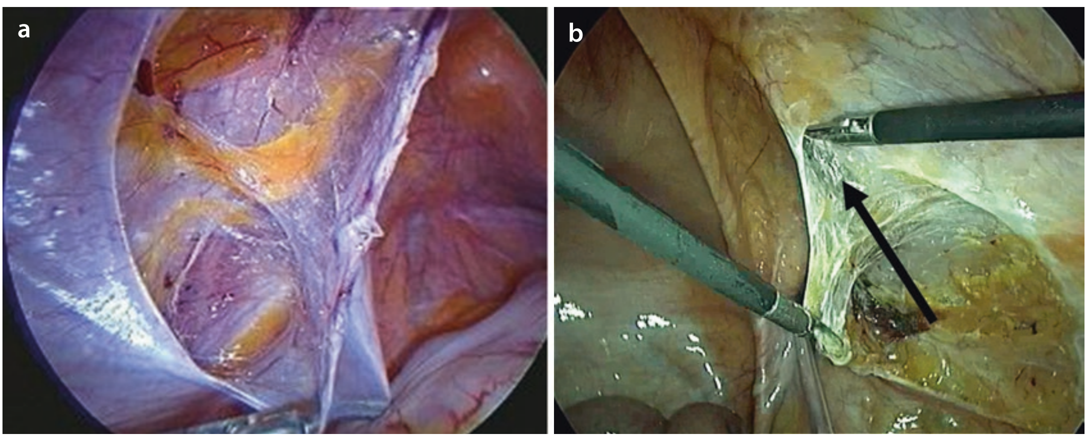


Fig. 1.7 **a** Deep layer of the transversalis fascia. **b** Access to the visceral laterally compartment from lateral-caudal. The deep layer of the transversalis fascia is protected

abdominal wall covered by the transversalis fascia. However, when crossing the epigastric vessels in order to dissect the medial compartment, it is necessary to break through the deep layer to approach the rectus muscle and the symphysis.

Medially, both laminae of the transversalis fascia insert inferiorly on the ligament of Cooper. Laterally, its course is less clear. Around the internal inguinal ring, the deep fibers may envelop the cord structures and contribute at least partially to the spermatic sheath as extensively described by Stoppa [19]. The morphology of the spermatic sheath is triangular with an anterior apex at the deep aspect of the inner inguinal orifice and a posterior medial base. The vas deferens makes up its medial border while the spermatic vessels delineate the lateral border. The base of the sheath disappears beneath the retracted peritoneal sac when parietalization is performed [19]. Additionally, the spermatic sheath covers the external iliac vessels which reside just deep to the triangle. Although the origin of this sheath is not clearly defined – prolongation of the urogenital fascia as Stoppa [19] suggested or a continuation of the deep layer of the transversalis fascia – for the surgeon it is of essential importance to recognize this sheath and not to violate it when dissecting the pelvic floor, except at the level of the internal

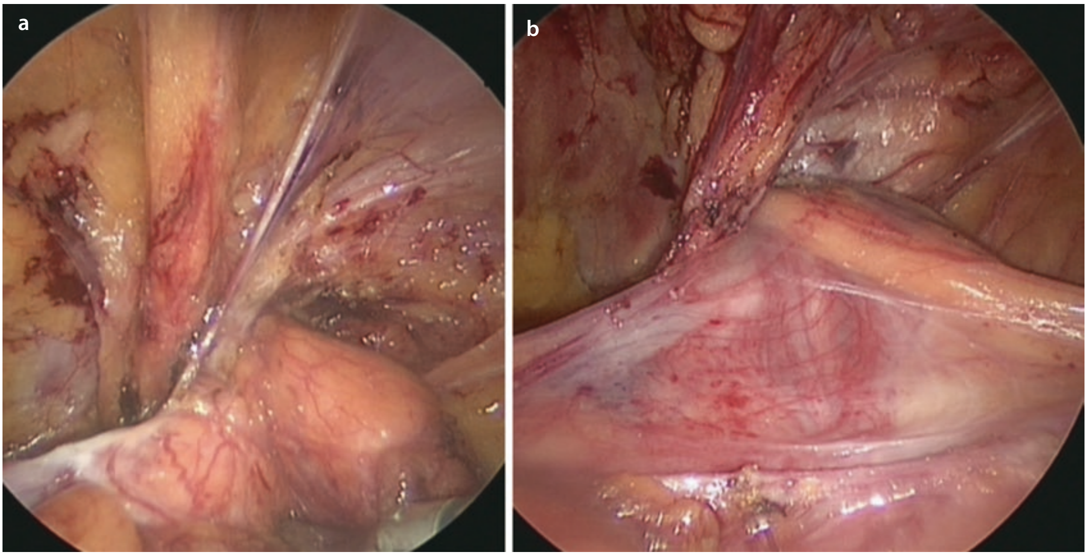


Fig. 1.8 **a** Transition of the deep layer of the transversalis fascia into the spermatic sheath (Stoppa). **b** The spermatic sheath is wrapping the cord structures

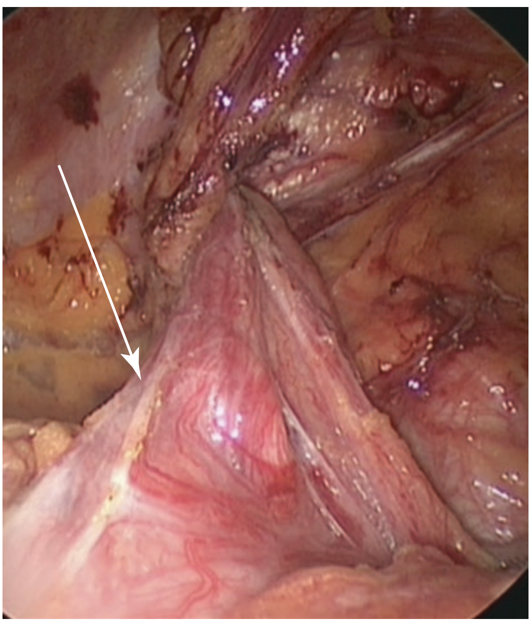


Fig. 1.9 The spermatic sheath is cut anteriorly to parietalize the hernia/peritoneal sac

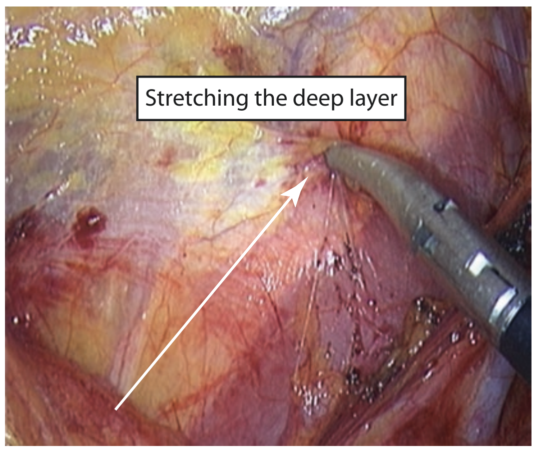


Fig. 1.10 The deep layer (extraperitoneal fascia) continues laterally into the iliac fascia which protects the nerve lying behind

inguinal ring anteriorly (Fig. 1.8a, b). With an indirect hernia, the sheath is opened at the ring to identify and reduce the hernia sac as well as when parietalizing the cord structures (Fig. 1.9).

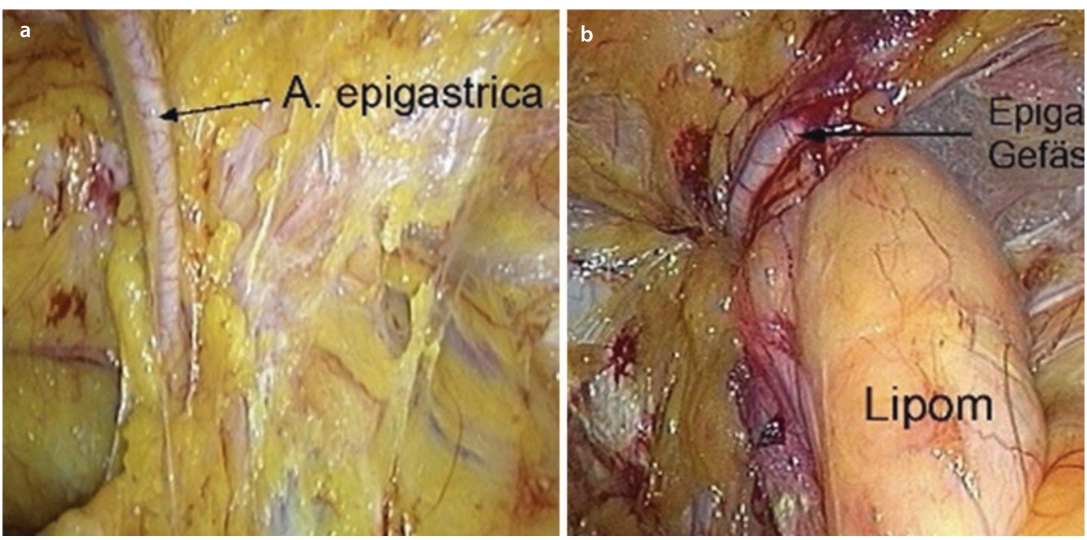
According to Stoppa et al. [19], the sheath (deep layer of the transversalis fascia) joins the lateral wall of the iliac fossa and may be a part of the iliac fascia which covers the inguinal nerves.

In summary, the spermatic sheath (deep layer of the transversalis fascia) should be preserved during separation from the hernia/peritoneal sac (parietalization) because it protects the external iliac vessels and the nerves that are lying beneath (Fig. 1.10). The surgeon must preserve this important fascial layer for two reasons: (1) to avoid an injury to the vessels or the nerves during dissection and (2) to avoid direct contact between the nerves and mesh which may produce pain in the later postoperative period due to perineural scarring. For the same reason, implantation of a slitted mesh cannot be recommended as the integrity of the fascia will be destroyed and the nerves, spermatic vessels, and vas are all placed at risk.

1.2.2 Preperitoneal Space and the Vessels

The location and the course of the vessels remain fairly constant with a few common variations, and identification is typically straightforward. The inferior epigastric vessels are perhaps the most important landmark in the myopectineal orifice and are easily recognized even in obese patients (see above). It is important to recognize that in case a large hernia sac or a lipoma is present, the vessels may be dislocated medially (◘ Fig. 1.11a, b). The epigastric vessels divide the myopectineal orifice into a medial and a lateral compartment. The proper dissection plane should be just in front of these vessels (from the posterior laparoscopic approach). When performing a TEP repair, creation of the preperitoneal space relies on this same dissection plane. With a dissecting balloon, the epigastric vessels should be above the plane of dissection before inflation and preserved against the abdominal muscles. With camera and manual dissection of this space, the areolar plane posterior to the epigastric vessels is developed separating the epigastric vessels from the peritoneum. The epigastric vessels originate from the external iliac vessels and may be surrounded by fatty tissue as well as lymph nodes. This tissue must be respected and not removed when dissecting the groin. The same consideration applies to the iliac vessels which are protected by the spermatic sheath. The iliac artery, located at the bottom of the pelvis and in the middle of the preperitoneal space, may be identified by following the epigastrics downward toward their origin (◘ Fig. 1.12a, b). The iliac vessels may be accompanied by fatty tissue and lymph nodes and over-dissection may lead to bleeding, potential nerve injury, or lymphatic leakage. Preservation of the spermatic sheath will avoid these issues. The iliac vein is located posterior and slightly medial to the artery. It may be visualized during dissection of the groove in the triangle between the lower branch of the pubic bone, the iliac vessels, and the wall of the urinary bladder (◘ Fig. 1.13).

Dissection of this region should be performed with special caution looking for the presence of a corona mortis, a vascular connection between the epigastric and obturator vessels. This variant, found in 20–30% of patients, is important because intraoperative bleeding from disruption can be difficult to control due to the dual vascular supply from the obturator and iliac vessels (corona mortis, ◘ Fig. 1.14). In case of bleeding from the corona mortis, control must be achieved from both sources of inflow. In this region, there may be several variants of anastomosing vascular branches between the pubic artery/vein and the epigastric and obturator vessels. These small vas-



◘ **Fig. 1.11** **a** The epigastric vessels just after reduction of the peritoneum with the deep layer of transversalis fascia. **b** Epigastric vessels dislocated medially by a large lipoma

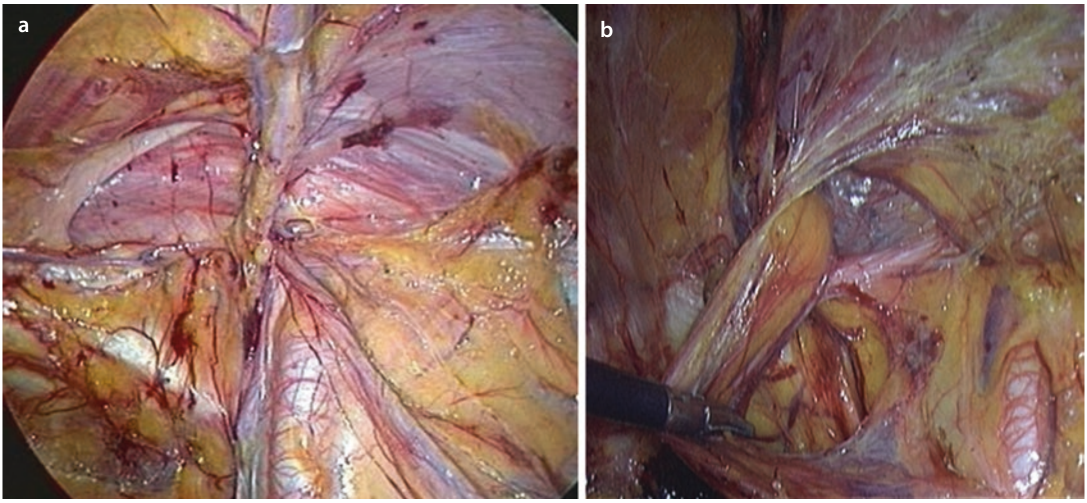


Fig. 1.12 **a** Pelvic floor after complete dissection. A. iliaca is visible directly in the middle. **b** A. iliaca dislocated laterally

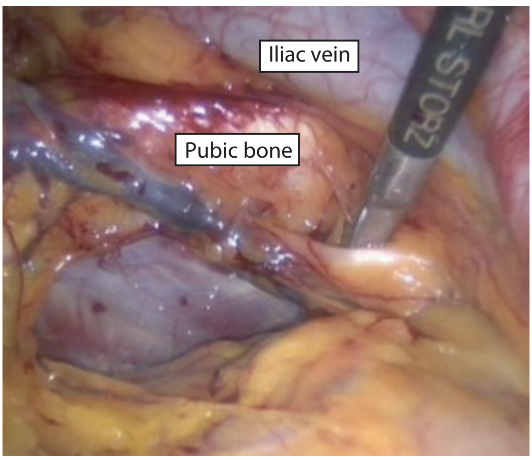


Fig. 1.13 Dissection of the "groove," exposing the obturator nerve and the iliac vein

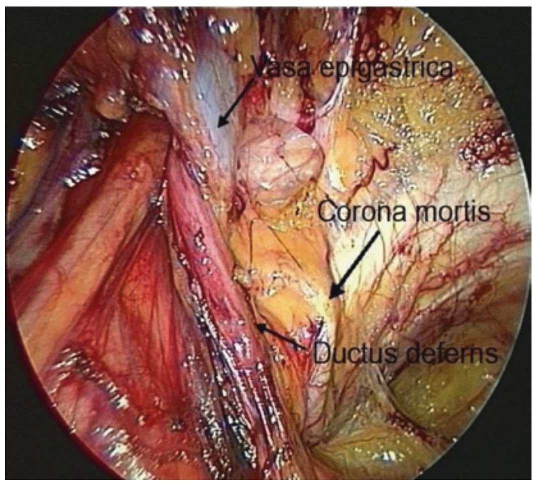


Fig. 1.14 Corona mortis

cular tributaries may form a network investing the pubic bone, Cooper's ligament, and the direct and femoral spaces (Fig. 1.15). From our clinical experience, these vessels and the underlying pubic bone are covered by a very thin membrane (deep layer of the transversalis fascia) which should not be disrupted.

The correct plane of dissection will preserve this membranous layer, and blunt dissection may be used to push away the urinary bladder developing the retropubic space for mesh placement. In special cases, e.g., recurrence after previous preperitoneal mesh repair, it may be necessary to continue the dissection downward to the urogenital space toward the origin of the remnant umbilical artery from the internal iliac artery (Fig. 1.16a, b). The vas traverses directly over the artery (Fig. 1.16a), and care should be taken when dissecting this region. The surgeon should be aware that the umbilical artery may be patent and, in the case of injury, bleeding may be profuse and difficult to control.

The testicular vessels are easily identifiable but can be most clearly defined at their caudal aspect between the external iliac vessels and the psoas muscle and course from caudal-lateral to cranial-medial. There are no significant vascular structures lateral to the testicular vessels. The testicular vessels meet the vas deferens at the apex of the triangle immediately at the entrance to internal ring. The vas deferens travels downward crossing the iliac vessels medially, following the "preperitoneal loop" (deep layer of the transversalis fascia [20]), but then changes its direction like a knee and dives down to the urogenital space to join the prostate gland. In order to complete the parietalization, it is important to cut this "preperitoneal loop" (Fig. 1.17)

1.2.3 Preperitoneal Space and Topographic Anatomy of the Nerves

The anatomy of the nerves located in the groin is extensively described by Rossner [5], Seid and Amos [6], Annibali et al. [7, 8], Rosenberger et al. [9], Loeweneck et al. [10], and recently by Reinpold et al. [11]. In total, six nerves are of interest in laparoscopic inguinal hernia repair and this neuroanatomy should be well understood by all surgeons. Anatomically, the n. hypogastricus and the n. ilioinguinalis are not involved in the dissection and repair planes utilized by laparoscopic hernia repair. These nerves have typically exited the retroperitoneum and entered into the anterior abdominal wall and inguinal canal lateral and superior to the anterior superior iliac spine. However, as a rule to the lumbar plexus neuroanatomy, there is tremendous anatomic variability especially progressing distally along the branches away from the spinal origin. In about 32% of cases, the course of the ilioinguinal nerve may be within the operating field and may be at risk dur-

Fig. 1.15 Network of pubic veins, protected by the deep layer of the transversalis fascia

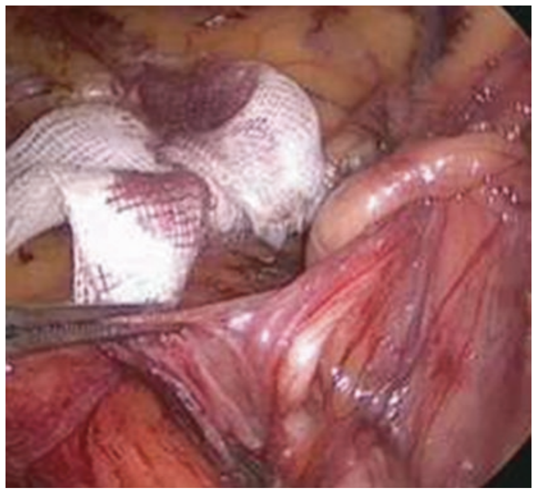


Fig. 1.17 The vas is riding on the preperitoneal loop which must be cut for complete parietalization [20]

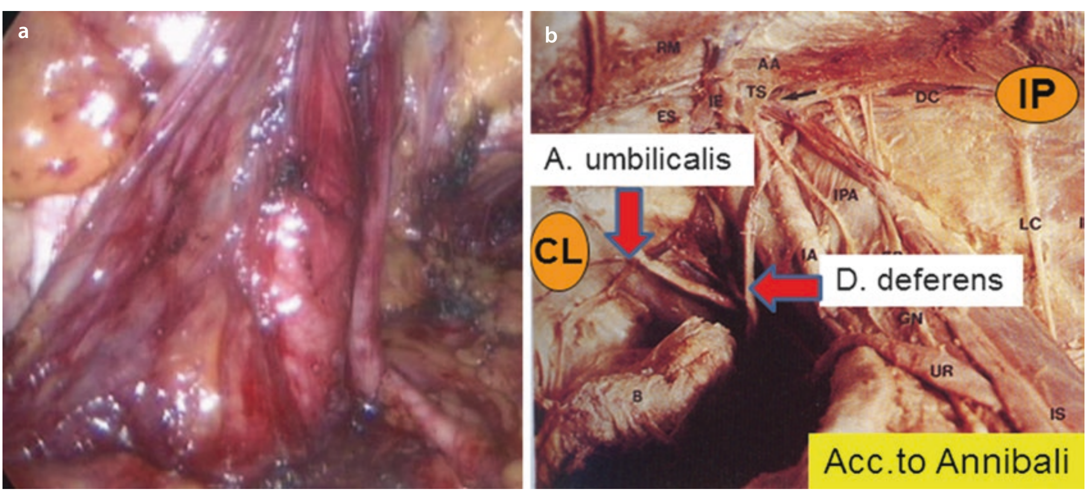


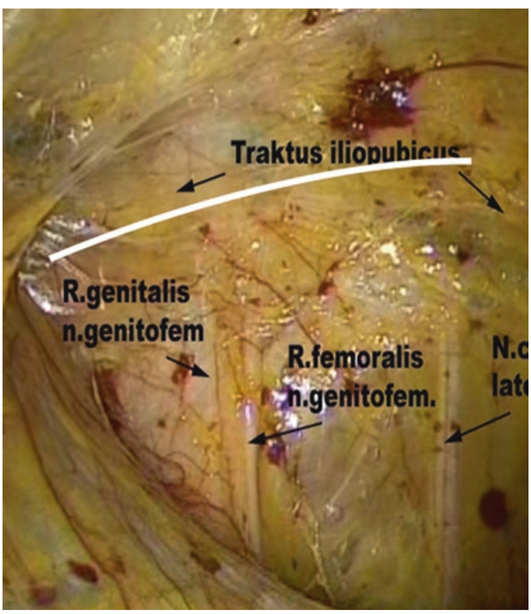
Fig. 1.16 a Remnant A. umbilicalis in situ, coming out of the internal iliac artery. b A. umbilicalis in cadaveric dissection

ing the placement of staples in the neighborhood of the anterior superior iliac spine (Rosenberger).

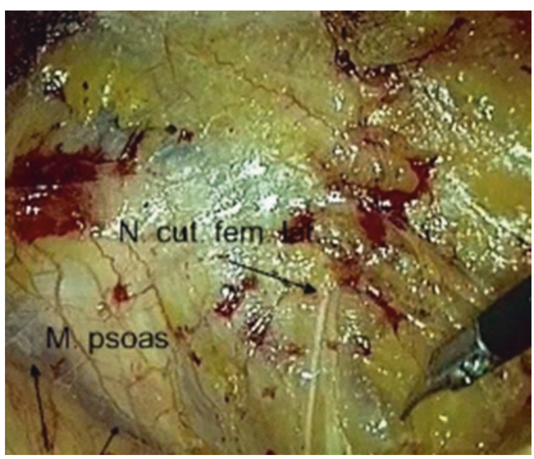
The femoral nerve, which arises from the dorsal branches of the ventral rami of the second, third, and fourth lumbar nerves, is located just lateral to the iliac vessels and lateral and beneath the testicular vessels. This is usually well protected by the psoas tendon, surrounding fatty and lymphatic tissue, and spermatic sheath or iliac fascia. Therefore, injury to this nerve is extremely rare during laparoscopic hernia repair. According to Loeweneck, damage of this nerve was seen in only 1.2% of all nerve injuries reported. Reported injury to the obturator nerve is rare and anecdotal as it shares the same origin as the femoral nerve and is well hidden deep in the triangle between the pubic bone and the iliac vessels (◘ Fig. 1.13) behind the vessels. The more common nerve injuries seen with laparoscopic inguinal repairs are lesions of the genitofemoral nerve and lateral femoral cutaneous nerve (◘ Fig. 1.18). However, in total in large series, the frequency of damage to these nerves is not higher than 0.3% [21, 22]. Nevertheless, each of these complications should be taken seriously, as it can have disastrous consequences for the patient. Intractable pain may arise when nerves are injured, clipped, tacked, or scarred to mesh. Therefore, precise knowledge of the topography of these nerves is essential to perform a high quality repair with optimal patient outcomes. While the course of the obturator and femoral motor nerves is largely predictable and constant, the course of the sensory nerves (genitofemoral and lateral femoral cutaneous) demonstrates great variability.

Most at risk during laparoscopic hernia repair are the lateral femoral cutaneous nerve (58.2% of all nerve lesions) and the femoral branch of the genitofemoral nerve (31.2% of all nerve lesions). Injury to the genital branch of the genitofemoral nerve comprises 4.7% of all published nerve lesions. The lateral femoral cutaneous nerve arises from the dorsal divisions of the second and third lumbar nerves. It emerges from the lateral border of the mid-psoas muscle and crosses the iliacus muscle obliquely traveling toward the anterior superior iliac spine. It then passes under the inguinal ligament, through the lacuna musculorum and then over the sartorius muscle into the thigh, where it divides into an anterior and a posterior branch. The anterior branch becomes superficial about 10 cm below the inguinal ligament and divides into branches which are distributed to the skin of the anterior and lateral parts of the thigh reaching as far as the knee.

The posterior branch supplies the skin from the level of the greater trochanter to the middle of the thigh. Intraoperatively, the surgeon should be aware that the lateral femoral cutaneous nerve will typically cross the middle of the operating field, but the majority (57%) demonstrates variability from the normal course. Single (44%), double (23%), or multiple nerve trunks may be identified (◘ Fig. 1.19). The point of exit where the nerve penetrates the abdominal wall is typically lateral to the



◘ **Fig. 1.18** Triangle of pain. The nerves are protected by the deep layer of transversalis fascia



◘ **Fig. 1.19** Two branches of the cutaneous lateral femoral nerve

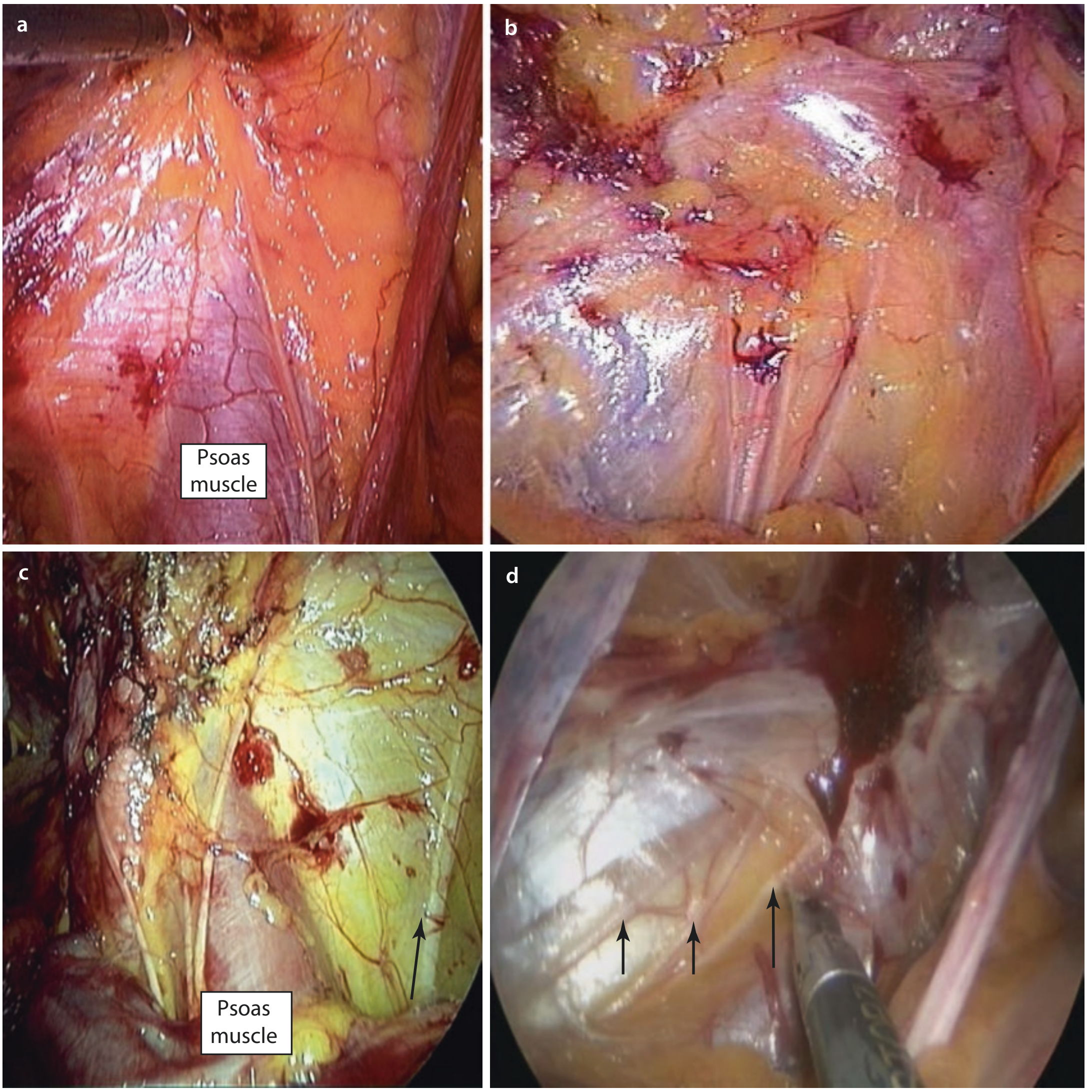


Fig. 1.20 **a** Only one branch of the genitofemoral nerve is visible. **b** Four branches of the genitofemoral nerve are visible protected by the deep layer of transversalis fascia. **c** Three branches of the genitofemoral nerve are visible. Laterally the n. cut. fem. lat. is visible (*arrow*). **d** Three branches of the genitofemoral nerve are visible

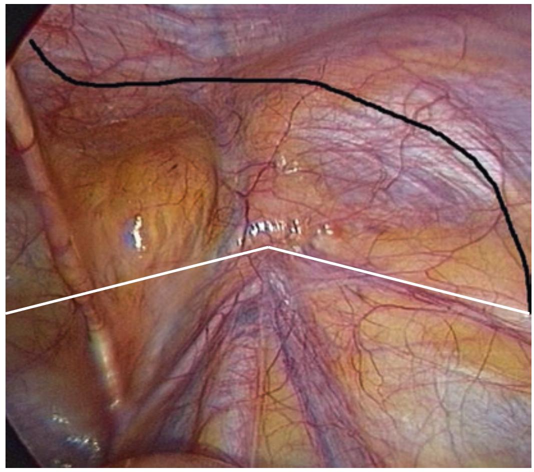
field 2–4 cm medial to the anterior superior iliac spine at the level of the ileo-pubic tract. However, this exit point also demonstrates significant variability and may be found up to 6 cm medially (only 3 cm lateral to the inner inguinal ring) and in 7% of the cases may even exit lateral and cranial to the anterior superior iliac spine [9]. The genitofemoral nerve arises from the upper L1–2 segments of the lumbar plexus. It passes downward and emerges from the anterior surface of the psoas major muscle. The nerve continues on the surface of the psoas muscle progressing caudally toward the inguinal canal and divides into two branches, the genital branch and the femoral branch (Fig. 1.18).

In men, the genital branch continues down and supplies the scrotal skin. In women it accompanies the round ligament and supplies the mons pubis and the labia majora. Wide variation in the course of this nerve are seen. In contrast to classically described anatomy, the genital branch runs through the inguinal canal in only 14% of cases. In 44% of cases, it consists of two to five branches (Fig. 1.20a–d); in 49% of the cases, the nerve perforates the abdominal wall 1–3 cm lateral to the deep inguinal ring just through the ileo-pubic tract and in 5% through the lacuna vasorum [9].

The femoral branch passes underneath the inguinal ligament (ileo-pubic tract) traveling adjacent to the external iliac artery and supplies the skin of the upper, anterior thigh. In 58% of the cases, two to five branches are found, and in 73% the branches perforate the abdominal wall 2–5 cm lateral to the deep inguinal ring. There is wide variation in the exit site with perforation of the nerve below (30%), above (16%), or through (54%) the ileo-pubic tract. In rare cases the nerve may run near the anterior superior iliac spine or through the inguinal canal [9]. The wide variation of the number and course of sensory nerves that traverse the preperitoneal space creates significant potential for overlap with the genital branch, femoral branch, lateral femoral cutaneous and even ilioinguinal nerve, and a wide area in which injury can occur. Respecting this proper dissection planes and knowledge of this neuroanatomy will minimize contact and risk.

1.3 The Ileo-pubic Tract and the Muscular/Vascular Lacuna

The ileo-pubic tract is one of the most important landmarks of the groin. Whereas the inferior epigastric vessels divide the groin in a medial and a lateral compartment, the ileo-pubic tract divides the groin in an upper and lower part. The operation should always commence with identification of the ileo-pubic tract cross-checking the anatomy with palpable surface features – an essential step of the operation (◘ Fig. 1.21). Careful dissection is imperative below the tract because of the important structures – vessels, cord, nerves –that reside in this field (trapezoid of disasters). Above this line, typically only the epigastric vessels pose any risk. However, as noted in the prior neuroanatomy section, some aberrant branches of the genitofemoral and lateral femoral cutaneous nerve can perforate the abdominal wall up to 1–2 cm above the tract. The ileo-pubic tract corresponds to the anteriorly identified inguinal ligament and is loosely connected with it when visualized from outside. The ileo-pubic tract is a thickened band of transversalis fascia fibers that curves over the external iliac vessels attached laterally to the iliac crest, arching across the front



◘ **Fig. 1.21** First laparoscopic view: cross-checking of anatomy. Identifying the ileo-pubic tract (*white line*)

of the femoral sheath and inserting as a broad attachment into the pubic tubercle and pectineal line. Furthermore, the tract is attached to the ileo-pectineal arch which forms a septum which subdivides the space deep to the inguinal ligament into a lateral muscular lacuna and a medial vascular lacuna, the latter hosting the iliac vessels and the femoral nerve. The ileo-pubic tract lies beneath the deep inguinal ring, forming the entire aponeurotic order of that aperture [5]. It is the ileo-pubic tract, not the lacunar ligament as usually described, that defines the medial border and roof of a normal femoral canal from the laparoscopic viewpoint, the place a femoral hernia may develop (◘ Fig. 1.22a, b) [5].

1.4 Conclusion

In-depth knowledge of the anatomy of the groin is indispensable for safe and successful laparoscopic hernia repair. The inferior epigastric vessels and the ileo-pubic tract are the major landmarks that define the field and facilitate identification of the essential structures of the groin and the characteristics of the hernia. A thorough understanding of the fascial architecture helps to identify the correct plane for an atraumatic dissection technique when reducing the hernia sac and preparing the pelvic floor for flat mesh implantation. Thorough knowledge of the course of the inguinal vessels and nerves and their multiple variations are absolutely necessary to avoid serious complications.

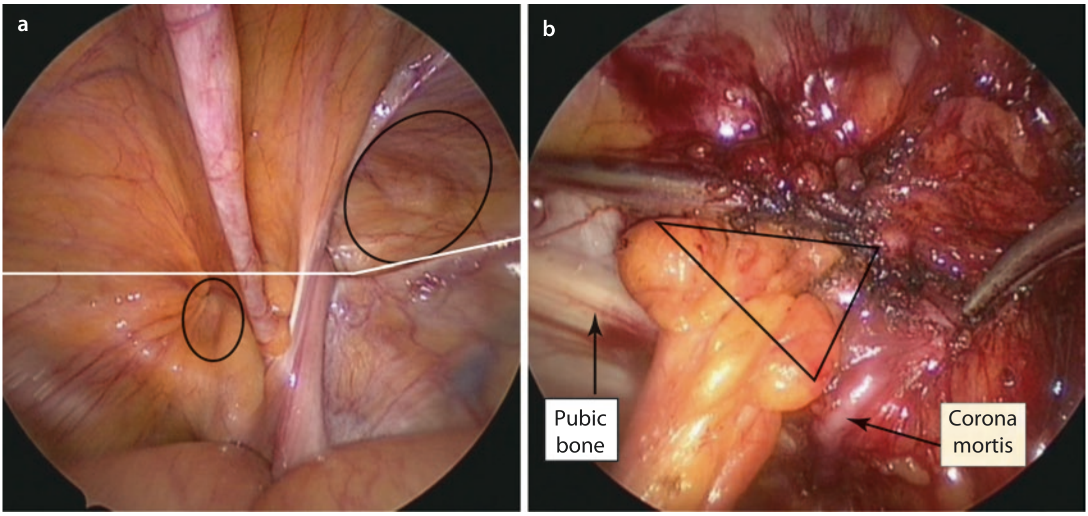


Fig. 1.22 **a** Indirect inguinal hernia above of the ileo-pubic tract; femoral hernia below of the tract (muscular lacuna). **b** Femoral canal (muscular lacuna, *black triangle*) after dissection of the peritoneum. Fatty femoral hernia content is partially reduced

Keep in mind: "A surgeon who is not familiar with the anatomy, he will be like mole-what he produces are nothing more than mounds of earth (graves)" [23].

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Diagnostics of Inguinal Hernias

Baukje Van Den Heuvel

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2.1 Part 1 How I Do It

2.1.1 General

For generations, careful physical examination of the groin in patients presenting with inguinal pathology has been regarded as an essential surgical skill. Already in the eighteenth century, the famous Dutch surgeon Petrus Camper emphasized: "Among the defects of our body there are none of any more concern therefore requiring precise investigation, than hernias" [12]. In current surgical practice, the presence of an inguinal hernia can be diagnosed quite accurately by history and physical examination, and additional diagnostic modalities are seldom needed [17, 28]. The presenting symptom of a groin hernia is either discomfort or pain in the groin in the majority of patients [10]. Approximately one third of all patients is asymptomatic at presentation and presents with the sign of a non-tender bulge in the groin.

A patient with an inguinal hernia is usually male and presents with a reducible bulge in the groin. The bulge emerges during increased intra-abdominal pressure such as sneezing, coughing, straining, or laughing and resolves during rest or lying down. At physical examination the inguinal hernia can be provoked by instructing the patient to blow at the back of his hand in an upright position. The intra-abdominal pressure increases and typically the inguinal hernia emerges. This procedure is called the Valsalva maneuver. The hernia can be reduced when intra-abdominal straining is released or in supine position and diagnosis of an inguinal hernia is confirmed. Hardly ever additional diagnostics are necessary.

However, not all patients with an inguinal hernia present as abovementioned, and the different diagnosis and its according diagnostic steps should be understood. Firstly, some patients present with a history of an intermittent bulge or vague localization of the bulge, but no bulging can be confirmed during physical examination and Valsalva maneuver. In that case an ultrasound is helpful. An ultrasound is a noninvasive dynamic modality with which possible herniation through the inguinal canal (indirect) or through an insufficient abdominal wall (direct) can be evaluated quite correctly. In a clinical nonevident groin hernia, the specificity of ultrasound in relation to surgical exploration is 81–100%, and its sensitivity is 33% [26]. If an ultrasound is inconclusive, an additional dynamic MRI can be initiated. The advantage of MRI is that other groin pathologies can be diagnosed accurately. Its specificity is 96% and its sensitivity is 95% [26]. The most common differential diagnosis of a swelling in the groin includes lymph node enlargement, varix, aneurysm, soft tissue tumor, abscess, genital anomalies, and endometriosis.

Secondly, some patients present with a history of inguinal pain, but no bulging during physical examination or Valsalva maneuver. In these patients an extensive differential diagnosis applies such as adductor tendinitis, pubic osteitis, hip artrosis, bursitis ileopectinea, irradiating low back pain, or endometriosis. In these patients an MRI should be requested. The MRI can differentiate accurately and can show an early diagnosis of different sport-related pathologies. A CT scan is a reliable alternative to MRI in detecting an occult hernia or other groin pathology but shows lower sensitivity and specificity compared to MRI [26]. Consequently, in most hernia practices, CT scan fulfills no routine modality in the workup for an inguinal hernia or inguinal pain.

Herniography used to be the standard imaging procedure since 1967 [21]. A herniography comprises radiography of the pelvic area after intraperitoneal injection of radiopaque dye. It is a cheap diagnostic modality with high sensitivity of 81–100% and specificity rate of 92–98%. However, herniography is associated with a small risk of complications such as contrast allergy, puncture of the intestine, abdominal wall hematoma, and short-lasting pain (0–4.3%) [11, 13, 19]. In addition, herniography has no value in diagnosing other pathology in the groin apart from inguinal hernias. It is therefore that herniography has no routine use in diagnosing inguinal hernia in most hernia practices.

2.1.2 Contralateral Side

When a patient presents with a unilateral inguinal hernia, the contralateral side should always be routinely examined. A contralateral inguinal hernia is not seldom found. The contralateral hernia in that case is often asymptomatic as the patient presents with a unilateral hernia. It is very likely according to the publications on the long-term results of Fitzgibbons et al. and O'Dwyer et al. that an asymptomatic inguinal hernia will eventually become symptomatic over the years [6, 8, 9, 20]. Both groups of authors designed a randomized controlled trial in which male patients with a minimal symptomatic or asymptomatic inguinal hernia were randomized for either surgical repair or for watchful waiting. In their series 50–72% of the male patients in the watchful waiting group developed symptoms requiring repair. It was also shown that few hernia accidents occurred in the watchful waiting group requiring emergency repair. It should be discussed with the patient that a minimal symptomatic or asymptomatic inguinal hernia on the contralateral side is likely to develop symptoms over the years requiring repair but that the incidence of hernia accidents is low and a conservative policy is safe. A bilateral repair however can be proposed.

Another prevailing phenomenon is the accidental finding of an occult inguinal hernia on the contralateral side during laparoscopic repair while indication for surgery was a symptomatic unilateral hernia. The “free” inspection of the contralateral side is considered one of the advantages of laparoscopic inguinal repair. In 8–51% of the patients who present with a unilateral inguinal hernia, an occult contralateral defect is found during laparoscopic intra-abdominal inspection [29]. When a laparoscopic unilateral inguinal hernia repair is scheduled, the surgeon should always discuss with the patient prior to surgery what to do when an asymptomatic occult contralateral defect is found. As mentioned above Fitzgibbons and O’Dwyer showed that a hernia accident is unlikely to occur, but most minimal or asymptomatic inguinal hernias do develop symptoms over the years. An immediate repair of such an occult defect can be easily undertaken, prolonging the laparoscopic repair by 7–25 additional minutes [29], requiring an additional mesh, while convalescence and morbidity remains the same.

2.1.3 Differentiation Between Medial and Lateral

Differentiation by physical examination in types of inguinal hernia, direct (medial) or indirect (lateral), is considered inaccurate and irrelevant by many. Differentiation might be challenging by additional diagnostic modalities as well [4, 22, 23]. Knowledge of the type of hernia seldom influences the indication to perform surgery or the surgical approach. However, with the development of minimally invasive procedures, the surgical possibilities to correct an inguinal hernia have greatly extended. During laparoscopic posterior repair of an inguinal hernia, evident differences in complexity are experienced between repairing a direct and an indirect inguinal hernia, while these differences are not present in an open anterior approach. Laparoscopic dissection of a direct hernia consists simply of the separation of two distinct planes, the hernia sac entailing peritoneum and the insufficient transversal fascia. As these planes have no relation to each other, separation is performed without difficulty. The laparoscopic dissection of an indirect hernia however can be technically challenging, as scar tissue of the obliterated vaginal process results in peritoneal fixation to the funicular structures. The peritoneal sac is most closely related to the funicular structures. Indifferent dissection of the peritoneum inevitably leads to the risk of damage to the vas deferens and the vascular funicular structures. The laparoscopic repair of an indirect hernia requires well-developed endoscopic surgical skills and may be time-consuming when performed with the essential caution, while the laparoscopic repair of a direct hernia is generally far less challenging and takes less time. Consequently, preoperative differentiation of the type of inguinal hernia results in useful information, both in training programs and in preoperative planning.

When differentiation in type of hernia is desired, the surgeon can reduce the inguinal hernia and press his fingers to the expected location of the deep inguinal ring. The patient is instructed to perform a Valsalva maneuver, and the inguinal hernia either appears immediately, indicating that the hernia is a direct type, or appears after releasing pressure of the surgeon’s fingers, indicating an indirect hernia. This method, the so-called finger occlusion method, appears indeed to be inaccurate [5, 14, 17, 18, 22, 23]. The overall accuracy diagnosing an indirect hernia with physical examination ranges from 72% to 92% and 55% to 65% for direct hernias. Subsequently, the European Hernia Society guidelines on the treatment of inguinal hernia in adult patients state that differentiation of hernia types by physical examination is unreliable [26]. The most plausible explanation for the inaccuracy in differentiating between the types of hernia in present literature is the difficulty of determining the exact location of the deep

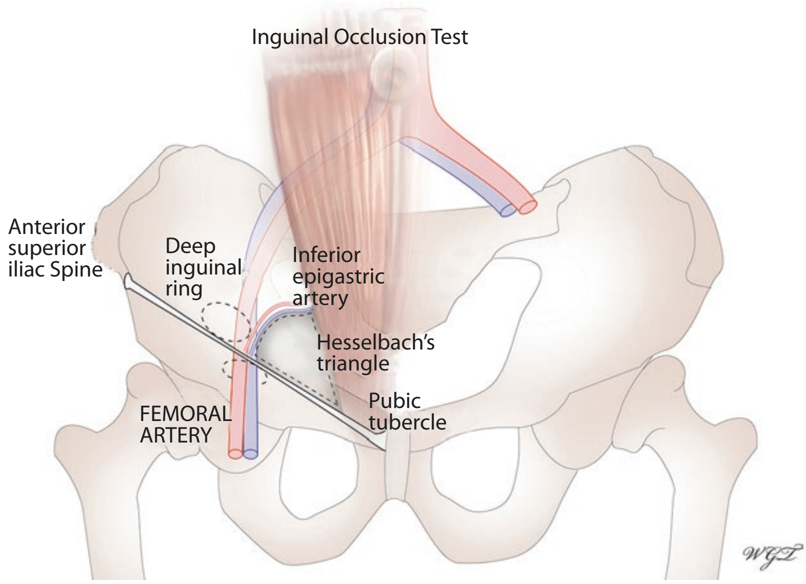

Fig. 2.1 Location of the deep inguinal ring

inguinal ring. During physical examination, the deep inguinal ring cannot be palpated, so its exact location can only be derived from anatomic landmarks. Four anatomical landmarks are of importance in assessing the location of the deep inguinal ring: the anterior superior iliac spine, the femoral artery, the inferior epigastric artery, and the pubic tubercle (see Fig. 2.1). It is often suggested that the deep inguinal ring is located midway between the anterior superior iliac spine and the pubic tubercle or slightly lateral to it. However, many reports contradict on the exact location of the deep internal ring and inguinal pathology might alter its location [1, 7, 15, 24, 25]. Protrusion of an indirect hernia is likely to push the location of the deep inguinal ring more medially and vice versa [24]. In this way, some of the indirect hernias, emerging through a dislocated deep inguinal ring, will protrude medial from the mid-inguinal point (and the occluding finger of the examiner) and thereby might be diagnosed as a direct hernia.

More accurate localization of the deep inguinal ring results therefore in an improved accuracy in preoperative differentiation of hernia type. The deep inguinal ring is with few exceptions located lateral from the inferior epigastric vessels both in the normal groin as well as in the groin with hernia pathology. A recent study of Tromp et al. [27] showed that after localization of the inferior epigastric vessels by a handheld Doppler device, the deep inguinal ring could be located much more accurately. Preoperative differentiation was accurate in 79% of the direct hernias and 93% of the indirect hernias [5] comparable to the accuracy of ultrasound in differentiating between hernia types [2, 3, 16, 30].

2.2 Part 2 Statements and Recommendations

Statements

Ultrasonography and MRI have high sensitivity and specificity in diagnosing a clinical unclear inguinal hernia.

Level of evidence: moderate

MRI has high sensitivity and specificity in revealing other inguinal pathology.

Level of evidence: moderate

Herniography has high sensitivity and specificity in unclear diagnosis of an inguinal hernia and has a low incidence of complications but is infrequently used in current hernia practice.

Level of evidence: moderate

An occult contralateral inguinal hernia is often found during laparoscopic exploration, and its incidence varies between 8% and 51%.

Level of evidence: low

Preoperative differentiation in type of hernia is possible with the finger occlusion test following localization of the inferior epigastric artery with high sensitivity and specificity.

Level of evidence: low

Recommendations

In case of an evident clinical inguinal hernia, no additional imaging diagnostics are indicated.

Weak

When an inguinal hernia is suspected but clinical findings are uncertain, the first diagnostic imaging modality is dynamic ultrasonography, followed by dynamic MRI.

Weak

The contralateral side in patients presenting with a unilateral inguinal hernia should be routinely physically examined to assess presence of an occult contralateral defect.

Weak

When a laparoscopic repair is initiated for a unilateral inguinal hernia, the contralateral side should be routinely visualized to assess presence of an occult contralateral defect.

Weak

Preoperative differentiation in inguinal hernia type can be accurately done after localization of the inferior epigastric artery with Doppler device followed by the finger occlusion test.

Weak

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Classification of Inguinal Hernia

Volker Schumpelick

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The results of hernia repair are related to the localization of the hernia orifice, the site of the fascial defect, and the overall collagen content of the fascia as well as the surrounding tissue. Therefore for evaluating hernia surgery, a precise classification of the hernias is indispensable. Furthermore, an unequivocal classification is important for the rational choice of treatments and for the analysis of scientific data. It also allows to compare the various treatments in clinical trials when hernias can be classified in an unequivocal manner (Campanelli, EHS Guidelines 2009 [1]). Current inguinal hernia classifications are numerous. All classification systems are based on a description of the relationship of the defect to the epigastric vessels. The simple classification of "direct" (medially to the vessels) and "indirect" (laterally) hernias dates back to Cooper in 1844 [2]. Hesselbach defined the inferior epigastric vessels as the reference point and used the term "external" and "internal" hernia [3].

Casten presented a classification in 1967 based on functional anatomy and surgical repair [4]. As stage 1 he describes an indirect hernia with a normal internal ring as seen in infants and children, treated by high ligation of the sac. Stage 2 encompassed those indirect hernias with an enlargement of the internal ring to be repaired by excision of the sac and reconstruction of the internal ring. All direct and femoral hernias were summarized under stage 3 with the indication of a Cooper's ligament repair.

In 1970, Halverson and McVay published a classification based on a description of the fascial defect and the repair technique. Their categories included small indirect inguinal hernias, medium indirect hernias, large indirect and direct hernias, and femoral hernias. They recommended high ligation of the neck of the sac followed by reconstruction of the internal ring for the first entity. For all the other types, they recommended the procedures known by their own names [5].

Gilbert presented a classification in 1989 which takes into account the functional and anatomical integrity of the internal ring and the tissue quality within the Hesselbach's triangle. Types I–III are indirect hernias, and types IV and V are medial defects of the inguinal canal; femoral hernias are not classified. In type I there is a hernial sac of any size passing through a small and firm internal ring. Type II and III show enlargement of the internal ring to admit one or two fingers, respectively. Hernias with a large defect of the canal floor are called type IV, whereas those with a small medial orifice are named type V [6]. Rutkow and Robbins added a type VI for hernias with both indirect and direct components and a type VII for femoral hernias [7].

The classification published by Nyhus in 1993 differentiates between four types [8]. It is based on the location and the size of the fascial defect and the strength of the posterior wall of the inguinal canal, but there is no precise measurement. In type I there is an indirect hernia with an internal ring of normal size, usually found in infants, children, and young adults. Indirect hernias with enlargement of the internal ring but normal strength of the posterior wall are categorized as type II. Hernias presenting with both enlargement of the internal ring and weakness of the floor are classified as type III. The crucial factor in type III is a defect of the posterior wall of the inguinal canal summarizing all direct hernias (III a), indirect hernias with a dilated ring (III b), and femoral hernias (III c). Type IV covers all recurrent groin hernias either direct (IV a), indirect (IV b), femoral (IV c), or a combination thereof (IV d).

In 1994, another classification of inguinal and femoral hernias was published by Schumpelick et al. [9, 10]. This intraoperative classification is based on the location ("M" medial/direct; "L" indirect/lateral; "F" femoral) and the transverse diameter (I < 1.5 cm, II 1.5–3 cm, III > 3 cm) of the hernia orifice. In cases of combined direct and indirect hernias, the diameter of both fascial defects is added up.

In summary, a reliable classification should include all types of inguinal hernias and should work equally well for classical open surgery and laparoscopic repairs. The classification should be clear and simple to allow unambiguous typing in routine clinical setting. The surgeon must be able to assign each patient to one category with ease and reliability [11]. In order to meet all these requirements, the European Hernia Society (EHS) proposed a new standardized classification system. The EHS classification is based on the size of the defect and the location to the important anatomical structure. Inguinal hernias are classified according to their relation to the inferior epigastric and femoral vessels as lateral ("L"), medial

Table 3.1 EHS (European Hernia Society) classification of inguinal hernia

EHS groin hernia classification	Size of the defect in primary and recurrent hernias				Recurrent hernia
	0	1	2	3	X
Lateral (L)					
Medial (M)					
Femoral (F)					

("M"), or femoral ("F"). The size of the hernia orifice is classified by its diameter as O = incipient, 1 = up to 1,5 cm, 2 = 1,5–3 cm, and 3 = above 3 cm (Table 3.1).

To measure the diameter, the surgeon should use his index finger tip that regularly has a diameter of 1.5 cm. For laparoscopic calculation the length of the scissor blades can be used, which are also 1.5 cm long, but recently a special measuring instrument for laparoscopic surgery is available. For example, a middle-sized indirect hernia with an orifice of 2 cm is classified as L2. In case of recurrence, an "X" should be added.

In conclusion, it is strongly recommended that the EHS classification system should be used in all clinical settings. However, two disadvantages must be mentioned: (1) The different biologic condition of the patients, e.g., collagen deficiencies, are not considered. (2) The same is true for the size of the hernia sac. Although in the literature no correlation was found between the size of the hernia sac and the recurrence rate, clinical experience shows that the larger the hernia sac, the more difficulties the surgeon has when dissecting the groin. Accordingly intraoperative and postoperative complication rates, e.g., hematoma and seroma, may be increased. In order to enhance the value of a hernia graduation, it is desirable that both these factors should be integrated parts of a future classification system.

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Chain of Events Leading to the Development of the Current Techniques of Laparoscopic Inguinal Hernia Repair: The Time Was Ripe

Maurice Arregui

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4.1 Introduction

In the late 1980s, laparoscopic cholecystectomy was started. At the time, this was radical and most surgeons opposed it. A few were courageous enough to believe in it and adopted it early on. This was a major milestone in surgery. Today, just over 30 years later, surgery residents in the USA rarely see open cholecystectomies, and many never see an open common bile duct exploration. In the USA, cholecystectomy is the most common general surgical procedure. Inguinal hernia repair is probably the second most common general surgical procedure, and approximately 690,000 groin hernia repairs were being performed annually in the USA in 1991. At that time nearly all were performed open, and patients stayed in the hospital for postoperative care. Recurrences were high. Today, in the USA, the vast majorities are performed as an outpatient procedure. Most are still performed with a variety of open approaches. The number of different techniques for inguinal hernia repair has greatly increased with both laparoscopic and open surgeries. There is no uniform agreement on the best repair. There is controversy over open repairs and controversies over the laparoscopic approaches. In fact there are more approaches today than 30 years ago. The penetration of the laparoscopic approach in the USA is probably only about 20–30%. This penetration is higher in some countries such as Germany than in others. In some countries with limited medical resources, this approach is not affordable. The laparoscopic approach requires general anesthesia that adds to the cost. Even without factoring in anesthesia, it is more costly to perform due to the added costs of laparoscopy and many of the specialty tools such as tacking devices, balloons, glues, modified meshes, etc. Nonetheless, in theory, the preperitoneal placement of mesh is probably the most anatomical. It is less painful and provides a quicker recovery with the lowest recurrence when done properly using large meshes. Even with the laparoscopic approaches, there is controversy over the best approach. Should a TEP or TAPP be done, what type and size of mesh should be used, and is fixation necessary? How extensive should the dissection be? Will we be seeing mesh migration such as in the gynecologic pelvic suspension procedures and hiatal hernia repairs?

In this chapter, I hope to answer three basic questions:

1. Why do we do laparoscopic repairs?
2. What was the basis for current laparoscopic repairs?
3. What are the advantages/disadvantages?

4.2 Why Do We Do Laparoscopic Hernia Repairs? How It Started

Because of the remarkable success of laparoscopic cholecystectomy and the enthusiasm surrounding this remarkable advancement, the obvious next common general surgical procedure to look at was the inguinal hernia repair. At the time of the laparoscopic cholecystectomy revolution in the late 1980s, the most common hernia repairs were open tissue repairs, including the McVey, Shouldice, simple ring closure, Bassini repair, and others. These were all tension and tissue repairs. Mesh was uncommonly used and recurrences in all repair types were high. Mesh repairs like the Lichtenstein repair and plug approaches were new and considered controversial. Most repairs were being done from an anterior inguinal approach. Pre- or "pro"peritoneal repairs were being done by a few but were reserved mostly for more complicated or recurrent hernias. In the USA and France, a few surgeons were proponents of a preperitoneal approach.

At the time, all these open operations were quite painful with a slow recovery. Surgery was mostly inpatient, and in the USA, patients were restricted from returning to work for at least 6 weeks. The hope was to find a laparoscopic approach that could greatly reduce the pain and recovery time, as did laparoscopic cholecystectomy. The laparoscopic hernia surgeons hoped to create a laparoscopic hernia repair revolution to solve all these problems. What we got was more controversy but also an overall much better understanding of hernias and repair techniques. We had great debates with our open hernia repair colleagues. Initially, we were polarized but then came together. In 1993, in Indianapolis, Indiana, USA, a meeting "Hernia '93: Advances or Controversies" brought together for the first time established leaders representing academic and private practice surgeons, open and laparoscopic surgeons, resident surgeons and professors in surgery from the USA, Canada, Brazil, France, England, Germany, Sweden, and Australia. This electric meeting was filled with more controversies and arguments from the open and the laparoscopic camps. Ultimately the two groups united and developed a great camaraderie. Later surgeons established regional, national, and international hernia societies (American, European, Asian, Indian, African hernia societies) to study and teach hernia repairs. We now have a journal dedicated to the study of hernias. We have also elevated the standards of hernia repairs and established and refined many great approaches. Clinical, animal, and basic research on repair, materials, infections, complications, and pain have been formalized. Hernia repairs are safer, better, less painful, and with fewer complications and recurrences. Convalescence and return to work are quicker. There, however remains no perfect and no standard repair for the groin hernia.

4.3 What Was the Basis for the Early Laparoscopic Approaches?

The laparoscopic revolution had started, and the time was ripe for developing laparoscopic hernia repairs. There was previous experience. The closure of the internal ring and intraperitoneal placement of mesh were the first attempts. The first to do this was Ralph Ger (1982) in the USA using Michel clips on the orifice of inguinal hernias found during open laparotomy for another abdominal procedure. He demonstrated that this worked and subsequently performed a laparoscopic repair of an indirect inguinal hernia with several Michel clips. Popp in Germany in 1990 reported a laparoscopic repair of an indirect hernia in a female with suture closure and sutured absorbable mesh over the peritoneum. In the USA, the intraperitoneal onlay mesh (IPOM) was championed by Robert Fitzgibbons and Morris Franklin. Schultz and Corbitt developed a laparoscopic plug approach to attempt to mimic the then current and successful open plug technique. These early attempts soon were abandoned. Failure rates were high for the plug approach. Intraperitoneal mesh is no longer advocated for inguinal hernia due to the concern for adhesions and bowel obstruction. But, as pointed out by Bob Fitzgibbons (who initially pioneered this approach), intraperitoneal mesh has been become established and is widely used for ventral hernia repairs both laparoscopic and open.

Open hernia surgeons had pioneered the techniques and indications for preperitoneal repairs. Lloyd Nyhus in Chicago was a strong advocate of open preperitoneal repair with a sutured patch. George Wantz in New York had published an excellent atlas of hernia surgery in which he beautifully described the unilateral and bilateral giant prosthetic replacement of the visceral sac (GPRVS) that was developed by Rene Stoppa and Warlaumont in France. They were members of Groupe de Recherche et d'Etude de la Paroi Abdominale (GREPA), a French society of surgeons formed in 1979 in Amiens, France, by JP Chevrel, Stoppa, and several other surgeons interested in the study and research of the abdominal wall to better understand hernias. This was due to the very high incidence of hernia repair recurrences in France of over 20% at that time. These new preperitoneal approaches were open placement of a large unilateral or bilateral prosthetic graft in the preperitoneal space entered through a midline incision to reinforce the anterior abdominal wall. The purpose of this approach was in part for complicated or recurrent hernias, and the basis was to replace the weakened transversalis fascia with a large mesh. The mesh used by these early preperitoneal approaches was a large sheet of Mersilene mesh that was sandwiched in the anterior abdominal wall between the transversalis fascia and the umbilical pre-vesicular fascia. These open approaches have served as the model for the current laparoscopic approaches. The transabdominal preperitoneal (TAPP) repair was the first approach to the preperitoneal space. Though Fitzgibbons had worked on an animal model for the TAPP, this was first clinically performed by Arregui in Indianapolis in October 1990, and the first series of 61 hernia repairs on 52 patients was reported in 1992. Dion in Canada also began with the TAPP in March 1991. Dulucq in France in June 1990 started performing the totally extraperitoneal (TEP) repair. Ed Phillips (Los Angeles) started performing TEP in November 1990. In 1992, George Ferzli published a series of 25 patients undergoing an extraperitoneal endoscopic hernia repair with mesh. In 1993 McKernan (Marietta) and Laws published 51 hernia repairs in 34 patients using a totally extraperitoneal (TEP) approach for placement of mesh in the extraperitoneal location to better mimic the open approach of Wantz and Stoppa. The date of his first case was not published. This was the basis for the current TEP using the technique of Stoppa and Wantz, the laparoscopic great prosthetic replacement of the visceral sac. These two approaches are currently the most widely used laparoscopic approaches.

4.4 What Are the Advantages and Disadvantages?

There is less pain with the laparoscopic approach for various reasons. No major skin incision is made. Even with the open approach of Stoppa using a midline approach, he reported less pain, mesh replaces the weakened transversalis fascia, and sutures are not required if a large mesh is placed. There is no tension since there is no tissue approximation. With a large mesh and no fixation, the chance of nerve injury is very low. The recurrences are less. In the words of George Wantz, "When done properly, recurrences are inconceivable." It is imperative that there is wide overlap of the myopectineal orifice of Fruchaud. It is also imperative that all lipomas or herniated preperitoneal fat is reduced. It is also imperative that the mesh lay widely and deep to the preperitoneal fat and that the mesh does not roll when the pneumo-preperitoneal air is released. A proper repair takes longer and is more difficult than many of the abbreviated laparoscopic repairs being done. Even the open preperitoneal approaches with small meshes such as the Nyhus approach had higher recurrence rates than reported with the Stoppa GPRVS repair.

The laparoscopic approach is more anatomical because the mesh which reinforces the myopectineal orifice of Fruchaud replaces the weakened transversalis fascia and occludes the defects in the inguinal floor. The mesh is permanent and is incorporated into the posterior abdominal wall.

The laparoscopic repair is ideal for bilateral hernias as it will be one operation and will not have the disadvantage of two incisions required with most open approaches. With the TAPP, inspection of the contralateral side is easily done. With the TEP, this may be more difficult. With my approach, I do a peritoneal inspection before starting the extraperitoneal dissection. If I see a contralateral hernia, I will repair both sides.

It is ideal for patients with recurrences after anterior repairs.

The disadvantages are increased costs, the operation is more difficult, and greater skill is necessary. Potentially more severe injuries can occur. It is not practical to do with a local anesthetic. Previous preperitoneal surgery is a relative contraindication.

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Indication for Surgery: Open or Laparoendoscopic Techniques in Groin Hernias

Jan F. Kukleta, Ferdinand Köckerling, and George Ferzli

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5.1 Indication for Surgical Repair of Groin Hernia

Vast majority of groin hernias of adult are operated as an elective procedure. The decision to operate depends on many factors (e.g., size, symptoms, discomfort, degree of disability, age, inguinal vs. femoral, family history, irreducibility, source of medical information, media, etc.). Few conditions make the indication for a hernia repair quite imperative; most of the others are rational reasons leaving enough time to look for the most convenient solution.

A bulge in the groin is often asymptomatic or very little symptomatic. It can take years until the inconstant swelling gets bigger causing a local discomfort and an individually variable necessity to push back the prolapsing tissue. Physical disturbance and insecurity are the most often reasons to undergo a surgical repair.

General attitude toward a groin hernia is to recommend a repair regardless of the symptoms based on a belief to have to prevent a possible threatening condition of strangulation. The prevalence of hernia disease supports the opinion of being a trivial circumstance, easy to repair for any surgeon, and having excellent outcomes.

A systematic review [1] reports 8% morbidity and 0.5% mortality in 85,585 patients between 1954 and 2004. The incidence of emergency repairs is approximately 7% in 103,537 repairs. The risk of incarceration and strangulation of groin hernias [2] was 3.6 per/1000 in males and 5.4 per/1000 in females per year. The inguinal hernias incarcerate and strangulate significantly less often than the femoral ones. The cumulative risk rises with age and duration of symptoms. The authors [1] conclude that considering the best available evidence, watchful waiting (conservative treatment for asymptomatic or minimally symptomatic inguinal hernias) is a safe and cost-effective treatment.

Concerning watchful waiting strategy, two important RCTs were published in 2006 which support the above conclusion [3, 4].

In 2011 Chung [5] reported that many patients in the observed group became symptomatic and found that evidence for watchful waiting policy was lacking. The estimated conversion rate for this group, with a mean age of 72 years at time of inclusion, was 16% at 1 year, 54% at 5 years, and 72% at 7.5 years.

Finally in 2013 Fitzgibbons [6, 7] after extending the follow-up of the original study [3] to 7 more years faced the estimated cumulative crossover rates of 68% (Kaplan-Meier analysis). Men older than 65 years crossed over at a considerably higher rate than younger men (79% vs. 62%). The most common reason for crossover was pain (54.1%). Men with inguinal hernia even when minimally symptomatic should be counseled that although watchful waiting is a reasonable and safe strategy, symptoms will likely progress, and an operation will be needed eventually [6].

In my personal opinion, postponing or delaying the decision to repair may be safe, but not a treatment.

Clear evidence supporting centralization of hernia repair in specialized hospitals is not available. However, one study [19] demonstrated that centralization of hernia repair within one hospital by referring all patients with hernias to a single dedicated surgeon resulted in fewer wound infections (5.9–0.45%, $p > 0.005$), fewer systemic complications (2.05–0.45%, $p > 0.05$), and lower recurrence rates (4.6–0.45%, $p > 0.001$).

There is no evidence that the indication to surgical repair of a groin hernia in men is the prevention of possible incarceration and strangulation [9]. On the contrary, in females the indication to surgery is to prevent complications due to seven times more frequent strangulations in femoral than in inguinal hernias. I fully agree with the statement [1, 8, 9]: The indication to surgical repair of a groin hernia in both genders is the treatment of current or future symptoms.

5.2 Indication for Laparoscopic/Endoscopic Groin Hernia Repair

In the EHS Guidelines [10], the open Lichtenstein and endoscopic inguinal hernia techniques are recommended as best evidence-based options for repair of a primary unilateral hernia provided that the surgeon is sufficiently experienced in the specific procedure.

The indication range for laparoendoscopic repair of groin hernias (LE) has continuously grown over time, parallel to surgeon's own learning curve and the collective experience with improved patient's outcome. LE repair can be applied in all groin hernias, inguinal and femoral, unilateral and bilateral, and primary and recurrent, in elective or emergency setting. The expert panel states that there are no absolute contraindications for endoscopic repair in adolescents aged 14–18 years [9].

The early accepted indications for LE repair were the recurrence after an open repair and a bilateral hernia. In bilateral hernias there are no hard data available to support the indication for LE repair over the open tension-free repair. Nevertheless the lower infection rates, lower acute and chronic pain rates [15], less surgical trauma, and faster return to normal activities make the preference of LE repair in bilateral groin hernias logical.

5.2.1 Bilateral Groin Hernia [9]: Level of Evidence (LoE) and Level of Consensus (LoC)

In patients with bilateral groin hernias, the expert group stated that endoscopic repair is ideal, because the standard three-trocar approach is used for both groins instead of two larger inguinal wounds (LoE, 5 for TEP/2b for TAPP; LoC, strong consensus, 154 of 161 = 96%).

When an occult contralateral hernia is discovered during endoscopic repair of a symptomatic unilateral hernia, the occult and the symptomatic hernia can be repaired in the same surgical procedure (LoE, 5; LoC, strong consensus, 148 of 154 = 96%).

In the absence of a groin hernia despite of preoperative diagnosis of bilaterality, prophylactic mesh placement on the contralateral side in endoscopic repair of a symptomatic unilateral hernia is not advisable (LoE, 5; LoC, consensus, 124 of 138 = 90%).

5.2.2 Recurrent Groin Hernia [9, 11, 16, 17, 18]

Endoscopic surgery is preferred in patients with a recurrent groin hernia after open repair (LoE, 1b; LoC, strong consensus, 151 of 158 = 96%) [9]. The patient satisfaction was significantly higher after LE repair than after Lichtenstein repair [18].

The Update of EHS Guidelines published in 2014 [11] reports level 1b evidence that endoscopic repair results in less postoperative pain and faster convalescence than the Lichtenstein technique in repair of recurrent inguinal hernia.

Conclusions: Level 1a. For recurrent hernias after conventional open repair, endoscopic inguinal hernia techniques result in less postoperative pain, faster convalescence, and less chronic pain than the Lichtenstein technique. Recommendations: Grade A. For the repair of recurrent hernias after conventional open repair, endoscopic inguinal hernia techniques are recommended (◘ Fig. 5.1).

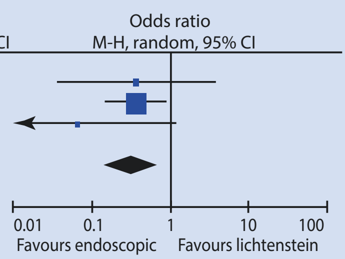
In an RCT comparing TEP versus TAPP versus Lichtenstein after previous conventional open repair, the endoscopic approach significantly increased the operative time (only TEP) but reduced perioperative complications, postoperative pain, analgesic requirement, and time to return to normal activities [27]. Another study comparing TAPP and Lichtenstein showed less postoperative pain and shorter sick leave for the endoscopic group [28].

5.2.3 Groin Hernia Repair in Women

According the EHS Guidelines [10], women have a higher risk of recurrence (inguinal or femoral) than men following an open inguinal hernia

Study or subgroup	Endoscopic Events	Endoscopic Total	Lichtenstein Events	Lichtenstein Total	Weight	Odds ratio M-H, random, 95% CI
Dedemadi 3 years	0	50	0	32		Not estimable
Demetrashvili 3 years	1	24	3	28	12.0%	0.36 [0.04, 3.73]
Eklund 5 years	8	73	19	74	80.3%	0.36 [0.14, 0.88]
Kouhia 3 years	0	49	6	47	7.7%	0.06 [0.00, 1.18]
Total (95% CI)		146		149	100.0%	0.31 [0.14, 0.70]
Total events	9		28			

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 1.29$, df = 2 ($P = 0.53$); $I^2 = 0\%$
Test for overall effect: Z = 2.82 ($P = 0.005$)



◘ **Fig. 5.1** Pooled data of four studies on chronic pain with follow-up 3–5 years after endoscopic vs. Lichtenstein recurrent hernia repair after previous open repair (From Update EHS Guidelines 2014) operation due to a higher occurrence of femoral hernias. (Level 2c). A preperitoneal (endoscopic) approach should be considered in female hernia repair (Grade D).

In Update of IEHS Guidelines [13], two large prospective, nonrandomized trials [20, 21] of the Danish and Swedish hernia database identified female gender as a risk factor for chronic pain, but only a small fraction of the patient population had an endoscopic hernia repair.

Endoscopic repair is the preferred surgical approach in case of a femoral hernia (LoE, 5 men/2c women; LoC, consensus, 108 of 144 = 75%) [9].

Koch et al. [22] report in 2005 from the Swedish hernia register that women have higher risk for reoperation than men (RR 2.6 in female, 1.9 in men). Women have lowest risk for reoperation with TAPP (0.31) or TEP (0.41) when compared with Lichtenstein repair (1.0).

5.2.4 Unilateral Primary Groin Hernia

Significant advantages for endoscopy over Lichtenstein include lower incidence of wound infection, hematoma, and chronic pain/numbness, with earlier return to normal activities or work [24].

Systematic review by Kuhry in 2007 [25] comparing open mesh and suture repair versus endoscopic TEP also showed a shorter hospital stay in 6/11 trials.

Sevonius et al. [23] report in 2011 significantly lower risk of reoperation after TAP/TEPP or open preperitoneal repair in men $P < 0.001$.

Aasvang et al. [26] presented in 2010 a study of predictive risk factors for persistent postherniotomy pain. There was about 50% less risk of persistent pain after the laparoscopic repair and with a lower intensity than after Lichtenstein repair.

To appreciate all the possible advantages of LE repair requires strict adherence to standardized TAPP or TEP techniques, delicate tissue handling, and sufficient operative experience [12, 13].

5.2.5 Complicated (Complex?) Groin Hernia

Unlike the LE repair in uncomplicated primary hernia, there are several conditions which require extensive expertise in corresponding technique. Scrotal hernias, incarcerated/strangulated hernias, recurrence after open repair using plugs or 3D devices, recurrence after TAPP or TEP, and groin hernias after radical prostatectomy are not the recommended indications for LE repair. Quite often feasible in very experienced hands but always a good reason to rethink one's own abilities and "in dubio pro reo" (open repair might not be ideal but safer).

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Patient Selection for Laparoendoscopic Inguinal Hernia Repair

Mazen Iskandar and George Ferzli

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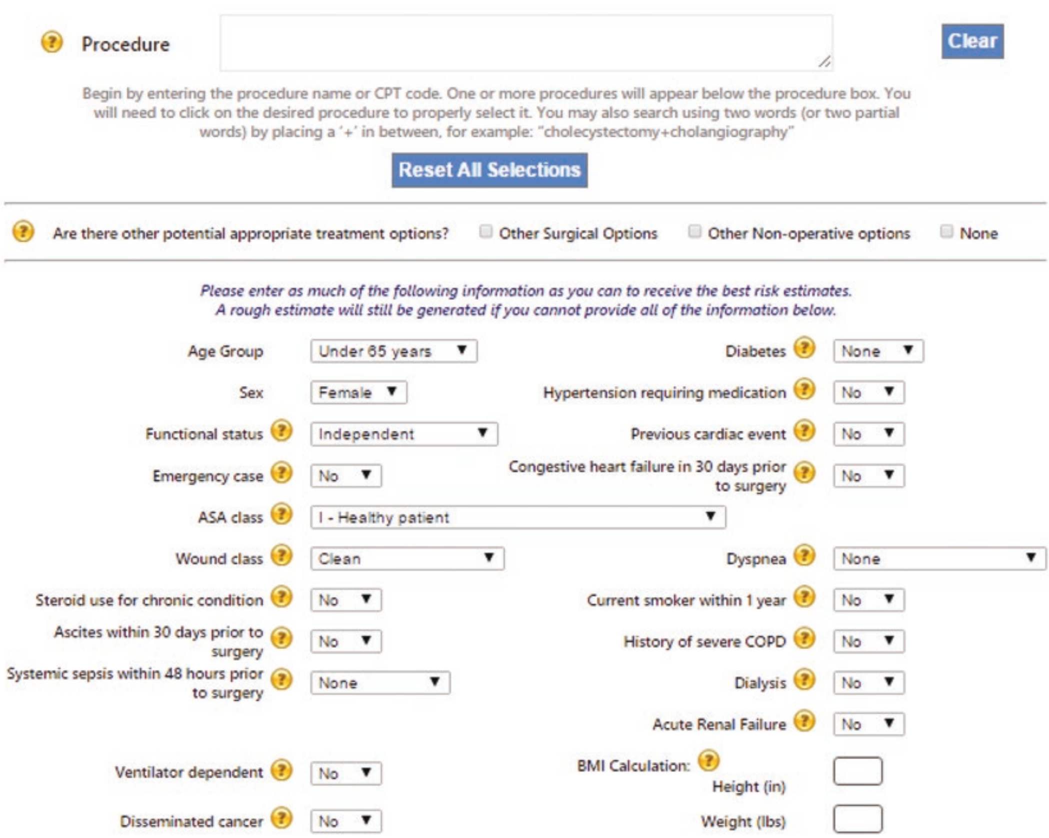
6.1 Introduction

When evaluating a patient with an inguinal hernia and considering a laparoscopic or endoscopic approach, several factors need to be accounted for. A tailored approach that takes into consideration patient-related, anesthesia-related, and surgeon-related factors offers the best outcome and reduces complications and recurrences. Experience not only helps in the operating room but is as important in patient selection and choice of operation. Proper patient selection would require a panoramic view of the patient as a whole and not just focusing on the hernia type or whether it's primary or recurrent.

The discussion on indications for laparoscopic inguinal hernia repair should commence by answering the question whether inguinal hernias need to be fixed in the first place. There is no controversy over the fact that all symptomatic hernias and hernias in women must be fixed to prevent hernia-related complications. The concept of watchful waiting in asymptomatic men with long-term follow-up (up to 11.5 years) was studied by Fitzgibbons in a large randomized trial that reported initially a low incidence of hernia-related complications but with the majority of patients (60–70%) crossing over to the surgical arm mostly due to pain [1, 2]. Therefore, watchful waiting is reasonable in asymptomatic patients that are aware to seek help when their hernias become symptomatic.

6.2 Patient-Related Factors

1. Risk stratification
   According to the AHA/ACC guidelines, perioperative risk for major adverse cardiac event (MACE) can be best predicted by using the NSQIP online risk calculator or the Revised Cardiac Risk Index incorporating the surgical risk (◘ Fig. 6.1 and ◘ Table 6.1) [3]. The NSQIP calculator may be a better tool because



◘ **Fig. 6.1** ACS NSQIP risk calculator

Table 6.1 Revised cardiac risk index

SIX independent predictors, 1999		
Clinical variable		*Points*
High-risk surgery		1
H/o Ischemic heart disease		1
H/o Congestive heart failure		1
H/o cerebrovascular disease		1
Insulin treatment for diabetes mellitus		1
Pre-operative serum creatinine levels >2.0 mg/dl (180 mcgmol/L)		1
Interpretation of risk score		
Risk class	Points	Risks of complications (%)
I. Very low	0	0.4 %
II. Low	1	0.9 %
III. Moderate	2	7.0 %
IV. High	3+	11.0 %

it also estimated noncardiac complications that need to be discussed with patients preoperatively. TEP, for example, would fall under the low-risk group because it is extraperitoneal and involves low-pressure insufflation and subsequently less hemodynamic changes attributed to pneumoperitoneum.

2. Comorbidities and modifiable risk factors
   The patient's medical history is one of the basic factors in hernia management. Conditions such as chronic obstructive pulmonary disease (COPD), diabetes mellitus (DM), and prostatism not only increase the risk of primary hernia formation but also of recurrences [4, 5]. Every effort to control or correct these conditions must be attempted prior to surgery. One cannot overemphasize the importance of weight loss in the morbidly obese patient and smoking cessation in the smoking patient [6]. Such modifiable risk factors and lifestyle changes also lead to improved short- and long-term outcomes. Care must also be taken to offer screening colonoscopy as indicated especially in patients with large inguinoscrotal hernias. Other rare conditions such as connective tissue and collagen disorders must be taken into consideration.
3. Patients on anticoagulation/antiplatelet therapy
   Each patient should be evaluated on an individual basis, taking into account their form of anticoagulation, duration of therapy, risk factors, and other comorbidities (Table 6.2). For example, a patient on antiplatelet therapy for a recently deployed drug-eluting stent is different from the patient on the same therapy for a bare metal stent. The patient on warfarin therapy for chronic atrial fibrillation is approached differently than the patient that needs anticoagulation for a metallic mitral valve. Involving the patient and their treating physicians in the decision-making process would help mitigate risk and stress associated with such cases.
4. Patients with previous lower abdominal surgery
   Lower abdominal incisions present a challenge for TEP or TAPP but are not a contraindication. The challenge arises from the presence of scarring and adhesions leading to distorted anatomy and potentially inadequate dissection, mesh placement, and increased risk of recurrence. Special attention is given to the patient with history of radical prostactomy and radiation therapy as these patients are notorious for developing intense preperitoneal fibrosis [7]. An anterior, conventional approach may be the safer approach in these patients avoiding dissection of the preperitoneal space. (For more details, please refer to ► Sect. 14.12.)
5. Patients with peritoneal dialysis catheters
   Patients undergoing peritoneal dialysis are prone to hernia formation and hernia recurrence after repair due to several factors such as increased intra-abdominal pressure, uremia, and anemia [8]. Moreover, the dialysate can extravasate along Scarpa's fascia into the scrotum mimicking a hernia. It is important to differentiate between a true hernia or dialysate extravasation with imaging as physical exam can be misleading.
6. Patients with liver cirrhosis and ascites
   Inguinal hernia repair can be safely performed in patients with Child-Turcotte-Pugh classes A and B even in the presence of ascites. For class C, there may be an increased risk of com-

Table 6.2 Overview of the indications, properties, and reversal of common anticoagulant and antiplatelet agents

Drug	Mechanism of action	Indications	Reversal	$t_{1/2}$
Heparin (UPH)	Activates antithrombin III which inactivates thrombin (IIa) and factors IXa and Xa Monitor aPTT	DVT prophylaxis, PE, VTE, ACS, DIC, angioplasty, CABG, dialysis	Protamine sulfate	Dose dependent 1.5 h
LMWH – enoxaparin (Lovenox)	Inactivates factor Xa	DVT prophylaxis, PE, VTE, ACS, orthopedic procedures	Partial with protamine	4–6 h
Warfarin (Coumadin)	Vitamin K antagonist Prevents activation of prothrombin and factors VII, IX, and X and proteins C and S by blocking the γ carboxylation of their glutamate residues Monitor INR	Prevent VTE progression and recurrence Mechanical prosthetic heart valves, atrial fibrillation 2° prevention TIA and MI	Vitamin K_1 (PO or IV) FFP rFVIIa	Duration of action: 2–5 days
Dabigatran (Pradaxa)	Direct thrombin inhibitor Liver metabolism to active metabolite Renal excretion Reduced risk of stroke	Atrial fibrillation of non-valvular origin	2/3 dialysis	12–17 h
Rivaroxaban (Xarelto)	Direct factor Xa inhibitor Liver metabolism no active metabolite 2/3 renal and 1/3 fecal excretion Reduced risk of stroke	VTE prophylaxis Orthopedic procedures Atrial fibrillation of non-valvular origin	None	7–11 h
Clopidogrel (Plavix)	Irreversible blockade of platelet $P2Y_{12}$ receptors, which prevents ADP-stimulated activation of the $GP_{IIb/IIIa}$ receptor preventing platelet aggregation	ACS 2° prevention stroke and MI Post angioplasty with stenting	Platelets	Effect 7–10 days
Aspirin	Irreversible inhibition by acetylation of cyclooxygenase, which is required by platelets to synthesize TX_{A2} which promotes aggregation and vasoconstriction Inhibits synthesis of prostacyclin	Primary and secondary prophylaxis of MI and stroke	None	Effect 7–10 days

Recommendations: Each patient should be evaluated on an individual basis, taking into account their form of anticoagulation, duration of therapy, risk factors, and other comorbidities

plications, and that should be outweighed by the presence of symptoms for hernia repair [9, 10]. Surgical repair in the elective setting avoids the high morbidity and mortality associated with repair in the case of bowel strangulation in this delicate and fragile population. An open anterior or endoscopic preperitoneal repair in experienced hands avoids entry into the abdominal cavity and wound complications associated with ascites.

6.3 Hernia-Related Factors

Classic indications for laparoscopic inguinal hernia repair focus more on the type of the inguinal hernia. Laparoscopic hernia repair has been reported in almost every possible scenario and is mainly dependent on the surgeon's comfort level and mastery of the technique. However, in certain scenarios, either the laparoscopic or the open approach is clearly favored. Namely, the laparoscopic approach has been advocated for recurrent inguinal hernias after an anterior approach, bilateral inguinal hernias, femoral hernias, hernias in women, and hernias in young men wanting a rapid return to their physical activities with high level evidence (see ► Chap. 11 for more details). The open approach has been favored for primary inguinal hernias in elderly patients, large inguino-scrotal hernias, prior pelvic surgery, and incarcerated and strangulated inguinal hernias. Other relative contraindications for an endoscopic or laparoscopic repair include previous laparoscopic repair and prior groin irradiation [11, 12].

6.4 Surgeon-Related Factors

A recurring theme in most laparoscopic hernia repairs is that of the learning curve associated with this technique. It is understood that proficiency of a surgeon and his/her ability to deal with complex hernias are proportional to the number of cases performed. The number of cases needed to achieve technical proficiency varies among different studies and can be as low as 30 or as high as 250 cases [13]. It is difficult to establish a golden number where proficiency is reached as different surgeons possess different abilities. However, not only the number of repairs performed is important for gaining proficiency but also at what place and in what quality was the training process. A well-standardized technique and a strict supervision are indispensable preconditions for proper learning best taking place in a recognized hernia center. It has been suggested that the learning curve can be overcome by mastery of the open preperitoneal repair, by the use of simulators, or by mentorship from an experienced surgeon [14, 15]. Once proficiency is achieved using a certain approach, the outcomes will be optimal independent of the technique selected. As an example, if a surgeon is proficient in the open anterior technique for a recurrent inguinal hernia and not as much in laparoscopic, it is best to perform an open approach or refer the patient to a high volume laparoscopic surgeon.

6.5 Anesthesia-Related Factors

The choice of anesthesia impacts short- and long-term outcomes in inguinal hernia surgery. Compared to local anesthesia, the use of general anesthesia is associated with increased short-term complications such as bleeding, pain, and urinary retention, whereas the use of general anesthesia in the long term is associated with a decreased rate of recurrence [16, 17]. Regional anesthesia falls in between in terms of incidence of short- and long-term complications. Therefore, when evaluating a patient and considering them for a certain approach, the short-term and long-term risks should be weighed against the patient's operative risk and life expectancy. It is important to note here that TEP, like the open approach, can be performed under a transverse abdominis plane (TAP) block or under regional anesthesia such as epidural, while TAPP requires muscle relaxation and general anesthesia to establish pneumoperitoneum [18].

6.6 Conclusion

In summary, not every patient with the same inguinal hernia needs to be treated the same way. Every patient is best served with an operation that his/her surgeon is comfortable with and that accommodates all the other patient and anesthesia factors discussed in this chapter. Experience will not only improve the surgeon's technical proficiency but also their ability to select the appropriate procedure for every individual.

Evidence [11, 12, 19, 20]

6.7 Indications for Treatment

Level 1B

Watchful waiting is an acceptable option for men with minimally symptomatic or asymptomatic inguinal hernias.

Recommendations

- **Grade A**: It is recommended in minimally symptomatic or asymptomatic inguinal hernia in men to consider a watchful waiting strategy; however, the patient should be informed that in the long run, in 60–70% of the patients, an operation becomes necessary.
- **Grade A (upgraded by the authors)**: It is recommended that strangulated hernias are operated on urgently. It is recommended that symptomatic inguinal hernias are treated surgically.

6.8 Risk Factors and Prevention

Level 3

Smokers, patients with positive family hernia history, patent processus vaginalis, and collagen disease; and patients with an abdominal aortic aneurysm, after an appendectomy and prostatectomy, with ascites, on peritoneal dialysis, after long-term heavy work or with COPD have an increased risk of inguinal hernia. This is not proven with respect to (occasional) lifting, constipation, and prostatism.

Recommendations

- **Grade C**: Smoking cessation is the only sensible advice that can be given with respect to preventing the development of an inguinal hernia.

Statement (Surgeon-Related Factors)

- **Level 2C**: For endoscopic techniques, adequate patient selection and training might minimize the risks for infrequent but serious complications in the learning curve. There does not seem to be a negative effect on outcome when operated by a resident versus an attending surgeon. Specialist centers seem to perform better than general surgical units, especially for endoscopic repairs.

Recommendations (Hernia-Related Factors)

- **Grade A**: The open Lichtenstein and endoscopic inguinal hernia techniques are recommended as the best evidence-based options for the repair of a primary unilateral hernia, providing the surgeon is sufficiently experienced in the specific procedure. For the repair of recurrent hernias after conventional open repair, endoscopic inguinal hernia techniques are recommended. When only considering chronic pain, endoscopic surgery is superior to open mesh.

  It is recommended that an endoscopic technique is considered if a quick postoperative recovery is particularly important. It is recommended that, from a hospital perspective, an open mesh procedure is used for the treatment of inguinal hernia. From a socioeconomic perspective, an endoscopic procedure is proposed for the active working population, especially for bilateral hernias.
- **Grade D**: For large scrotal (irreducible) inguinal hernias, after major lower abdominal surgery, and when no general anesthesia is possible, the Lichtenstein repair is the preferred surgical technique. In endoscopic repair, a mesh of at least 10 × 15 cm should be considered. It is recommended that an anterior approach is used in the case of a recurrent inguinal hernia which was treated with a posterior approach. In female patients, the existence of a femoral hernia should be excluded in all cases of a hernia in the groin

  A preperitoneal (endoscopic) approach should be considered in female hernia repair. All surgeons graduating as general surgeons should have a profound knowledge of the anterior and posterior preperitoneal anatomy of the inguinal region. Complex inguinal hernia surgery (multiple recurrences, chronic pain, mesh infection) should be performed by a hernia specialist.

6.9 Anesthesia-Related Factors

Statements

- **Level 4**: TEP is more suitable for regional anesthesia.

Recommendations

- **Grade D**: In selected patients having a contraindication for general anesthesia; TEP under regional anesthesia can be done.

6.10 Inguinal Hernia in Women

Statement

- **Level 2C**: Women have a higher risk of recurrence (inguinal or femoral) than men following an open inguinal hernia operation due to a higher occurrence of femoral hernias.

Recommendations

- **Grade D:** In female patients, the existence of a femoral hernia should be excluded in all cases of a hernia in the groin. A laparo-endoscopic approach should be considered in female hernia repair because a better evaluation of the femoral canal is possible.

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Watchful Waiting as a Treatment Strategy in Patients with Asymptomatic Inguinal Hernia

Brian Biggerstaff, Shreya Shetty, and Robert J. Fitzgibbons, Jr.

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7.1 Introduction

An inguinal hernia is one of the most commonly encountered conditions seen by a general surgeon, with more than 20 million inguinal herniorrhaphies performed worldwide annually [1]. The lifetime risk of an inguinal hernia is 27% in men and 3% in women [2]. Approximately one-third of inguinal hernias are asymptomatic or minimally symptomatic at the time of their discovery [3].

With such a prevalent disease, it is important to develop a treatment strategy that is both in the patient's best interest and medically cost-effective. While the decision to repair symptomatic hernias is obvious, it is less clear how to best manage the subgroup of patients with asymptomatic or minimally symptomatic inguinal hernias. Historically, surgeons have been taught that all inguinal hernias regardless of symptoms should be repaired at the time of diagnosis. The main reason for this recommendation was the perceived risk of a hernia accident, defined as strangulation and/or incarceration with bowel obstruction. Furthermore, repair in the emergent setting was felt to result in increased morbidity and mortality. Indeed pooled analysis of older mostly retrospective studies of both symptomatic and asymptomatic patients has revealed a fourfold increased morbidity and tenfold increased mortality for emergent surgery for hernia accidents when compared to elective herniorrhaphy [4]. These older studies were the basis for the recommendation by some authorities that elective repair of inguinal hernias should be undertaken soon after the diagnosis to minimize the risk of adverse outcomes [5]. This concept has been challenged in recent years for patients with asymptomatic or minimally symptomatic hernias. Two landmark studies performed in the last decade have shed new light on the natural history of untreated, asymptomatic, or minimally symptomatic inguinal hernias [6, 7]. Current recommendations for treating this subgroup of patients are the focus of this chapter.

Over the past 15–20 years, much progress has been made in understanding the natural history of asymptomatic inguinal hernias. While historically it was assumed that the incidence of hernia accident was frequent enough to justify surgical repair as a stand-alone indication, this had never been verified by long-term randomized controlled studies. In fact, part of the difficulty with establishing an accurate natural history was the fact that most asymptomatic inguinal hernias were repaired shortly after diagnosis, as dictated by the prevailing doctrine [8]. As a result of the two recent randomized controlled trials (RCTs) which will be discussed in detail later, we now know the actual rate of a hernia accident in asymptomatic or minimally symptomatic patients is very low at approximately 2.5% over 10 years [1, 2], or 0.2% per year (0.2 per 100 person-years) [1], and should not be considered as an indication for surgical repair in and of itself [8]. Both studies went on to report long-term follow-up data, which further illuminate the clinical picture (Table 7.1).

7.2 North American Trial

This multicenter RCT performed in North America randomized 720 men to either watchful waiting (WW; i.e., observation) ($n = 364$) or standard, tension-free Lichtenstein repair ($n = 356$) [6]. Primary outcomes in this trial were pain and discomfort, as well as change in physical component score (PCS) from baseline, at 2 years follow-up. In addition, complications, patient-reported pain, functional status, activity levels, and satisfaction with care were measured as secondary outcomes. An intention-to-treat analysis of the primary outcome at 2 years showed that pain as measured by a questionnaire and discomfort as measured by change in the PCS of the SF-36 quality of life tool were not significantly different between the two study groups. Crossover from WW to repair was 23% over the 2-year period. The most common reason was development of pain and discomfort (86%). Given this high rate of crossover, an as-treated analysis was also performed. At 2 years, the percentage of patients who had pain interfering with activity was not significantly greater in the patients who had crossed over (8.6% in the crossover group vs 1.5% in the group receiving surgical repair as assigned). However these patients did experience significantly larger improvement from baseline in PCS relative to patients receiving surgical repair as assigned.

Is WW safe? One patient (0.3%) in the WW group experienced acute hernia incarceration

Table 7.1 Comparison of two randomized controlled trials looking at observation (watchful waiting) versus treatment (surgical repair) as treatment strategies for asymptomatic or minimally symptomatic inguinal hernias

Comparison of trials on watchful waiting		
	North American trial	*UK trial*
n	720	160
Follow-up	2 years	1 year
Inclusion	No pain, *including* chronically incarcerated hernias	No pain, visible bulge, *excluding* chronically incarcerated hernias
Primary outcome	Pain/discomfort interfering with daily activities and change in physical component score of the SF-36	Pain (visual analog scale), change in general health status (SF-36)
Rate of crossover	23% at 2 years	20% at 1 year; 26% at 15 months
Hernia accident in WW group	2 out of 279	1 out of 75
Long-term results		
n	254	80
Follow-up	7–11 years	6–8 years
Crossover	68% at 10 years	72% at 7.5 years
Reason for crossover	Pain	Pain

(without strangulation) within the 2-year time period. Depending upon the time of enrollment in the 2 and 1/2-year recruitment timeframe, some patients were actually followed up to 4 and 1/2 years. A second accident happened at 4 years follow-up. The patient presented with a bowel obstruction secondary to acute incarceration. It was reduced with sedation and the hernia later repaired electively with an uneventful recovery. This translates into an overall frequency of hernia accidents of 1.8/1000 patient-years. For those patients randomized to the operative group, the incidence of postoperative complications was 22.3% and included wound hematoma (6.1%), scrotal hematoma (4.5%), urinary tract infection (2.1%), wound infections (1.8%), orchitis (1.6%), seroma (1.6%), urinary retention (0.3%), and other minor complications (5.8%). There were three serious complications (0.8%), which included postoperative bradycardia, deep vein thrombosis, and post-op hypertensive emergency. Recurrence was 1.4% for the 379 patients who underwent hernia repair with variable follow-up depending upon when they were enrolled in the study or when they crossed over to surgery (maximum 4.5 years). Occurrence of postoperative, hernia-related complications was similar in patients who received repair as assigned and in WW patients who crossed over to surgery.

The findings of the initial report led the authors to conclude that WW is an acceptable option for men with minimally symptomatic inguinal hernias. The authors concluded that delaying surgical repair until symptoms increase is safe because a hernia accident with an asymptomatic or minimally symptomatic inguinal hernias is rare.

Characteristics which were associated with an increased chance of crossover in the North American study were age over 65, prostatism, and higher education level [1, 8]. In a separate, secondary analysis, the data collected from the North American trial was used to look at baseline characteristics which could predict failure of watchful waiting strategy [9]. In that analysis, the strongest predictors of crossover were pain during strenuous activity, chronic constipation, prostatism, marital status, and better general health (ASA I or II) status.

7.3 UK Trial

The other index RCT pertaining to asymptomatic inguinal hernias was performed in the United Kingdom by O'Dwyer et al. [7]. The investigators in this study randomized 160 men, age 55 and over, to observation ($n = 80$), or tension-free mesh repair ($n = 80$), with primary outcome of pain and general health status as measured by the SF-36 at 1 year. Results at 1 year showed no significant difference in pain at rest (28% observation group versus 30% repair; $P = 0.86$) or with movement (39% vs 30%, respectively; $P = 0.31$) between the two treatment groups. There was also no significant difference in any of the eight dimensions of the SF-36 (physical functioning, bodily pain, role limitations owing to physical or emotional problems, general mental health, social functioning, energy/fatigue, and general health perceptions). There was, however, a reported improvement in overall health among those patients whose hernias were repaired as measured by the overall change in health status from baseline as measured by the SF-36. The rate of patients crossing over from the observation group to surgical treatment in this study was higher than anticipated, with 20% at 12 months and 26% at 15 months, with the most common reason for crossover being pain, followed by increase in hernia size.

Factors identified in the UK analysis found protrusion of the hernia of 1 cm or more to be the only significant predictor of crossover [7]. On the other hand, patients that were more likely to remain in the WW group were younger and more likely to have chronic cough and alcohol intake at baseline [8].

The initial reports from both the North American and UK RTCs were similar in that there was not a significant difference in pain between WW and surgery groups. Both groups noted relatively high crossover from WW to surgery, with the most common reason being pain. Both groups analyzed data as intention-to-treat, so it may be worth noting that those in WW who crossed over due to pain, and whose pain subsequently improved due to hernia repair, were still analyzed within the WW group. Indeed in the as-treated analysis, patients who crossed over to surgery because of symptoms had a significant improvement in the overall PCS scores from baseline when compared to patients operated upon as assigned. Both the UK and North American investigators went on to report long-term follow-up data on their respective study populations.

7.4 Long-Term Follow-Up

The results from the *Fitzgibbons* et al. trial were updated in 2013. Using Kaplan-Meier analysis, the predicted crossover rate was 68% at 10 years. On subgroup analysis, the crossover rate was found to be even higher for those men aged 65 or older (79%). The most common reason for crossover was pain, either as the sole reason (54.1%) or in combination with other symptoms (30.9%). Three (2.4%) patients required an emergency operation for hernia accident, but there were no deaths as a result of these. The incidence of hernia accident was 0.2 per 100 person-years for the whole cohort (0.56 per 100 person-years for patients younger than 65 years and 0.11 per 100 person-years for patients older than 65).

The authors of this study concluded that men presenting to their physician with asymptomatic inguinal hernias be counseled that although WW is a reasonable and safe strategy, symptoms will likely progress and an operation will be needed eventually.

O'Dwyer et al. followed their UK population to a median of 7.5 years. The estimated rate of conversion from observation to surgical repair at 7.5 years was 72%. Again, the main reason for conversion was pain. Two patients (2.5%) presented with acute hernia accident—a finding similar to the 2.4% rate observed by the North American study. Three had recurrent hernias. The authors concluded that most patients with painless inguinal hernia go on to develop symptoms over time. The authors went on to recommend surgical repair for medically fit patients with a painless inguinal hernia, based on the high likelihood of future need for surgery due to development of symptoms.

A cost-effectiveness study based on the data from the original North American RCT was performed [10]. This is important because even a small savings per patient adds up because of the high volumes. By 2 years, the average cost for tension-free repair (TFR) patients was approximately $1800 higher than for WW group. When looked at in terms of quality-adjusted life-years (QALY), the average cost per additional QALY unit per patient for TFR patients was $59,065. It is generally agreed that in order for a procedure to qualify for public funding, a cost per QALY should be $50,000 or greater. The authors concluded that at 2 years, both surgery and WW are reasonable treatment approaches for asymptomatic inguinal hernias from a cost-effectiveness standpoint.

Of significance, this cost analysis was done at 2 years follow-up, by which time 23% of the WW patients had decided to cross over to receive surgery for various reasons, mostly pain. By 10 years of observation, however, this number approaches 75%. As such, the conclusion/results cannot be considered valid at 10 years. While the initial data are insightful, additional work must be done to evaluate a more long-term cost analysis. Currently, there are insufficient data to say whether watchful waiting or surgical management strategies are more cost-effective.

The data presented in this chapter should be used by physicians and patients to make informed decisions about the care for their inguinal hernias. Certainly patients should have the right to choose to have their hernias repaired whether symptomatic or asymptomatic. A word of caution must be made about these data being used by insurance companies and governmental organizations to set policy regarding appropriate care. As an example based on the findings from both initial RCTs, a blanket policy of watchful waiting for asymptomatic inguinal hernias was implemented by the Birmingham and Solihull NHS primary care trust cluster in the UK in 2010 [11]. This trust serves a large population of over one million people. A prospectively managed database was queried retrospectively to compare the 16 months prior to implementation to the 16 months after. The proportion of emergency surgery for acute hernia presentation was significantly higher after implementation of the watchful waiting policy, with 59% relative increase (3.6% vs 5.5%). Emergency repair was associated with higher morbidity (4.7% vs 18.5%) and mortality (0.1% vs 5.4%).

Finally chronic groin pain has emerged as the most significant problem facing inguinal hernia surgeons now that the recurrence rate has been reduced so dramatically. Chronic post herniorrhaphy groin pain (defined as groin pain occurring at 3 months and beyond) has an incidence ranging from 11–50% [12, 13]. This incidence is higher than originally thought and can significantly affect patient health-related quality of life [14]. The rate of chronic groin pain that adversely affects activities of daily living and/or employment is estimated to be 0.5–6.0% [15]. Of course, avoiding surgery eliminates this possibility.

7.5 Summary

The past two decades have been very productive in terms of understanding the natural history of asymptomatic inguinal hernias. Additionally, we have further increased our understanding of operative morbidity and mortality, recurrence rates, and incidence of acute and chronic pain syndromes associated with inguinal hernia repair.

This increased understanding allows for improved counseling of patients about treatment options. At this point, a one-size-fits-all recommendation for asymptomatic inguinal hernias cannot be made. Rather, treatment options should be individualized for each patient taking into consideration all pertinent factors discussed in this chapter (■ Table 7.2). Ultimately, both operative and nonoperative strategies are acceptable options based on current literature.

Watchful waiting has been proven to be a safe option because the rates of incarceration and strangulation are low. However patients need to be counseled that there is a high probability (approaching 75% at 10 years) that they will develop symptoms in the future necessitating surgery and that there appears to be subjective feeling of improved well-being among those who undergo hernia repair. On the other hand, the risk of chronic pain syndromes after a herniorrhaphy is not insignificant and should also be taken into consideration.

Rejoinder to Watchful Waiting

Pradeep Chowbey, Reinhard Bittner

The term "asymptomatic hernia" is a misnomer. The primary symptom of hernia is appearance of a lump [16]. Pain, discomfort, and other symptoms are additional symptoms that may develop as the course progresses [2]. It follows that appearance of lump constitutes a symptomatic hernia.

The natural progression of hernia is a gradual increase in size over time due to the exacerbating

Table 7.2 Factors which should be addressed with patients when counseling about watchful waiting as a treatment strategy for asymptomatic or minimally symptomatic inguinal hernia. Figures based on data from North American randomized controlled trial on watchful waiting vs repair of inguinal hernia in minimally symptomatic men

Patient counseling considerations for asymptomatic inguinal hernia	
1. Overall incidence of minor complications for elective repair:	22%
(a) Wound hematoma	6.1%
(b) Scrotal hematoma	4.5%
(c) Urinary tract infection	2.1%
(d) Wound infection	1.8%
(e) Orchitis	1.6%
(f) Seroma	1.6%
(g) Urinary retention	0.3%
(h) Other minor complications	5.8%
2. Serious complications of elective repair	0.8%
3. Mortality rate of elective herniorrhaphy	Approaches 0%
4. Incidence of activity-limiting, chronic post herniorrhaphy groin pain (at 4 years)	1.3%
5. Recurrence rate (at 2 years)	1.4%
6. Incidence of hernia accident	2.4% over 10 years
7. Mortality for emergent surgery (0/3 patients)	Approaches 0%
8. Rate of crossover from WW to surgery over 10 years	68%
(a) Age < 65	61%
(b) Age > 65	79%
9. Factors increasing chance of crossover to surgery:	
(a) Pain during strenuous activity	
(b) Chronic constipation	
(c) Prostatism	
(d) Lower baseline score on ambulatory component of AAS score/ ASA 1	

effects of factors that precipitated the hernia. It appears logical to assume that symptoms from hernia correspondingly increase with time as the hernial defect gradually enlarges with time [17]. This has been demonstrated as significant crossover rates (patients crossing over from watchful waiting to surgery) of 68% at 10 years and 70% at 7.5 years in the North American and UK trial, respectively [1]. In the context of clinical management, prudent advice may be to offer surgery at the appearance of the first symptom (onset of hernia) rather than wait for additional symptoms or symptoms to get worse. Crossover patients were also demonstrated to have significantly greater improvement in physical component scores (PCS) as compared to patients assigned to surgical care group.

The recurrence rates after surgery for larger hernias are greater [18], which is another strong reason to advocate early repair. Moreover, patients who are fit to undergo surgery at the time of detection of hernia may acquire medical conditions and comorbidities that renders them at greater risk for surgery a few years later. The inevitable increase in hernia symptoms and eventual need for surgery renders a policy of "watchful waiting" to be untenable.

The experience from Birmingham and Solihull NHS primary care trust where a blanket policy of watchful waiting for "asymptomatic" hernias was implemented is significant. The proportion of emergency surgery for acute hernia presentation was significantly higher after implementation of the watchful waiting policy, with 59% relative increase (3.6% vs 5.5%). Emergency repair was associated with higher morbidity (4.7% vs 18.5%) and mortality (0.1% vs 5.4%). It needs to be appreciated that these are figures from western urban centers where medical supervision is readily available and emergency access to tertiary care facilities is quick and easy. It is likely that morbidity and mortality rates for acute hernia incarceration (hernia accident) would be much higher in many other parts of the world.

In fact, access to surgical opinion and treatment may be difficult and rare in many parts of the world today. Also, large populations in different region may not be educated or aware enough to realize implications to be able to participate completely in surgical decision making. In these circumstances, a policy of "watchful waiting" may not only be impractical but also dangerous.

Patients should indeed have the right to choose to have their hernias repaired even the so-called asymptomatic. However, the advice of the surgeon needs to be consistent with the natural evolution of hernia as also the available evidence. As always, surgical advice and opinion has to be preferred in the best interests of the patient with the unique status, condition, and circumstances of that individual patient foremost. There is a strong case for surgical advice for early intervention (not watchful waiting) in a patient in whom surgical repair of hernia is not otherwise contradicted.

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Perioperative Management of Laparoscopic Inguinal Hernia Repair

Henning Niebuhr, Bernd Stechemesser, and Reinhard Bittner

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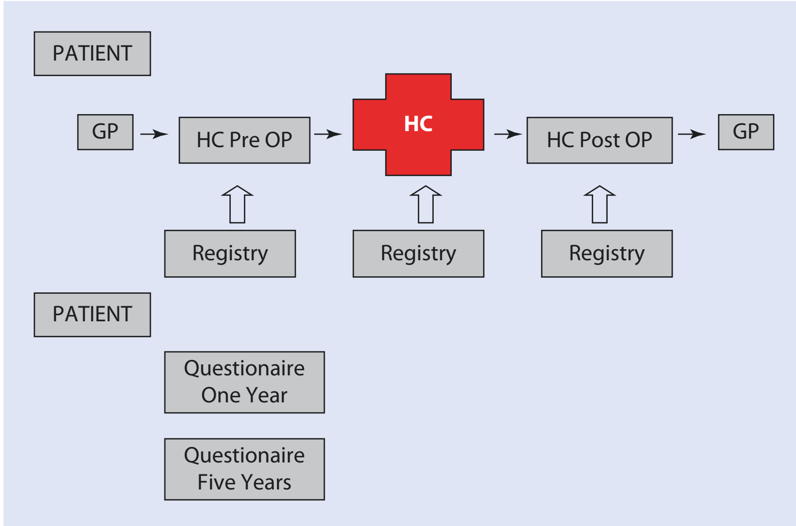

Fig. 8.1 Patient´s work flow

8.1 Surgical Consultation at Hernia Center (Pre-op)

A patient with inguinal complaints will visit his general practitioner (GP) at first. The GP will ask for the history and will undertake a clinical examination. Dependent on the results, the patient should be referred first to a specialized surgeon/hernia center Fig. 8.1.

8.1.1 Surgical Case History and Clinical Examination

The clinical examination includes the surgical case history and the general as well as the local examination of the patient.

The following systemic diseases should be excluded or further examined Table 8.1.

For the local examination, the following differential diagnoses must be considered:

Local examination:

- Lymph adenopathy/adenitis
- Lymphadenosis (Hodgkin disease, AIDS)
- Lymph node metastasis
- Lipoma
- Inguinal strain trauma
- Adductor tendinitis
- Rectus muscle tendinitis
- Abscess/pus collection
- Aneurysm of femoral artery
- Varicosis of the saphenous vein
- Endometriosis
- Round ligament varicosis in pregnant women
- Neurological disease: GFS, IIS, IHS
- Testicle disease, e.g., atrophy, hydrocele, tumor, varicocele
- Epididymis disease

Table 8.1 General examination

Cardial disease	(Right) Heart insufficiency
Pulmonal diseases	Bronchitis, emphysema
Hepatic diseases	Ascites, portal hypertension
Metabolic disease	Diabetes, thyroid dysfunction
Vascular disease	Aneurysm of the aorta, PAOD (peripheral arterial obstructive disease)
Arthrotic disease	Coxarthrosis, disc prolapse
Neoplastic disease	Peritoneal carcinosis - > symptomatic hernia, pelvis bone metastasis
Urological disease	Prostatic hyperplasia, concrements, varicocele, hydrocele
Intestinal disease	Obstipation, colonic neoplasia

For further differentiation between inguinal lump/swelling and/or inguinal pain, the following two tables, Tables 8.2 and 8.3, should be regarded and followed.

Table 8.2 Differential diagnosis of groin swellings

Inguinal	Inguinoscrotal	Femoral	Inguinofem.	Scrotal
Inguinal hernia	Inguinal hernia	Femoral hernia	Inguinal lymph nodes	*Skin*: boils sebaceous cysts papillomas, warts
Lymph nodes	*Hydrocele*: encysted hydrocele of the cord infantile hydrocele of the hernial sac	Lymph nodes	Distended psoas bursa	*Subcut. tissue*: lymph scrotum filariasis *Tunica vaginalis*: hydrocele, pyocele, hematocele, chylocele
Encysted hydrocele of the cord	*Spermatic cord*: varicocele, funiculitis lymph varix diffuse lipoma of the cord hematoma of the cord	Saphena varix	Effusion in the hip joint	*Testis:* orchitis (acute/chronic)neoplasms
Testis: undescended testis	*Testis*: undescended ectopic testis	Ectopic testis		*Epididymis*: cysts acute or chronic infections
In female or pregnant women: varicosis of round ligament				*Spermatic cord:* varicocele lymph varix

The technique of clinical examination is simple: In vertical (upright) or horizontal (supine) position, the size and consistency of the hernia tumor, the width of the hernia ring, and the reducibility of the lump will be assessed initially by inspection and then by palpation with or without coughing (pressing) using the Valsalva maneuver.

The examination of the male inguinal region is performed by palpation of the inguinal canal with a via invagination of the scrotal skin in the inguinal canal inserted finger: Hereby, an incipient hernia can be felt as a small lump while the patient is coughing.

A complete hernia is defined as a bulging of the hernia sac above the level of the transversal fascia.

The differentiation of inguinal hernia in medial or lateral is clinically uncertain but widely irrelevant for the further therapeutic decision.

The clinical examination alone permits in about 80% to achieve the correct diagnosis of an inguinal hernia.

For the missing 20%, a combined approach (clinical examination and complementary technical examination) is required. The following additional techniques are in use:

- Dynamic inguinal ultrasound (DIUS)
- Dynamic MRI
- CT
- Herniography

Dynamic examination, particularly real-time imaging of the abdominal wall and its movement during Valsalva maneuvers, plays a major role in the diagnostics of the groin region. Employing these procedures is the only way to depict the penetration and the reduction of a hernia sac through the hernia orifice.

8.1.2 Dynamic Inguinal Ultrasound (DIUS)

The up-to-date procedure of undertaking a clinical examination only cannot embrace the complexity of the issue addressed. Employing imaging procedures can contribute to a better process of distinction as well as improve the detection of femoral hernias, initiating hernias and more seldom specific types of hernias (e.g., obturator hernia).

The Four Step Technique of DIUS

Step One In a vertical section above the pubic bone, the rectus muscle, the rectus sheath, the transversal fascia, and the peritoneum will be depicted.

Table 8.3 Differentiation of pain in the groin region

Orthopedics muscular/tendon	Orthopedics/traumatology osseous/cartilaginous
Gracilis	Pubic symphysis
Sartorius	Stress fractures
Adductor longus	Hip joint: arthrosis/impingement
Iliopsoas	Avulsion fractures (juvenile)
Rectus femoris	Epiphysiolysis capitis femoris
Quadratus lumborum	Perthes disease
Hernia surgery soft tissue	*Neurology/hernia surgery postoperative nerve syndromes*
Inguinal hernia	Ilioinguinal syndrome
Femoral hernia	Genitofemoral syndrome
Obturator hernia	Iliohypogastric syndrome
Sportsman's groin/hernia	
Bursitis	
Swelling of lymph nodes	
Neurology/orthopedics referred pain	*Neoplastic alterations*
Neural impingement syndrome	Hemangioma
Sacroiliitis	Fibromatosis
Blockages in the ISJ	Neurinoma
LDH	Osteoid osteoma
Urology/gynecology referred pain	Fibrosis/dysplasia
Urinary tract infection/prostatitis/epididymitis	Bone cysts
Torsion of the testis	*Angiology/vascular surgery varia*
Endometriosis/ovarian cyst/round ligament varicosities [10/12]	Vascular diseases/PAOD

Step Two A slightly diagonally adjusted section displays the spermatic cord longitudinally and under Valsalva maneuver the hernia sac, respectively. In female, the round ligament is identified. Using the color duplex in this step, a varicosis of the round ligament is easily revealed in pregnant women.

Step Three In the following, the transducer will be rotated by 90° in order to receive a cross-sectional picture. At this angle, the epigastric vessels are easily identified – they contribute to the distinction of lateral/indirect and medial/direct hernia within the process of another Valsalva maneuver.

Step Four In a last step, the transducer will be moved further toward the lateral side, until reaching the femoral and iliac vessels (again performing a slightly diagonal longitudinal position). While employing the Valsalva maneuver, this position allows the display of a possible echoic protrusion (femoral herniation) beneath the inguinal ligament within the vascular lacuna and in projection to the femoral vein.

In male patients, the vertical and longitudinal examination of the testicles completes the procedure.

Results

Material and Methods

In order to find out the number of inguinal or femoral hernia diagnoses that were sonographically confirmed and to also consider the cases, in which a sonographical examination led to the detection of an inguinal or a femoral hernia, where as a clinical examination neglected this diagnosis, the ultrasound examinations of the groin area executed in a 5-year period between 2010 and 2015 were analyzed retrospectively. The results were compared to the intraoperative findings.

Material

Between July 2010 and June 2015, 4951 ultrasound examinations of the groin area were executed in the Hanse Hernia Center Hamburg.

Results and Conclusion

The results show that standardized ultrasound examinations of the groin area with high-frequency small part linear transducers also serve to display femoral and other small groin hernias accurately. The high-level specificity (0.9980) and sensitivity (known to be strongly dependent on the examiner) (0.9758) are proof of the procedure quality.

The recent international guideline (Herniasurge) is recommending the combined use of a clinical examination (CE) and DIUS:

The key question: "Which diagnostic modality is the most suitable for diagnosing patients with obscure pain or doubtful swelling?" lead to the following statement and recommendation:

Statement:	*QoE*	*Recommendation*
CE and US combined is recommended as most suitable for diagnosing patients with vague groin swelling or possible occult groin hernias. Dynamic MRI or CT can be considered for further evaluation if US is negative or non-diagnostic	+++	Strong (upgraded by Herniasurge)

Discussion

The criterion standard for hernia diagnosis is CE of the groin with a sensitivity of 0.745 and a specificity of 0.963 reported in a prospective cohort study from 1999 [119]. Three consensus guidelines have been published on groin hernia treatment [13, 92, 111]. All published statements on diagnostic work-up are weak, mainly focusing on CE alone. Only groin pain that is obscure or groin swelling of unclear origin (possible occult hernia) is noted to require further diagnostic investigation [26, 65, 70, 75]. No consensus exists presently on the best imaging modality for these diagnostic dilemmas.

CE alone can miss hernias, especially those that are small, e.g., femoral hernias in obese women and men and multiple hernias where only some of hernias are apparent with physical examination [119]. US, MRI, CT, and herniography have all been studied in various settings in an attempt to close this "diagnostic gap" [2, 3, 21, 26, 33, 39, 50, 53, 57, 58, 64, 67, 71, 77, 83, 100].

Two RCTs with a total of 510 patients showed that US is highly sensitive and a useful way to identify hernias [26, 32, 57]. Several other studies have echoed this finding [67, 70, 71, 83, 90] ◻ Figs. 8.2, 8.3, and 8.4.

If a final diagnosis is certain, a treatment concept can be provided/established.

When no final diagnosis can be achieved, further consultations and examinations should depending on the differential diagnostic assumptions be undertaken:

- Radiology - > CT MRI [11]
- Neurology
- Orthopedy
- Urology
- Gynecology

8.1.3 Treatment Plan

In case of a clear hernia diagnosis, different proposals for an individualized treatment in terms of a tailored approach should be considered. The patient must be offered a final treatment concept.

(For treatment options, see related ▶ Chap. 5.)

Concerning the schedule for treatment, three questions have to be answered: Where? When? How?

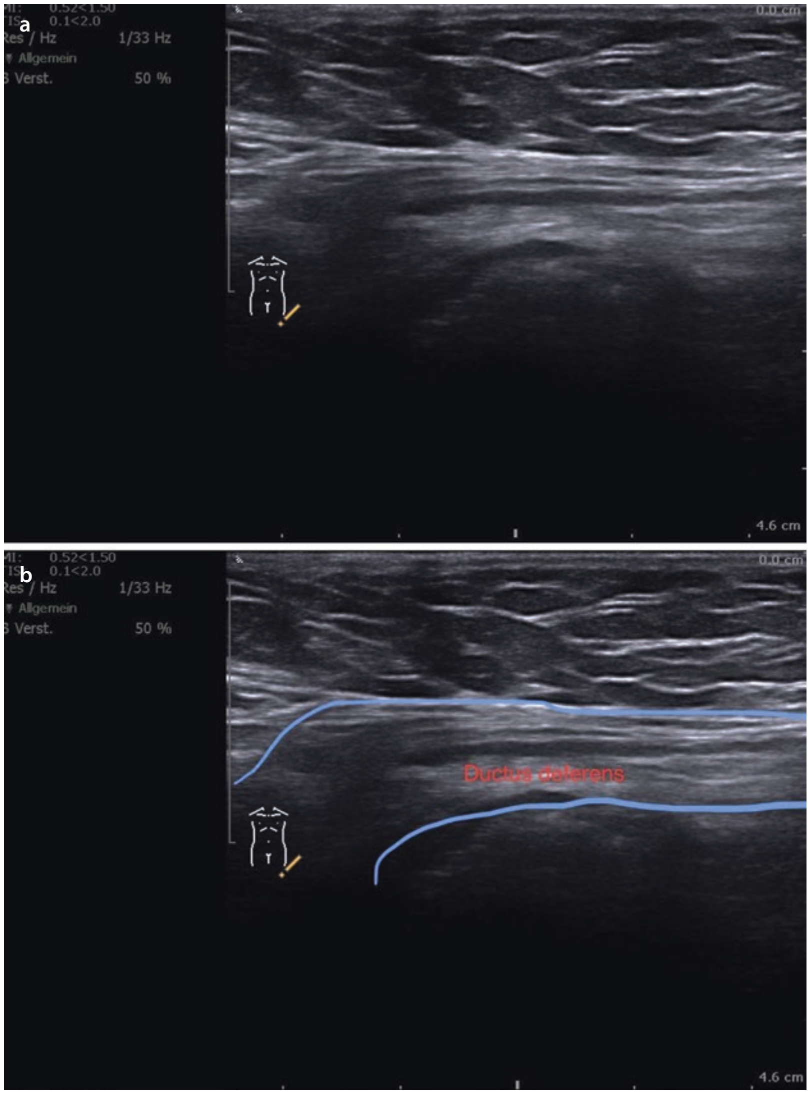

Fig. 8.2 **a** Longitudinal section (moderately diagonal transducer position) above the inguinal canal showing the spermatic cord and the surrounding tissue. **b** Longitudinal section over a medium size inguinal hernia during the Valsalva maneuver (*blue mark*)

"Where" indicates the institution when different options are possible.

"When" fixes the date of the procedure.

"How" discusses the options "day case surgery (DCS)" or "short-stay treatment (SST)."

See also ▶ Sect. 8.3 Day Care (DC) or Short-Stay Treatment (SST).

When antithrombotic medications for factor X or thrombocyte inhibition are in use, a clear plan on how to act prior to the scheduled procedure has to be handed out to the patient. This plan must be part of the informed consent. It must be clear who is responsible for the practical procedure to stop or/and bridge the drug in correct time before the operation.

See also ▶ Sect. 8.3.3 Thromboembolic Prophylaxis.

The informed consent must be discussed and signed.

An individualized standard report and a re-referral to GP consultation for blood sample and ECG findings are handed out to the patients and sent to the GP. The patient receives a folder to attach all necessary documents.

The documentation of the consultation and the data input to the registry (Herniamed) are finalizing the preoperative surgical consultation.

Then the patient is referred to the anesthesia and admission consultation.

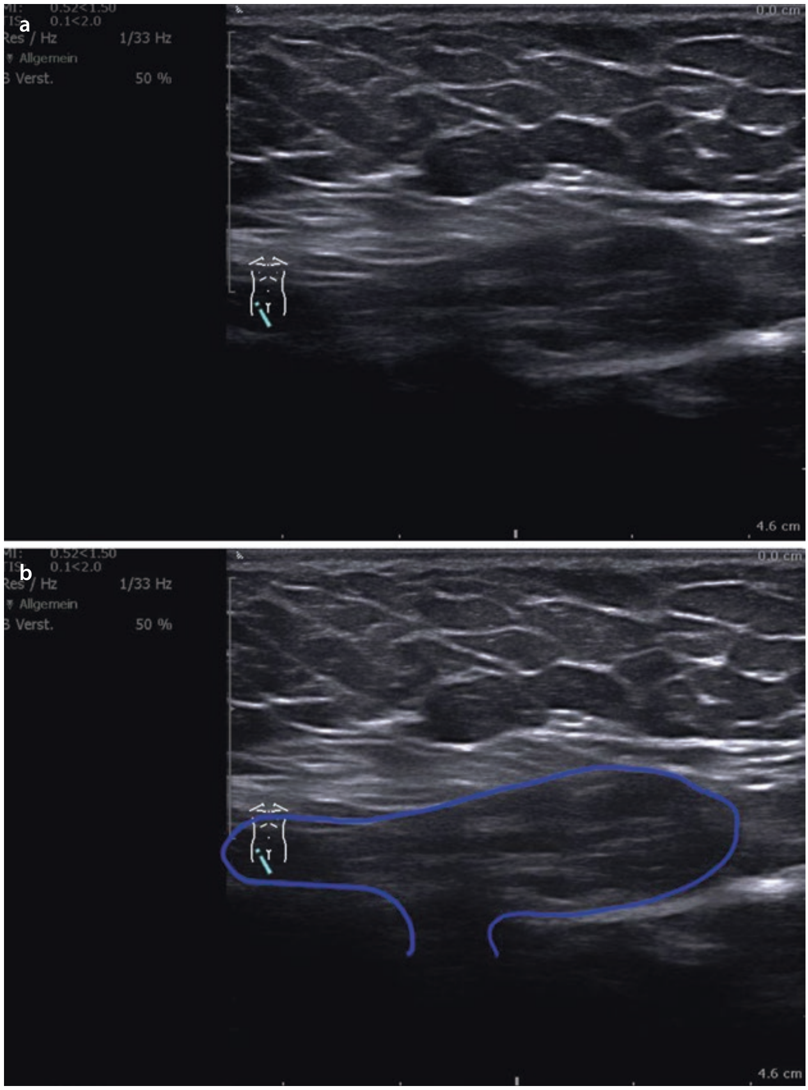

Fig. 8.3 Femoral hernia (echo density) in projection on the femoral vein (background echo-free) during the Valsalva maneuver (blue mark)

8.2 Anesthesia and Admission Consultation at Clinic

While in this consultation, the technique of anesthesia is discussed and defined/appointed.

(For anesthesia options, see related ► Chap. 46.)

The final schedule of date and time of admission and operation is arranged.

A nursery consultation including MRSA check and discharge planning is included.

See also ► Sect. 8.3.9 Discharge Management.

The informed consent must be discussed and signed.

8.3 Day Care (DC) or Short-Stay Treatment (SST)

In case of a necessary surgical repair of an inguinal hernia, the question whether the patient can be treated under day care (DC) conditions or preferably as inpatient (SST) must be considered.

Day care surgery for inguinal hernia repair has become increasingly common over the past several decades. Synonyms for "day surgery" include outpatient surgery, ambulatory surgery, same-day surgery, and day case and indicate that patient discharge occurs the day of operation. It is commonly

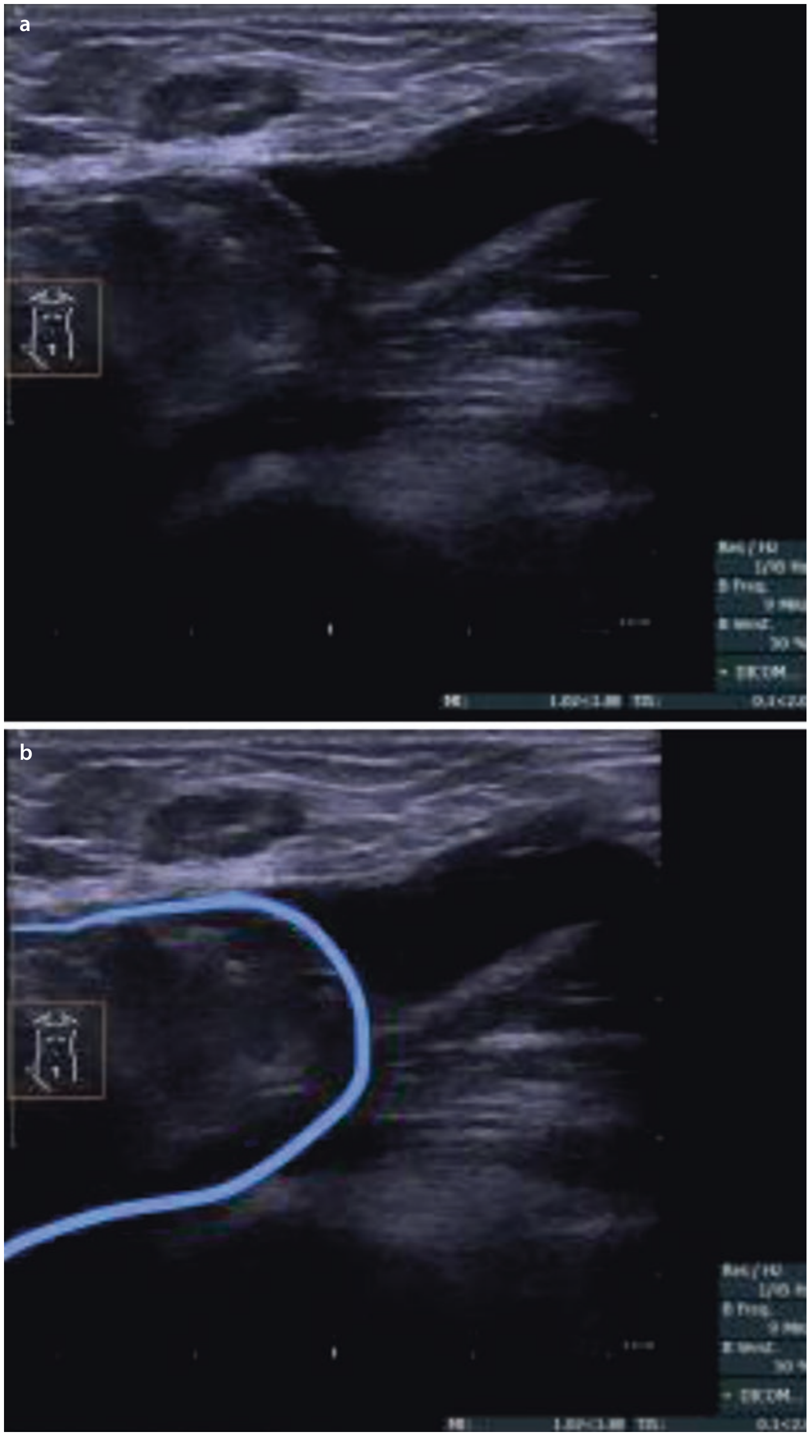

Fig. 8.4 **a**, **b** Femoral hernia (echo density) in projection on the femoral vein (background echo-free) during the Valsava maneuver (*blue mark*)

known that day surgery is safe and feasible for many inguinal hernia repairs. Several studies prove that day surgery is cost-effective when compared with inpatient treatment. However, it is unclear which complex inguinal hernias should not be repaired as day cases.

In the guidelines, "complex cases" include:

1. Groin hernias with signs of incarceration, strangulation, infection, and relevant preoperative chronic pain, difficult local findings in the groin such as large (irreducible) scrotal hernias, (multiple) recurrence(s), recurrence

with previous mesh repair, and a relevant history of lower abdominal surgery, radiation, and comparable problems
2. Groin hernias in patients with relevant comorbidities (cardiovascular/pulmonary/endocrine/immune deficiency/hepatic/renal/gastrointestinal/mental disorders/anxiety, immune deficiencies, posttransplantation status, coagulopathies, antithrombotic medications)
3. Difficult intraoperative findings (severe adhesions, abnormal anatomy, excessive bleeding) and intraoperative complications such as damage to viscera, blood vessels, nerves, and genitals
4. Symptoms and signs of postoperative local complications (bleeding, hematoma, thromboembolism, urinary retention, bowel obstruction, peritonitis, sepsis, infection, orchitis) and or general complications (cardiovascular, respiratory, renal, hepatic, gastrointestinal, cerebral organ failure, anxiety, psychic, mental distress)

The recent international guideline (Herniasurge) [14] is recommending to consider day surgery even for laparoscopic repair of simple inguinal hernias.

Discussion

Day surgery for inguinal hernia repair involves patient discharge the same day of surgery after a period of medically supervised recovery [42].

In a first publication on the subject in 1955, the advantages of outpatient inguinal hernia surgery are mentioned for the first time: faster mobilization, lower costs and positive patient acceptance [37]. Subsequently, several retrospective case series and three small randomized studies were published comparing inguinal hernia repair day surgery with inpatient treatment [43, 82, 91, 94]. Another randomized study surveyed patient preference for site (inpatient or outpatient) of surgery [97]. These studies all concluded that day surgery is cheaper than, and as safe and effective as, inpatient repair of selected inguinal hernias.

A 2006 Danish study of nearly 19,000 day surgery patients noted a 0.8% hospital readmission rate [35]. A 2012 Danish multicenter study of over 57,700 day surgeries found a 1.1% complication rate leading to hospital readmission following day surgery for inguinal hernias [76].

Although tension-free repair under local anesthetic seems most suitable for day surgery, published series support the use of other surgical and anesthetic techniques in this setting [5]. Day surgery should be considered for all simple inguinal hernia repairs (both open and endoscopic) provided adequate aftercare is organized [68, 76, 79]. However, after laparoscopic repair (TAPP/TEP) and posterior open mesh repair, severe pre-/retroperitoneal afterbleed may occur in rare circumstances. In most of the cases, this infrequent complication occurs within the first 24–48 h postoperatively. Since the laparoscopic management of large hematoma is often only possible after immediate diagnosis, short stay inpatient treatment (SST) of these patients should be considered.

There are insufficient data to routinely recommend outpatient repair of complex inguinal hernias (see above). However, if adequate aftercare is arranged, some of these cases may be suitable for ambulatory surgery. Operations on strangulated and acutely incarcerated hernias should not be performed as day cases. Barring the exclusions cited above, inguinal hernia day surgery can be considered for every patient with satisfactory care at home, including stable ASA III patients [31, 54, 78, 93, 101, 103].

A recent publication based on data of 82,911 patients with inguinal hernia operations which were documented in the German hernia registry "Herniamed" revealed that patients with prophylactic or therapeutic use of platelet aggregation inhibitors and oral anticoagulants had a significant higher risk of bleeding complications (3.9% vs. 1.1%; $p < 0.001$) compared to those patients without such a medication [61]. These data suggest that inguinal hernia day care surgery of patients under anticoagulants cannot be recommended.

A number of additional factors will either encourage or discourage day surgery. The anesthesiologist's preoperative assessment is extremely important, because he has primary responsibility for the perioperative and immediately postoperative phase [93]. Other hospital-, physician-, and patient-related factors must be considered also [42]. In a facility with considerable day surgery experience and a good infrastructure (i.e., easy availability of pre-assessment consultation and a smoothly functioning day surgery center), a large percentage of inguinal hernia repairs may take place in day surgery. Surgical factors (quick operations and few complications) and anesthetic factors (effective pain and nausea control making rapid patient discharge possible) may influence the decision to proceed with day surgery.

8.3.1 Preoperative Admission to the Clinic

Prior to the operation, the patient comes to the clinic at the scheduled date and time. Administrative procedures are passed through. Following the patient will be prepared for the operation.

8.3.2 Perioperative Antibiotics

Perioperative antibiotic prophylaxis in hernia surgery is still controversial. The aim of antibiotic prophylaxis is to reduce surgical site infections. By prophylaxis, a multiplication of pathogens that contaminate the surgical field should be prevented. This must be evaluated by the toxicity, allergic reactions, development of resistance, and higher perioperative costs. Antibiotic prophylaxis cannot replace evidence-based hygiene measures for the prevention of postoperative infections, but it can only complement [120].

Hernia operations are by definition "clean procedures" [52]. In contrast, there are also a significant number of patients associated with risk factors that may promote an increased rate of surgical site infections [1, 4].

In the literature, very heterogeneous information about postoperative rate of wound infections are given, ranging from 0% to 8.8% with antibiotic prophylaxis and from 0% to 8.9% without prophylaxis [15]. In an updated Cochrane review of 2012, a group of authors came to the conclusion that a general antibiotic prophylaxis in inguinal surgery cannot be recommended [102]. Publications that are explicitly emphasizing the difference between open and laparoscopic technology are rare. In the laparoscopic surgery, the infection rate varies from 0% to 2.8%. In the open surgery, it varies from 0.7% to 3.1% [15].

Data from the Herniamed registry study could show that only the positive influence of the endoscopic or laparoscopic technique is enough on postoperative infection rate, and an additional benefit is not reached by perioperative antibiotics. At the same time, these data show a benefit of perioperative effect of antibiotics in open inguinal hernia procedures [62].

A general antibiotic prophylaxis cannot be recommended, therefore, in endoscopic routine inguinal hernia repair [92]. Existence of additional risk factors should evaluate in each case the decision in favor of an antibiotic. Risk factors are listed in ◘ Table 8.4.

The optimal time of antibiotics, depending on the half-life of the antibiotic, should be within a period of 60 min before cutting, ideally at the time of anesthetic induction [48, 122]. A single dose of PAP is preferred [127].

In our facility, an antibiotic is introduced 30 min before incision in all open inguinal hernia.

◘ **Table 8.4** Individual risk factors mod [1]

Patients factors	Surgical skills	Intraoperative	Postoperative
Age	Emergency	Time <2 h	Revision
Diabetes mellitus	Contaminated	More than one procedure	Drainage more than 3 days
Immunodeficiency		Complication	Reoperation
Adipositas			
MRSA			
Dialysis			
Drug abuse			
ASA-Score > 3			

Table 8.5 Standards in the Hernia Center Cologne

Procedure	Generic	Single shot
TEP	–	–
TEP + Umbilicus	Cefuroxim 1.5 g	X
TEP + Risk factors	Cefuroxim 1.5 g	X
Lichtenstein	Cefuroxim 1.5 g	X
Shouldice	Cefuroxim 1.5 g	X
TIPP	Cefuroxim 1.5 g	X

The endoscopic surgery without additional risk situation such as diabetes mellitus no routine antibiotic prophylaxis is carried out.

Table 8.5 shows an overview of the standards in the Hernia Center Cologne.

Selection of the appropriate antibiotic is carried out primarily by the expected spectrum of pathogens, resulting from the normal or pathological colonization of the surgical field and its immediate cutaneous and mucosal environment. In addition, care must be taken individually for each patient on a possible antibiotic allergy [60].

Deciding which antibiotic is used depends primarily on the expected range of bacteria specific to operating region. Microbiological results of the specific region should be considered. The antibiotic should have few side effects, be little allergenic and inexpensive. For groin ampicillin is recommended with sulbactam and cephalosporins group one and two [120]. There is no advantage in multidose antibiotic prophylaxis [88].

8.3.3 Thromboembolic Prophylaxis

The annual incidence of DVT in the general population is between 0.05% and 0.1 without any surgical treatment [6]. According to the American College of Chest Physicians, the prevalence of DVT is in general surgery at 15–40% [6, 40].

Thromboembolic events in inguinal hernia repair are very rare. According to the most existing guidelines worldwide, unilateral inguinal hernia repair is a low-risk procedure [15, 40].

Despite the low risk is a prophylaxis against DVT in view of the potentially fatal risk of a pulmonary embolism useful and is done by the most surgeons [4]. These results in the need for a prophylaxis, as a thrombosis can throw just in the early stages clots in the blood stream without clinically tangible symptoms. A reliable test for determining the individual risk of thrombosis is currently not available [40]. Hence the need for a general thromboembolic prophylaxis in the repair of inguinal hernia arises, even for ambulatory surgery, although this is not explicitly required in the international guidelines.

The indication and the choice of prophylaxis should be carried out individually and risk adapted. The risk of developing a VTE is influenced by two different factors: on the one hand the risk that is caused by the exposition in the kind and duration of operation and the risk at the patient's disposition to develop a VTE on the other. A special role is played by the patient's medical history with regard to previous thromboembolism.

All data about inguinal hernia repair is counted in the group of general surgical operations. Individual studies on the risk of DVT or VTE in inguinal hernia repair are not available. A recent study showed a slower flow in the femoral vein after implantation of a mesh but with no influence on the development of thrombosis [15]. Laparoscopic procedures considering to the positioning of the patient and intra-abdominal pressure may have a higher risk for the occurrence of DVT [7, 51]. The thromboembolism must be weighed against the risk of increased bleeding tendency and thus increased postoperative complications. Patient-related risk factors are [116]:

- Active cancer or cancer treatment
- Age over 60 years
- Critical care admission
- Dehydration
- Known thrombophilias:
  - Inherited thrombophilias, for example:
    - High levels of coagulation factors (e.g., factor VIII)
    - Hyperhomocysteinemia
    - Low-activated protein C resistance (e.g., factor V disease)
    - Protein C, S, and antithrombin deficiencies
    - Prothrombin 2021A gene mutation
- Obesity (body mass index [BMI] over 30 kg/m^2)

- One or more significant medical comorbidities (e.g., heart disease; metabolic, endocrine, or respiratory pathologies; acute infectious diseases; inflammatory conditions)
- Personal history or first-degree relative with a history of VTE
- Use of hormone replacement therapy
- Use of estrogen-containing contraceptive therapy
- Varicose veins with phlebitis
- Women who are pregnant or have given birth within the previous 6 weeks

Therapeutic Approach

Physical Activities

- Early mobilization
- Compression stockings
- Intermittent pneumatic compression

The early mobilization in hernia surgery is a standard. In an age increasingly outpatient operations performed, it is a conditio sine qua non. Only disabled patients represent a high-risk group. The discussion about compression stockings is still controversial, although no study shows a clear benefit was observed, also there is no evidence that they harm [56, 105]. But without accompanying pharmacological thromboprophylaxis, they are not suitable alone. Intermittent pneumatic compression is not an option for inguinal hernia repair patients.

Heparin

Heparin is a naturally occurring anticoagulant produced by basophils and mast cells. Heparin acts as an anticoagulant, preventing the formation of clots and extension of existing clots within the blood. While heparin does not break down clots that have already formed, it allows the body's natural clot lysis mechanisms to work normally to break down clots that have formed. Heparin and its low-molecular-weight derivatives (e.g., enoxaparin, dalteparin, tinzaparin) are effective at preventing deep vein thrombosis and pulmonary emboli in patients at risk, but no evidence indicates any one is more effective than the other in preventing mortality.

Heparin binds to the enzyme inhibitor antithrombin III (AT), causing a conformational change that results in its activation through an increase in the flexibility of its reactive site loop. The activated AT then inactivates thrombin and other proteases involved in blood clotting, most notably factor Xa. The rate of inactivation of these proteases by AT can increase by up to 1000-fold due to the binding of heparin [19, 27, 47].

A serious side effect of heparin is heparin-induced thrombocytopenia (HIT), caused by an allergic reaction of the body. HIT is caused by the formation of abnormal antibodies that activate platelets. HIT antibodies have been found in individuals with thrombocytopenia and thrombosis who had no prior exposure to heparin, but the majority are found in people who are receiving heparin [121]. Frequencies for HIT are given with 2.6% for unfractionated heparin and 0.2% for low-molecular-weight heparin [73].

The common application for heparin has become the low-molecular-weight fractionated form. There is no sure medical benefit to low-molecular-weight heparin comparing to unfractionated heparin, except for the once-daily administration form [22, 30].

Table 8.6 shows an overview of the approved LMWH and pentasaccharide in the prophylaxis of VTE [6].

Other Medicaments Used for Thromboembolic Prophylaxis

Indication may be a HIT or other intolerances to heparin or derivates.

Table 8.6 Approved LMWH and pentasaccharide in the prophylaxis of VTE

Generic	Trade name	Dosage
Certoparin	Mono Embolex NM	3.000 I.E. anti-Xa
Dalteparin	Fragmin P	2500 I.E. anti Xa
Enoxaparin	Clexane 20	20 mg/40 mg
Nadroparin	Fraxiparin 0,2–1,0	1900 I.E. – 9500 I.E. anti-Xa
Reviparin	Clivarin	13,8 mg/25 ml
Tinzaparin	Innohep	3500 I.E.
Fondaparinux	Arixtra	2,5 mg
Danaparoid	Orgaran	2 × 750 I.E. anti-Xa

Not Vitamin K-Dependent Oral Factor Xa Inhibitors [97, 98] ◘ Table 8.7

◘ **Table 8.7** Not vitamin K-dependent oral factor Xa inhibitors

Generic	Trade name	Dosage
Rivaroxaban	Xarelto	10 mg (oral)
Apixaban	Eliquis	2,5 mg (oral)

Direct Thrombin Inhibitors [9, 125] ◘ Table 8.8

◘ **Table 8.8** Direct Thrombin inhibitors

Generic	Trade name	Dosage
Argatroban	Argatra	2 µg/kg/min. i.v.
Dabigatran etexilate	Pradaxa	75 mg up to 150 mg

Vitamin K Antagonists ◘ Table 8.9

◘ **Table 8.9** Vitamin K Antagonists

Generic	Trade name	Dosage
Warfarin	Coumadin, Jantoven	Individ. INR
Phenprocoumon	Marcumar, Falithrom	Individ. INR

Duration of VTE-Prophylaxis

The duration of the VTE-prophylaxis depends and orientates on the individual risk of the patient. In inguinal hernia, it's only necessary if there are risk factors on patient, e.g., inherited thrombophilias.

8.3.4 Preoperative Hair Removal of the Operation Field

In the Hanse-Hernia Center Hamburg, the following procedure is used: After informing the staff of the ward to prepare the next patient for surgery, one of the issues is the surgical site hair removal. It is performed as electric clipping. According to the planned procedure, the area of hair removal is determined: for laparoscopic TAPP or TEP repair, a bigger area is requested than for open inguinal repair.

In three reviews [59, 112, 113] and one RCT [84], no strong evidence was found to advocate against preoperative hair removal. Furthermore, there was strong evidence to recommend that when hair removal is considered necessary, shaving should not be performed. Instead, a depilatory or electric clipping, preferably immediately before surgery, should be used [8].

8.3.5 Intraoperative Procedures: Anesthesia and Operation

(For anesthesia and surgical treatment options, see related ► Chap. 46.)

8.3.6 Postoperative Documentation and Data Input to Registry

Immediately after the procedure, the documentation is done and a report sent to the GP. The related data have to be put in to the registry.

8.3.7 Postoperative Readmission to the Ward

After the stay in the anesthetic recovery room, the patient is readmitted to the ward in case of short-stay treatment where the postoperative treatment follows nursery standards. In case of day case surgery, the patient can be discharged directly from the anesthetic recovery room or from the ward.

See also ► Sect. 8.3.9 Discharge Management.

8.3.8 Postoperative Pain Control

One of the most important treatments immediately after the surgical procedure is an effective pain control. Early pain within the first week after TAPP and TEP is most severe on the first postoperative day, and the pain pattern is dominated by deep abdominal pain [114]. The pain control treatment should always follow a clearly defined standard procedure.

Table 8.10 Concept of postoperative pain control [63]

	Concept 1	Concept 2
Basic pain value acc. NRS	NRS value >4- > Step 1 NRS value >8 Inform doctor in charge	NRS value >4- > Step 1 NRS value >8 Inform doctor in charge
Step 1	Paracetamol p.o. 4 × 1 g /24 h or Paracetamol i.v. 4 × 1 g/24 h and Ibuprofen p.o. 3 × 600 mg PPI 20 mg/24 h when indicated	Metamicol p.o. 4 × 1 g/24 h or Metamicol i.v. 4 × 1 g/24 h
Control pain value acc. NRS	NRS value >4- > Step 2 NRS value >8 Inform doctor in charge	NRS value >4- > Step 2 NRS value >8 Inform doctor in charge
Step 2	Pitriamid 7.5 mg s.c. Up to 4 × /24 h or Pitriamid 7.5 mg i.v. Up to 4 × /24 h Offtime always 4 h *When indicated* Oxycodon 10/5 mg p.o. 2 × /24 h	Pitriamid 7.5 mg s.c. Up to 4 × /24 h or Pitriamid 7.5 mg i.v. Up to 4 × /24 h Offtime always 4 h *When indicated* Oxycodon 10/5 mg p.o. 2 × /24 h
Control pain value acc. NRS	NRS value >4- > evaluate repeated drug administration (regard off times) NRS value >8 Inform doctor in charge	NRS value >4- > evaluate repeated drug administration (regard off times) NRS value >8 Inform doctor in charge

It is evidence based that laparoscopic inguinal hernia repair leads to less postoperative pain as well for the early postoperative period as for the time up to 3 months after surgery (chronic inguinal pain/CIP).

The use of regional anesthesia instead of the traditional general anesthesia does not seem to adversely affect the quality of repair. Whether it offers the patient an anesthetic alternative leading to less postoperative pain remains unclear [118].

Nevertheless, a postoperative pain control treatment is necessary which should be started already intraoperatively.

For the Hanse-Hernia Center Hamburg, the following flow sheet/treatment instruction is actually in practical use Table 8.10:

Hereby, a sufficient postoperative pain control is provided as well after laparoscopic hernia repair as after open procedures.

Discussion

The EHS Guidelines conclude (Level 1A) that endoscopic inguinal hernia techniques result in an earlier return to normal activities or work than the Lichtenstein technique. The Grade A recommendation says that an endoscopic technique is considered if a quick postoperative recovery is particularly important [111].

Different meta-analyses revealed that after an open mesh procedure, patients recovered 4 days earlier on average than after a conventional repair and recovered 7 days earlier on average following an endoscopic operation than after an open technique with mesh [17, 18, 23, 28, 45, 49, 66, 68, 80, 104, 107]. The main cause of prolonged recovery is predominantly pain [24].

The use of a titanized ELW mesh for laparoscopic hernia repair did not affect the rate of chronic pain, but it seems to improve early postoperative convalescence [16].

In addition to the pre- and intraoperative pain prevention and treatment methods (above), non-opioid and nonsteroidal anti-inflammatory medications (acetaminophen, NSAIDs, and selective COX-2 inhibitors) should be used for postoperative pain management [12, 25, 34, 106, 109, 117]. Paracetamol (acetaminophen) has insufficient effect as single-agent therapy for moderate to severe pain. However, the combination of paracetamol and a nonsteroidal anti-inflammatory drug, given in a timely manner, seems to be optimal and provides sufficient analgesic during the early recovery phase provided that there is no contraindication [55, 86].

Opioids may cause adverse effects such as nausea, vomiting, and constipation, among others, which may delay postoperative recovery. Therefore, non-opioid analgesics should be used whenever possible. However, opioids can be used for moderate- or high-intensity pain, in addition to non-opioid analgesia or when the combination of an NSAID, and paracetamol is not sufficient or is contraindicated [124].

Whether extraperitoneal local anesthesia treatment administered after the mesh placement in endoscopic hernia repair is useful remains unclear. A RCT [10] recommends to consider it's use, while a large meta-analysis regarding the same issue says that an extraperitoneal bupivacaine treatment is not more efficacious for the reduction of postoperative pain than placebo [115].

8.3.9 Discharge Management

Discharging the patient after the surgical procedure means either to go home or to stay in a nearby hotel on the same day (DC) or after one or two nights at ward regarding the patient's condition (SST). It is necessary to follow an individual approach for making the decision depending on the medical evaluation of the patient resources.

See also ► Sect. 8.3. Day Care (DC) or Short-Stay Treatment (SST).

Discharge planning begins on the preoperative consultation prior to a patient's admission to the hospital/the hernia center. Patients will be asked about their needs for the recovery period in advance of an elective surgery.

Discharge planning is a service to assist patients in arranging the care needed following a hospital stay as well as to monitor the hospital stay to ensure that optimal care is delivered in the most efficient and cost-effective manner.

The discharge planner will collaborate with the patient and their family, the therapy team, and the physician to ensure that the patient's discharge needs are identified, and the patient is transitioned to the appropriate setting.

The discharge planner can assist with providing information and referrals to community agencies, assist with transitions to skilled nursing facilities or long-term care facilities, and provide information for home care services, rehabilitative care, and out-patient medical treatment as well as provide assistance obtaining needed home medical equipment.

When needed a social worker case manager can collaborate with an interdisciplinary team and community agencies to coordinate care across the healthcare continuum.

The administratory case manager works closely with the physicians and the insurance companies to ensure that the patient's hospital stay is meeting medical guidelines and that insurance will provide financial reimbursement. Insurance regulations and strict federal and state laws require continuous monitoring of the patient's treatment and length of stay to ensure the level of care is appropriate.

The requirements for a successful discharge of patients are:

- Uninterrupted supply of medicines including weekends
- Prescription of remedies as necessary
- Prescription of home care as necessary
- Certificate of disability
- Scheduled postoperative consultation
- Emergency management after discharge (accessibility)
- Continuous registration (Herniamed) data input
- Discharge information (handout)

Discharge information (FAQ) should contain the following items and should be handed out to every patient already while the preoperative consultation:

- Partial physical resilience 2 weeks after surgery: easy jogging and bicycling are allowed.
- Full physical resilience 4 weeks after surgery.
- Showering allowed immediately after surgery: (water may reach the surgical wounds).
- Change of wound dressing.
- Drug management: Analgetics, Antithrombotics, "Bridging of Antitrhrombotics".
- Certificate of disability.
- Emergency call after discharge: Hernia Center, Hospital, General Emergency Call 112.
- Scheduling post-op consultation: Phone number Hernia Center.

A Cochrane database systematic review revealed that the evidence suggests that a discharge plan tailored to the individual patient probably brings about reductions in hospital length of stay and readmission rates for older people admitted to hospital with a medical condition. The impact of discharge planning on mortality, health outcomes, and cost remains uncertain [108].

Combined information sheets and questionnaires are helpful in the successful realization of a discharge management [29, 36].

8.4 Surgical Consultation at Hernia Center (Post-op)

8.4.1 Clinical Examination

8

When the patient presents at the scheduled postoperative consultation about 1 week after discharge, a clinical examination is undertaken containing a wound inspection, the examination of the surgical site/inguinal region and the abdomen for swelling, pain, signs of infection, and/or dysfunction.

8.4.2 Postoperative Dynamic Inguinal Ultrasound (DIUS)

After the clinical examination, an ultrasound examination is performed routinely with the aim of depicting the correct position of the mesh, of swellings, e.g., pseudo recurrence by hematoma of the inguinal cord, testicular blood supply, and or abnormal tissue findings. The ultrasound is performed according to the above-described four-step technique.

See also ► Sect. 8.1.2 Dynamic Inguinal Ultrasound (DIUS).

8.4.3 Late Postoperative Pain Control

Normally, a prescribed postoperative analgetic therapy is no longer requested as 3 days to 1 week. In our practice in case of longer-lasting inguinal pain, the first choice of therapy is the administration of NSAID continuously when necessary in combination with PPI for about 2 to 3 weeks. In case of severe testicular pain in terms of genitofemoral syndrome, local infiltrations of bucain and dexamethason should be considered.

(For late postoperative pain control options, see related ► Chap. 17.)

8.4.4 Timing the Period of Disability

The certificate of disability is even handed out by the general practitioner or by the Hernia Center. The length of disability depends on the patient's profession. When performing physical work it may take up to 4 weeks before returning to the job.

There is strong evidence that endoscopic inguinal hernia repair leads to significant shorter times of disability. Different meta-analyses revealed that after an open mesh procedure, patients recovered 4 days earlier on average than after a conventional repair and recovered 7 days earlier on average following an endoscopic operation than after an open technique with mesh [17, 18, 23, 28, 45, 49, 66, 68, 80, 104, 107]. The main cause of prolonged recovery is predominantly pain [24].

8.4.5 Documentation and Data Input to Registry

The documentation of the postoperative consultation and the data input to registry (Herniamed) are finalizing the postoperative surgical consultation.

A last report sent to the GP is completing the surgical treatment of the patient in case of no further complaints.

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Transabdominal Preperitoneal Patch Plasty (TAPP): Standard Technique and Specific Risks

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9.1 Introduction

About 25 years after the first description of a reliable technique in laparoscopic inguinal hernia repair [1], the penetration rate of this new technique is still below 20% in most countries. The reasons for the slow acceptance of laparoscopic hernioplasty are firstly that the technique is estimated as difficult and time demanding, secondly that life-threatening complications are feared, and thirdly that higher costs in comparison to open surgery are expected. Most of these concerns date back to the early days of laparoscopic surgery. Meanwhile knowledge and skills have increased enormously. It is well proven that using a strictly standardized technique and being well trained, laparoscopic hernia repair may be simple, safe, and cheap to perform.

Key feature in the process to make laparoscopic inguinal hernia repair more popular is the continuous improvement of the technique (transabdominal preperitoneal patch plasty (TAPP)) which must be precisely standardized, reproducible, and reliable.

9.1.1 Indication for TAPP

TAPP can be used on any type of inguinal hernia (Fig. 9.1a, b), *with the exception of huge, nonreducible scrotal hernia (more than double the size of a man's fist) if experience is present. In our patient pool with more than 1100 hernia repairs yearly, TAPP can be applied to about 98% of the cases* [2]. *Preconditions for a successful operation are deep knowledge of anatomy, fully standardized technique, precise operative strategy, visualization of operative steps, and mental simulation of an ideal operation.*

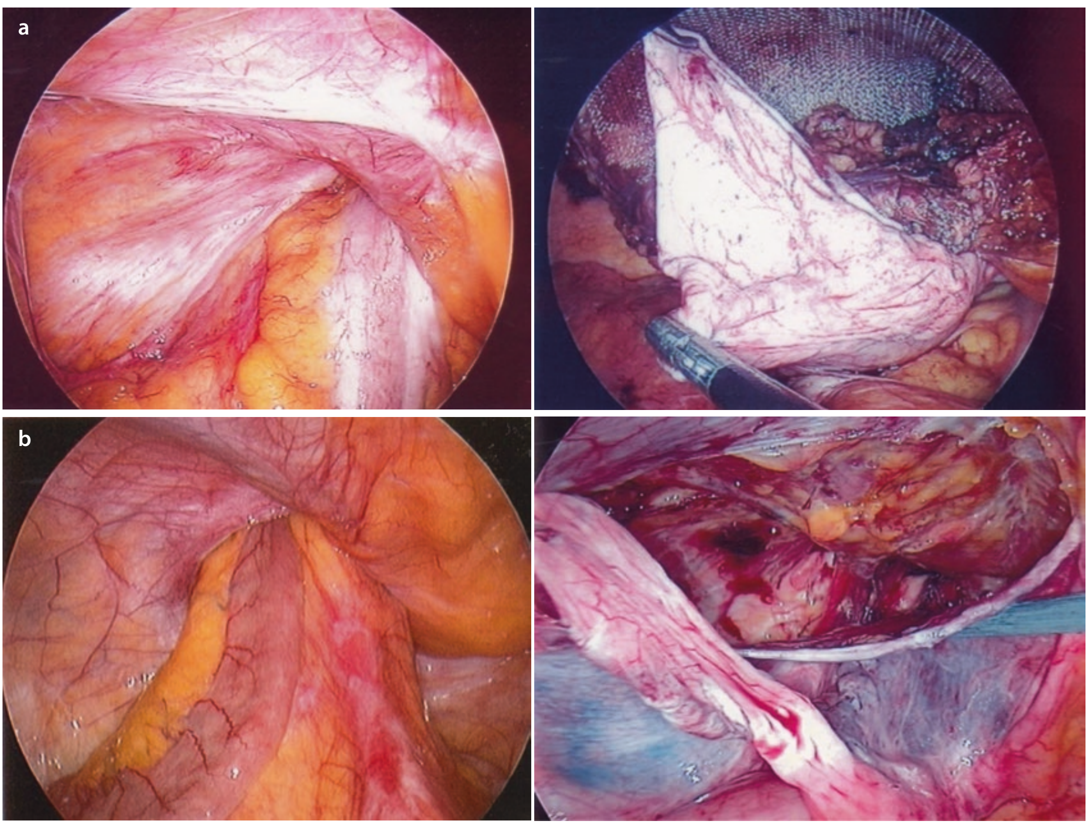


Fig. 9.1 **a, b** Scrotal hernias with completely removed huge hernia sacs

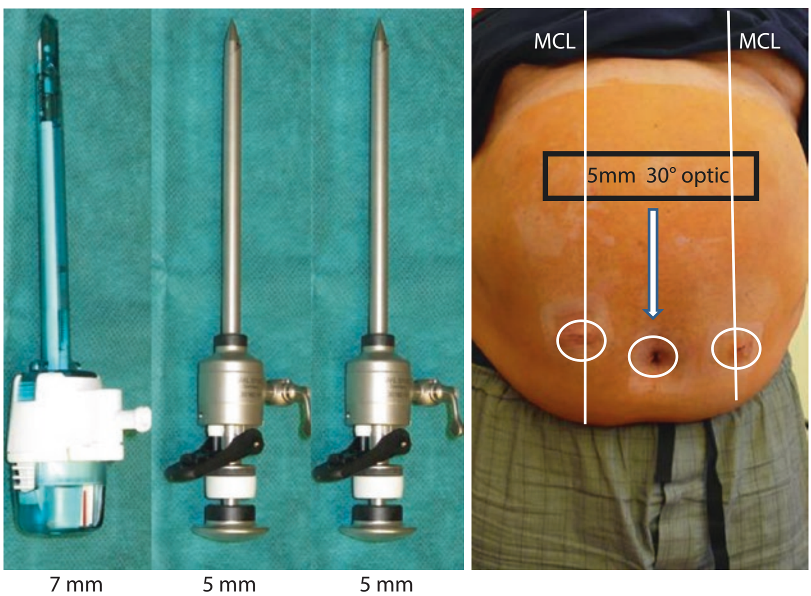
9.1.2 Instruments

- Veress needle
- Two 5 mm trocars
- One 7 mm trocar
- 30° camera (5 mm)
- Two endo-graspers (Overholt, Maryland)
- One endo-scissor (Metzenbaum)
- Blunt dissector (Reddick-Olsen)
- Gauze for hemostasis
- Dissection swab (Kelly)
- Endoscopic needle holder

All the trocars and instruments used by us are non-disposable except the 7 mm working trocar (▣ Fig. 9.2). It is important that the trocars should have perforators not cutting through the tissue; *we use trocars with a blunt, a conical tip, and a radially expanding effect*. With this design we saw significant less bleeding from the trocar site and less port-site hernias later on. Endo-Overholt and endo-scissor have a connection to monopolar electrocoagulation. In case of large hernia sac, the dissection is carried out using two Endo-Overholts like a rope ladder. We recommend the Reddick-Olsen atraumatic forceps to push the mesh which is fixed at one edge by the clamp through the 7 mm trocar. *The use of a 30° optic allows better view behind some structures like the plica umbilicalis medialis (inspection of spatium Retzius) or down to the lateral retroperitoneum when doing the parietalization*. Mostly not lockable instruments are used. The peritoneum is closed with running suture.

9.1.3 Operative Room Setup

The patient is supine and flat on the operating table when installing the pneumoperitoneum. During operation the patient is placed into a *Trendelenburg position* and turned at an angle of about 15° to the surgeon. *The surgeon stands on the side opposite to the hernia; the camera assistant is sitting on the ipsilateral side of the hernia*. Both of the patient arms are positioned at the side of the body, so that in case of bilateral hernia, the surgeon can easily change sides. The monitor is placed at the foot of the patient.



▣ **Fig. 9.2** Trocars and position in bilateral hernias

We Do Not Use a Urinary Catheter The patient is ordered to evacuate the urinary bladder immediately before leaving for the operating theater. Should a full bladder be found during laparoscopy, however, a suprapubic urinary catheter can be inserted via percutaneous puncture.

9.1.4 Key Points of Technique

Creation of Pneumoperitoneum and Placement of Trocars

A lot of techniques are described promising more safety for the patients; however, *a systematic review could not demonstrate a significant difference in safety and effectiveness of the different methods of establishing pneumoperitoneum* [3, 4]. Routinely we use the Veress needle and perform all the safety tests (snap, slurp, and aspiration tests) according to Semm [5]. Initially, a longitudinal skin incision about 5 mm long is made in the region of the center of the umbilicus. The edges of the wound with the abdominal layers are held under maximum tension (with the help of two Backhaus clamps), and the Veress needle is inserted under careful monitoring, as described by Semm (Fig. 9.3). *It is important to develop special feeling when perforating the different layers of the abdominal wall (snap test).*

Despite lack of evidence proving their usefulness, *we are convinced the careful performance of safety tests can help to minimize the danger for lesion of intra-abdominal organs when doing this first "blind" step of the operation at least due to continuous reminder that these serious complications can happen*. Furthermore, beginning with the insufflations, the intra-abdominal pressure and the rate of gas flow must be monitored carefully. Pressure must initially be 0 mmHg, and the gas flow must be 2–3 L CO^2/min. If something is wrong (e.g., at the beginning already high pressure and low flow), stop insufflation, check the position of the needle, or change to open access (Hasson). *In patients being after previous periumbilical surgery, there are two possibilities: (1) Insert Veress needle at the palmer point (just below the left costal margin, midclavicular line (MCL)). (2) Start with an open access (Hasson) at the umbilicus.*

When intra-abdominal pressure reaches *12 mmHg* and aspiration test is regular, then the optical trocar is inserted again under countertension of abdominal wall with the help of the Backhaus clamps. This trocar is inserted in the direction of the center of the naval with slightly forth and back rotating movements, the most effective way to avoid slipping of the trocar on the fascia.

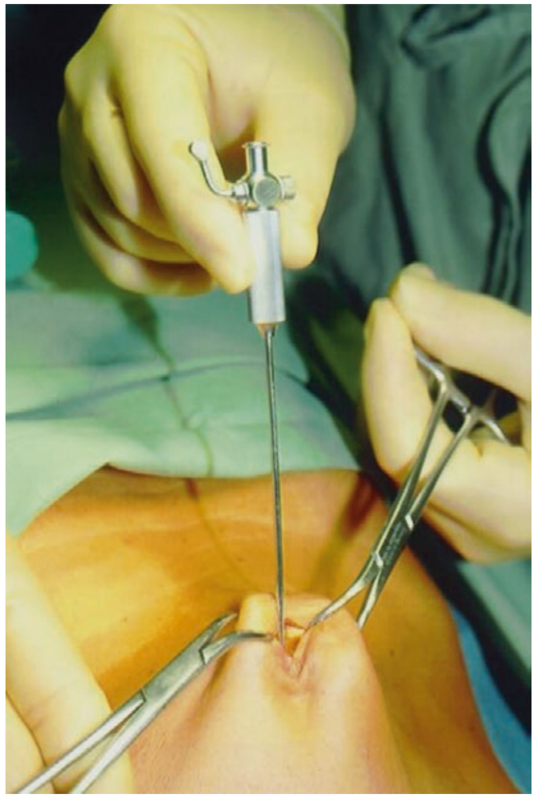


Fig. 9.3 Creation of pneumoperitoneum (snap test)

9.1.5 Implantation of Working Trocars

Three possibilities:

1. Use of a *10 mm optical trocar* (umbilicus) and two *5 mm working trocars.* Position – in bilateral hernia midclavicular line at the level of umbilicus, perforating rectus muscle. *Advantage* – better cosmesis. *Disadvantage* – mesh, needles, and gauze can only be introduced blindly via the optic trocar, and this needs more time.
2. Alternatively use of *a 5 mm trocar* on the left side of the patient and on the right side a *10/12 mm trocar*. *Disadvantage* – worse cosmesis and some danger for trocar hernia later on. *Advantage* – easy and rapid introduction of meshes, gauzes, needle holder with needle, or hernia stapling instruments if needed.

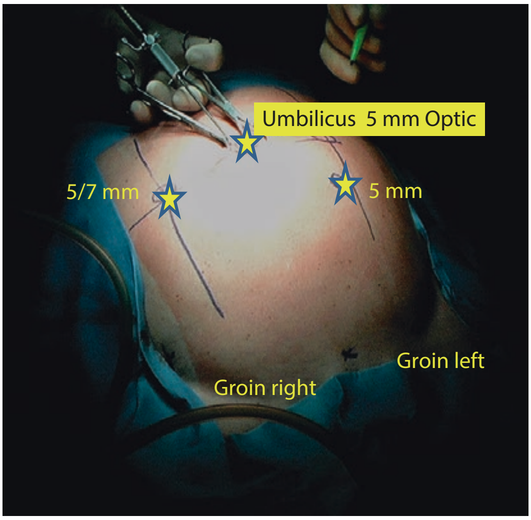


Fig. 9.4 Standard positioning of the ports in right-sided hernia

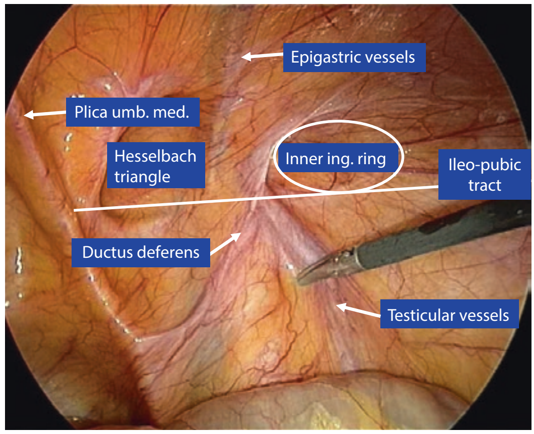


Fig. 9.5 Laparoscopic view of the right inguinal region

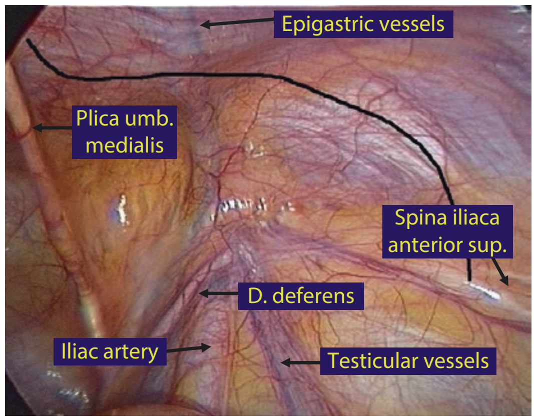


Fig. 9.6 Wide opening of the peritoneum along the *black line*

3. Recently a 5 mm 30° optic nearly as effective as the 10 mm is available. Insofar, *actually our standard is* (Fig. 9.4) (1) 5 mm optic at the umbilicus, (2) 5 mm working trocar left mid-clavicular line at the level of umbilicus, and (3) 7 mm plastic working trocar right MCL at the level of umbilicus (Figs. 9.2 and 9.4). *Advantages of this minimized approach*: excellent cosmesis, less pain, and no trocar hernias.

In unilateral hernia we recommend insertion of the ipsilateral working trocar about 2–3 cm above the naval area and the contralateral working trocar 2–3 cm below the umbilical level (Fig. 9.4). In this way, collisions with the optic trocar can be minimized. In bilateral hernia both working trocars are positioned at the same level.

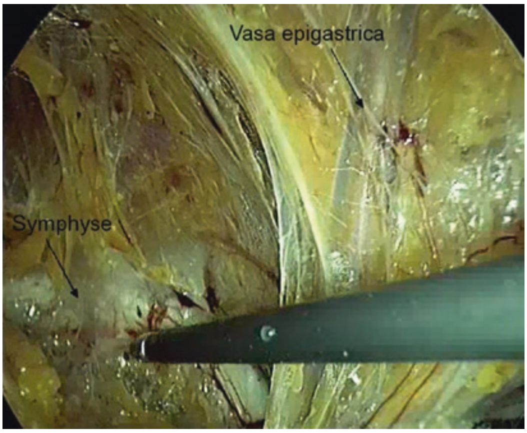
Diagnostic Round View

In contrast to TEP, the transabdominal technique allows immediate assessment of the hernia situation – unilateral or bilateral, occult contralateral hernia, direct or indirect, size of hernia defect, hernia content, and other abdominal pathology.

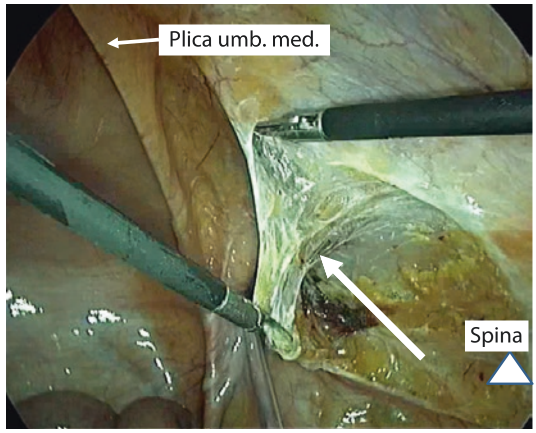
Operation: Complete Dissection of the Pelvic Floor

Step 1 Identifying the anatomical structures (Fig. 9.5) and cross-checking with the camera guide (assistant). *Precise knowledge of anatomy is an indispensable precondition for the success of the operation and for avoidance of complications.* Spina iliaca ant. sup. is identified by palpation from outside. *If there are adhesions between the omentum or the bowel and the hernia sac, it is not recommended to take it down* – this is unnecessary and carries the risk for lesion of bowel. Adhesions are removed “en bloc” together with the peritoneum when opening it to enter the preperitoneal space. Adhesiolysis is only indicated if you cannot approach the inguinal region because of severe adhesions in the lower abdomen, but in these cases special expertise in laparoscopic surgery is demanded.

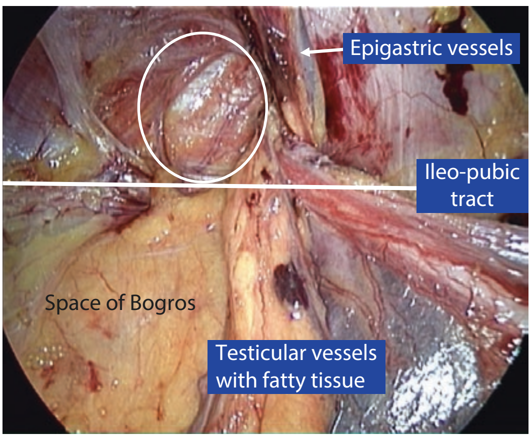
Enter the preperitoneal space by performing a wide incision of the peritoneum (Fig. 9.6), starting at spina iliaca ant. sup. The incision is placed 3–4 cm above all possible hernia openings and ends at the plica umbilicalis medialis. *The plica is not cutted* (danger for bleeding from occasionally open umbilical artery). If you need more space, go parallel to the plica cranially.



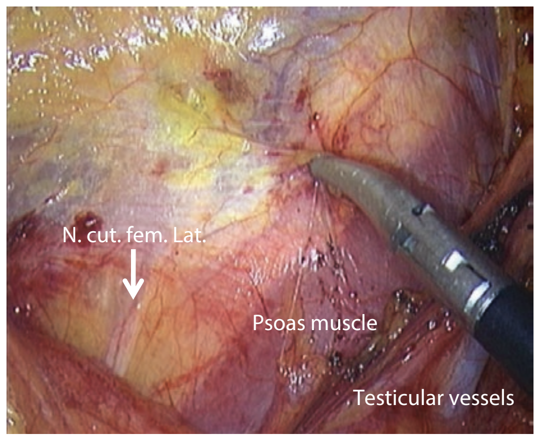
■ **Fig. 9.7** Dissection of the preperitoneal space of Retzius



■ **Fig. 9.9** Right inguinal region: start of the dissection laterally in the region of spina iliaca ant. sup.



■ **Fig. 9.8** Left inguinal region: lateral preperitoneal space of Bogros and inner inguinal ring



■ **Fig. 9.10** Left inguinal region: space of Bogros with lumbar/spermatic fascia protecting the inguinal nerves

Step 2 When continuing the dissection, follow a *precise strategy*. This is especially important in complicated hernias (e.g., scrotal). After entering the preperitoneal space, start first with the dissection of the medial compartment (■ Fig. 9.7 – spatium Retzii) and/or the lateral compartment (■ Fig. 9.8 – spatium Bogros). *Sometimes if dissection in front of the rectus muscle can be difficult due to additional fascial tissue belonging to fascia transversalis, then it is better to start lateral* (■ Fig. 9.9), identify the anatomical structures (e.g., iliopubic tract, transversalis arch, epigastric vessels), and dissect medially afterward. *The dissection can be done mainly blunt in an avascular plain, called "spin-web" like tissue zone* (■ Figs. 9.7 and 9.9). Develop tissue feeling when doing blunt dissection. If you are in the right plain, it is an easy and fast procedure. If there is some bleeding, *we use monopolar electric* very meticulously, so that the operation field always is free of blood and has a yellowish-pink color. The peritoneum with its surrounding preperitoneal fatty tissue will be pushed away from the fascia transversalis and the rectus muscle. *Keep in mind:* The aim of the dissection is a nearly fatty-free abdominal wall exposing all important anatomical structures, but the aim is not to attain a fatty-free peritoneal flap. Following the described technique, damage to the peritoneum which may result in large tears can be avoided, and closure of the peritoneal flap after mesh implantation will become more easy.

When dissecting the lateral caudal compartment below of the iliopubic tract, it is essential to respect the fascia spermatica/lumbar and especially a thin membrane dividing the retroperitoneal space in a visceral and parietal compartment (■ Fig. 9.10). The nerves are located

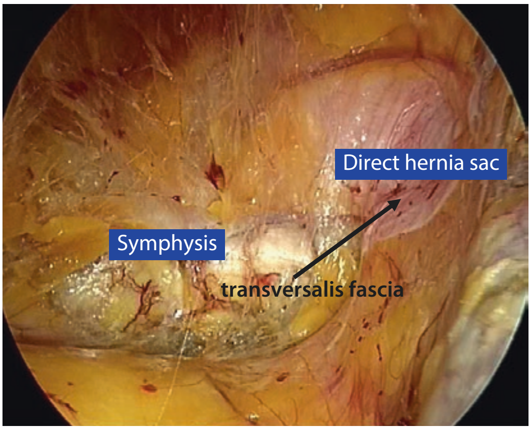


Fig. 9.11 Preperitoneal space of Retzius and a direct hernia sac

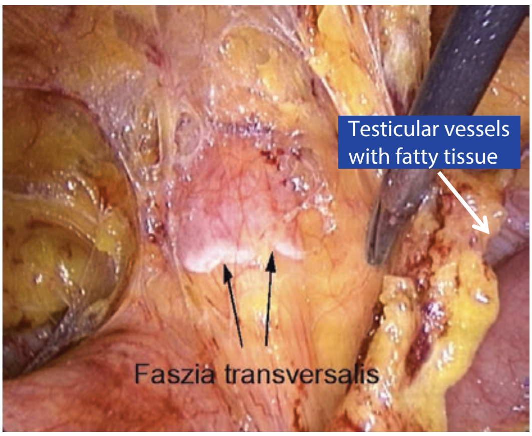


Fig. 9.12 Right inguinal region, medial compartment. Pseudosac-like enlarged fascia transversalis

in the parietal space behind this membrane, and so they are protected by these fascial structures which must not be interrupted by rough operating technique.

Step 3 In case of direct hernia when dissecting the medial compartment, you will find the direct hernia sac easily (Fig. 9.11a). At once you can take down all the fatty tissue forming the hernia content and *expose the pseudosac-like enlarged fascia transversalis* (Fig. 9.12). *When doing this step, use electrocoagulation very generously* to close all even the smallest blood and lymphatic vessels. Applying this technique you can prevent sero-hematoma formation later on. In very large hernia pseudosacs, in order to avoid any dead space (which may promote sero-hematoma significantly)

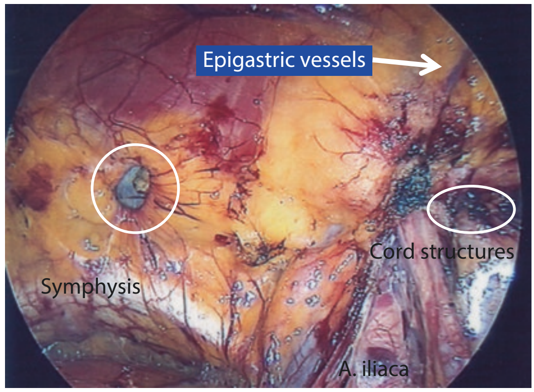


Fig. 9.13 Suprapubic hernia opening in recurrent hernia after previous Lichtenstein repair

in the former bed of the hernia, it is recommended to invert the sac and to fix it to Cooper's ligament by suture or tacks [3, 4] or close the sac by using a Roeder sling.

Two further basic principles are to be taken into account when dissecting the medial compartment:

1. *Dissection has to go beyond the middle of the symphysis* to the opposite side in order to identify a suprasymphytic hernia orifice (Fig. 9.13), not uncommon in recurrence after Lichtenstein, and also to create a large enough space for plain and wrinkle-free placement of a large mesh. Usually this preparation is simple and carries no risk for an injury of urinary bladder. Problems may be expected, however, in cases of previous operations in this area *(e.g., prostatic resection). Due to the significant risk of bladder injury, such operations should only be performed by very experienced laparoscopic surgeons*; otherwise an open approach should be chosen from the start.
2. *In the direction toward lateral, the medial compartment should be dissected as far as the iliac vessels, in order to clear the femoral hernia site* (Fig. 9.14). Preparation should be done very carefully to avoid any injuries not only to the iliac vessels but also to "corona mortis," being present in 20–30% of cases (Fig. 9.15).

Step 4 Dissection of the lateral compartment is significantly more difficult, especially in patients with a large amount of fatty tissue accompanying a large indirect hernia sac and in patients with

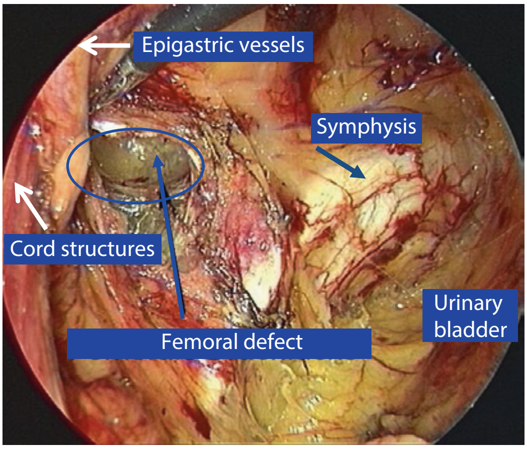


Fig. 9.14 Exposition of a femoral hernia site

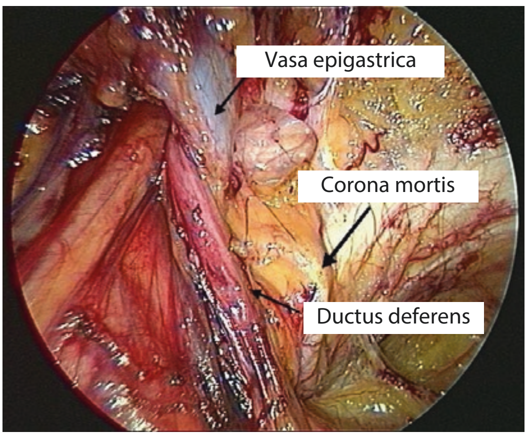


Fig. 9.15 Dissection of the medial compartment: corona mortis

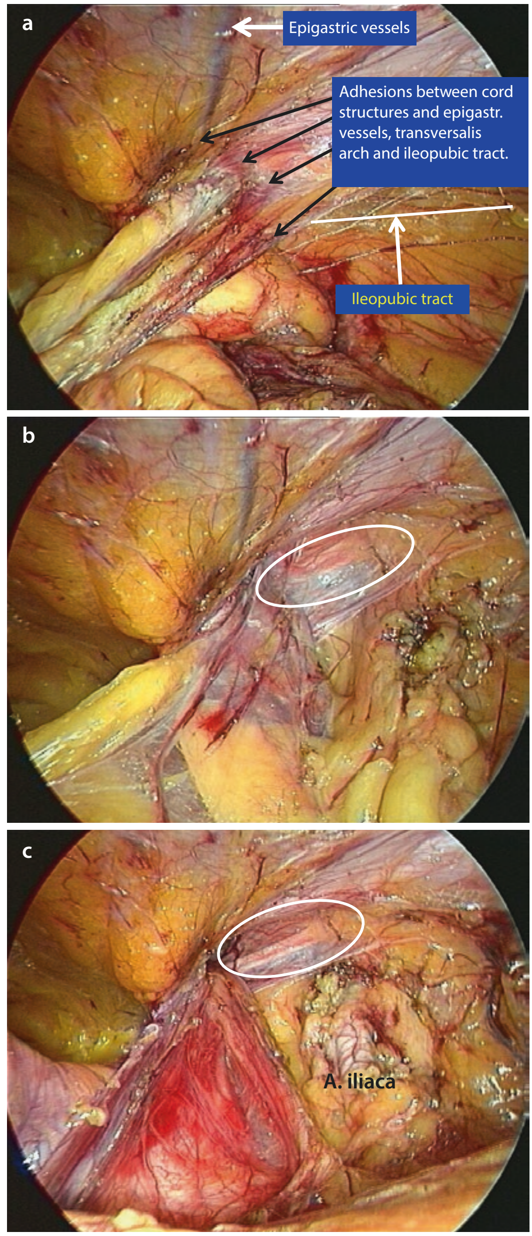


Fig. 9.16 **a**, **b**, **c** Right inguinal region: first rule – clearance of the inner inguinal ring

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dense scar tissues between hernia sac and cremasteric muscle. *To do dissection of a large hernia sac safely, a first rule demands to perform fatty-free dissection of the inner inguinal ring* (Fig. 9.16a, b, c) and identify all important anatomical landmarks (epigastric vessels, transversalis arch, tractus iliopubicus, symphysis, and Cooper's ligament). *A second rule demands in unclear topography of hernia sac and surrounding fatty tissues to identify first the testicular vessels in the farthest caudal- lateral part of the lateral compartment* (Fig. 9.17) and use these vessels as guiding landmark for dissection of hernia sac.

The third rule concerns cord lipomas (Fig. 9.18). *In these cases it is recommended first to reduce the lipoma, and then very often the hernia sac is reduced too.* In any case all lipomas have to be reduced.

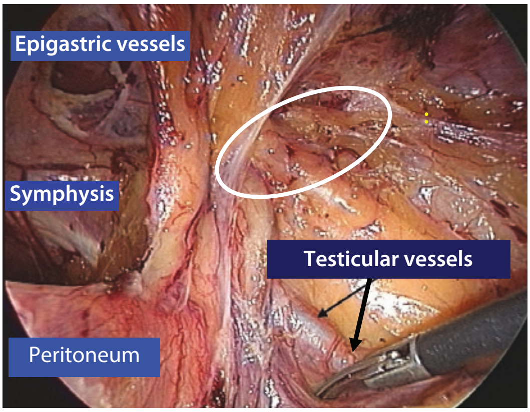


Fig. 9.17 Right inguinal region: second rule – identifying of testicular vessels far caudal/lateral

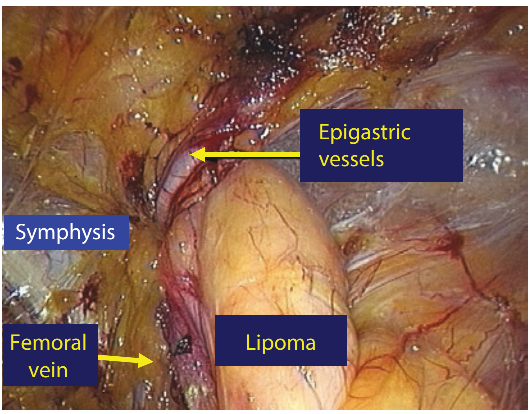


Fig. 9.18 Right inguinal region: third rule – reduction of cord lipomas

Special attention must be paid when performing dissection underneath the level of the iliopubic tract, in order to avoid injury to the nerves (n. cutaneous fem. lat., n. genitofemoralis (Fig. 9.19a, b)) or vessels. Clumsy and unprecise use of electrocoagulation and placements of clips are strictly prohibited in this region.

Step 5 Dissection of an indirect hernia sac (Fig. 9.20) is much more difficult compared to the direct sac due to the very close relationship to the cord structures. *Dissection is mainly blunt, adhering strictly to the hernia sac with careful hemostasis and visualizing the testicular vessels continuously* (Fig. 9.21). The dissection is carried out parallel to the testicular vessels in a medial-ventral direction to the angle between the iliopubic tract and epigastric vessels. If there are very dense adhesions between hernia sac and the

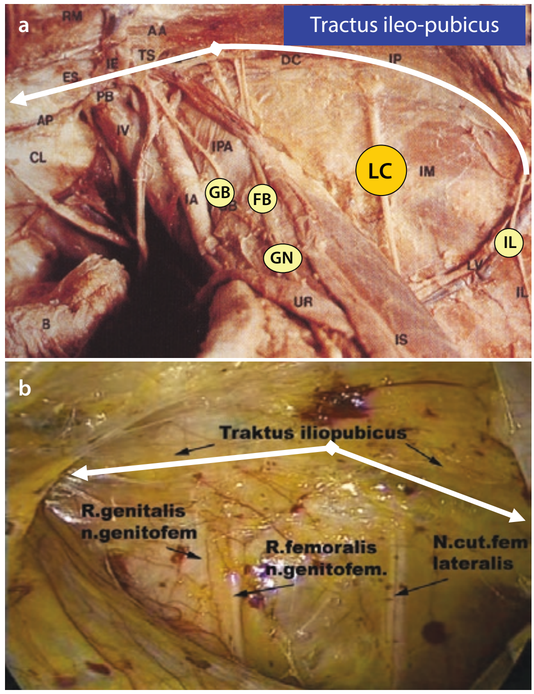


Fig.9.19 **a** Space of Bogros: course of n. cutaneous fem. lateralis (*LC*), n. genitofemoralis (*GN*), and n. ilioinguinalis (*IL*) in cadaver dissection (according to Anni-bali). **b** Space of Bogros: course of n. cutaneous fem. lateralis (*LC*), n. genitofemoralis (*GN*), and n. ilioinguinalis (*IL*) during laparoscopic dissection

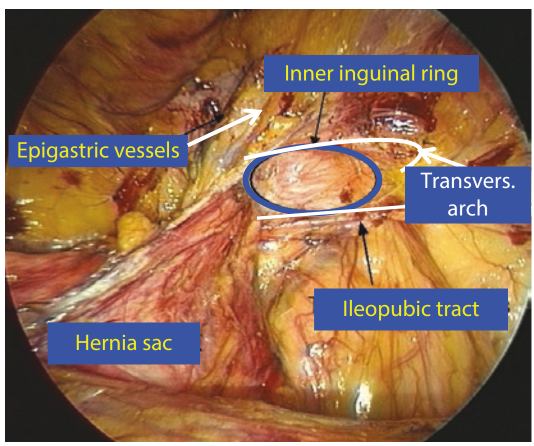
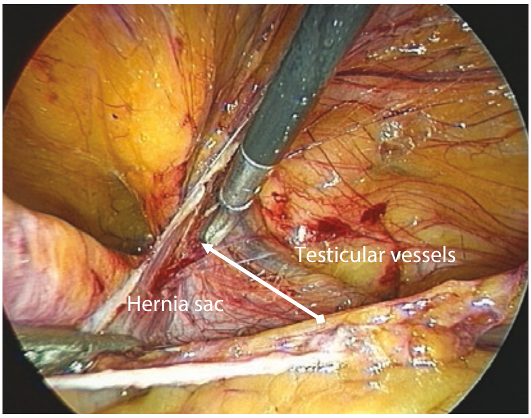
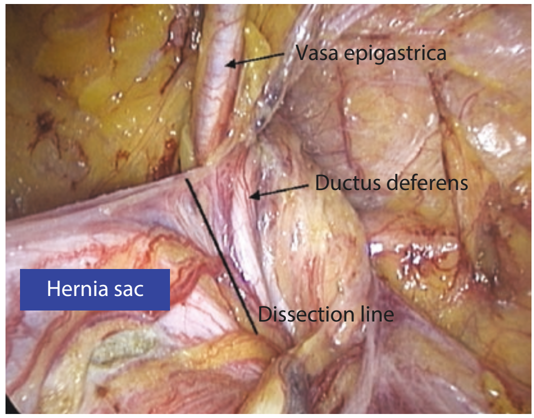


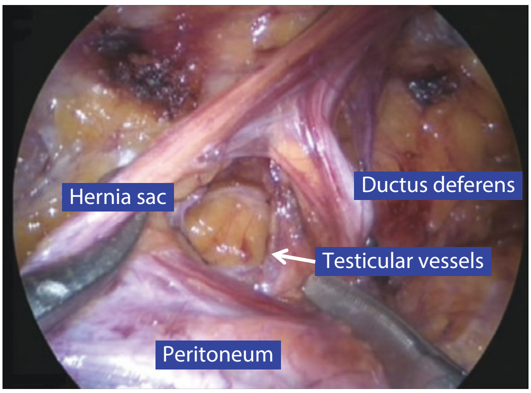
Fig. 9.20 Dissection of an indirect hernia sac after identifying the anatomical structures (e.g., ileopubic tract, transversalis arch, epigastric vessels)



■ Fig. 9.21 Dissection of an indirect hernia sac



■ Fig. 9.23 Start of the parietalization after approaching the top of the hernia sac



■ Fig. 9.22 Creation of a window between the hernia sac and the cord structures

cremasteric tube or the cord structures, then these are carefully dissected by superficial use of electrocoagulation, and then they can be pushed away easily. If the hernia sac is very long, it may need a strong tug with the left hand holding the Endo-Overholt to remove the hernia sac from its bed in the inguinal canal. To prevent the hernia sac from slipping back, we recommend dissection with two Endo-Overholts using *the so-called* rope-ladder technique. It can sometimes be helpful to create a dorso-caudal window between hernia sac and cord structures, especially in the case of scrotal hernia (■ Fig. 9.22). *If complete removal of hernia sac may seem too difficult with respect to the risk of injury to the spermatic cord, then the hernia sac can be severed.* In this case proximally the hernia sac should be closed by suture, distally left open.

Once the top of the hernia sac has been reached, the rest of the procedure is simple. *All adhesions between the hernia sac and the cord structures have to be taken down* (■ Fig. 9.23). Mostly blunt, partly sharp (very superficial electric) dissection is now carried out in the direction of the abdominal cavity. The hernia sac and the peritoneum are completely detached from the cord. This procedure is known as *parietalization. It should provide fold- and wrinkle-free placement of a large mesh with direct contact to spermatic fascia without any fat located in between* (■ Fig. 9.24a, b). The parietalization should go down to the mid-psoas muscle laterally and medially to the point the vas turns down to the prostate gland. *Later manipulation of the peritoneum must not lead to a change in the position of the cord structures. The same should be true with the mesh after its placement.*

After this dissection, the *entire myopectineal orifice is free* of peritoneum and fatty tissue, thereby allowing complete identification of epigastric vessels, internal inguinal ring, Hesselbach's triangle, Cooper's ligament, symphysis, iliopubic tract, testicular vessel bundle, and vas deferens (■ Fig. 9.25).

Step 6 Implantation of a lightweight mesh (below 50 g/m^2) with large pores (>1 mm) and at least 10 × 15 cm in size. The mesh will be pushed like an umbrella through a 10/12 mm trocar with the help of a blunt Reddick-Olsen clamp or like a coat wrapping the clamp through a 7 mm trocar. *It will be*

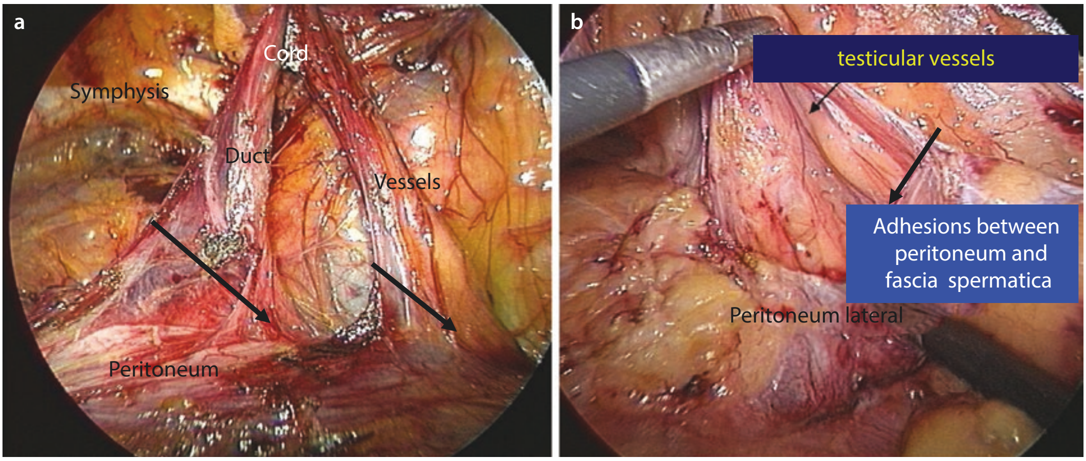


Fig. 9.24 **a**, **b** Parietalization: detachment of all adhesions between the peritoneum and the cord structures/fascia spermatica (following the *arrows*)

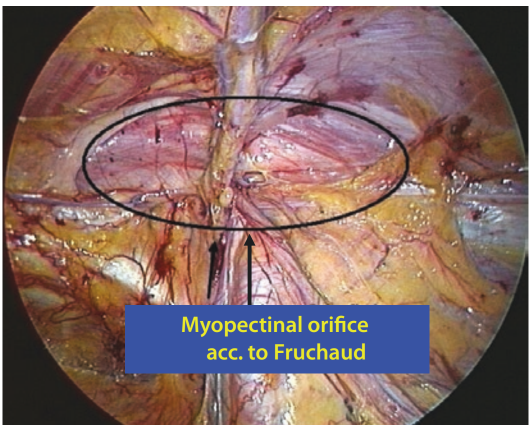


Fig. 9.25 Right inguinal region after complete dissection

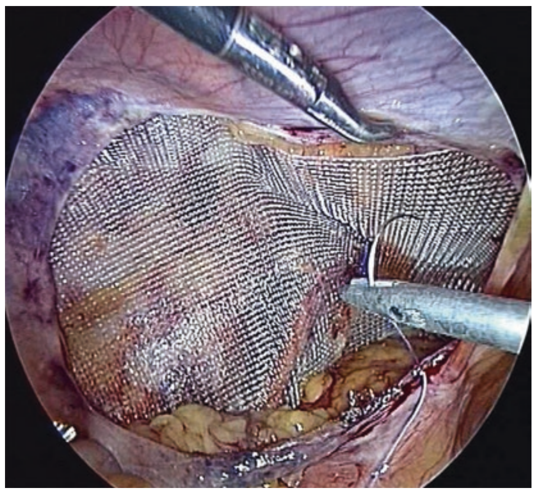


Fig. 9.26 Placement of mesh without any folds

placed absolutely flat without any folds or wrinkles covering the whole myopectineal orifice with an overlap of all possible hernia openings of at least 3–5 cm (Fig. 9.26). There is a *basic rule*: "The larger the defect is, the mesh should be more stiff, larger, and more overlapping."

Step 7 TAPP works according to the principle of Pascal [6]. Insofar *fixation is not necessary for stabilization of reconstruction but only for prevention of dislocation* in the very early postoperative period when the patient is starting heavy coughing, pressing, and moving. *Our recommendation*: In very small hernia defects (<3 cm), fixation is not necessary. In indirect hernia defects (>4–5 cm), we recommend a noninvasive fixation with glue. *Fixation with glue is possible in the triangle of doom and pain* (Fig. 9.27). In larger direct hernial defects (>3 cm), we recommend fixation with tacks (absorbable). Recommended tack position: 2–3 to Cooper's ligament, one or two to the rectus muscle, and one or two lateral to the epigastrics about 4 cm high above the iliopubic tract to avoid any damage to the nerves. *But always keep in mind that fixation cannot compensate insufficient dissection technique or inadequate mesh size.* In very large hernia defects, a larger mesh (12 × 17) is recommended too [3, 4].

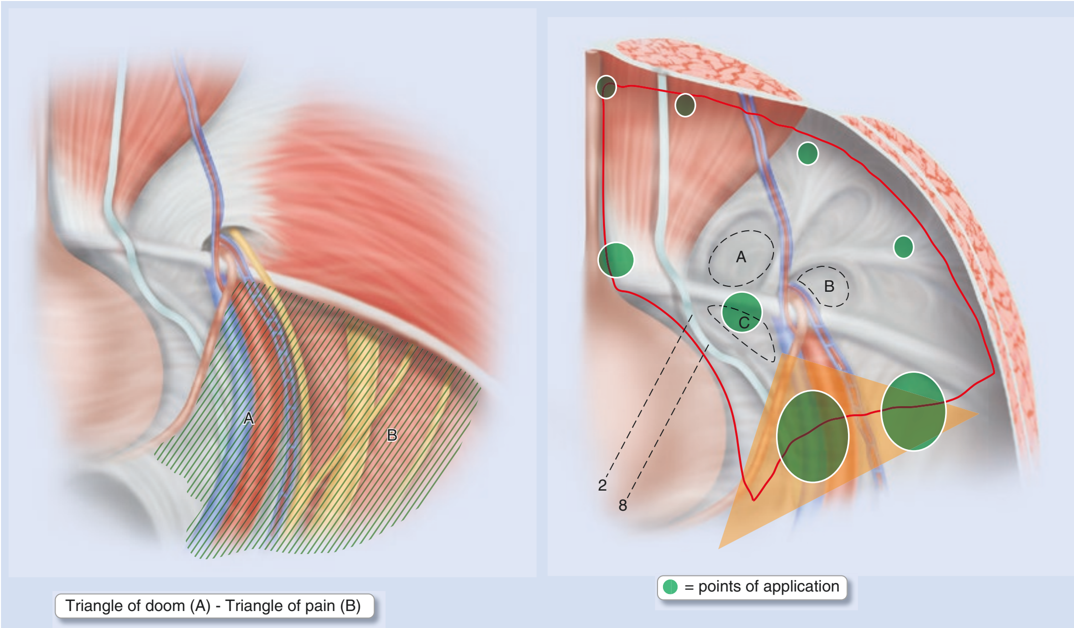


Fig. 9.27 Fixation of mesh with glue

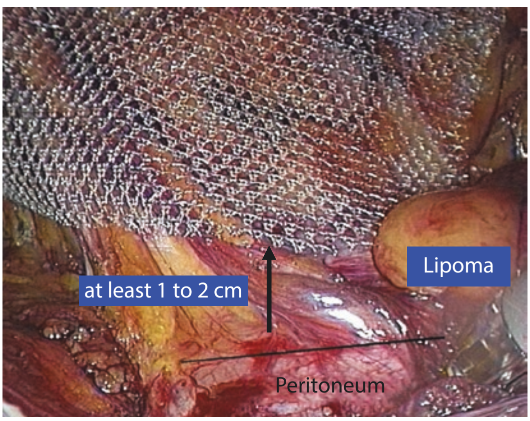


Fig. 9.28 When elevating the peritoneum for closure, the mesh must not move

Step 8 *Before the peritoneum is closed, it is lifted and the extent of parietalization is checked.* The covering peritoneal fold should be at least 1–2 cm distal of the lower edge of the mesh which should not move when elevating the peritoneum (Fig. 9.28). *The peritoneum should meticulously be closed by absorbable running suture* (Fig. 9.29). The suturing has to be absolutely without any gaps, because gaps larger than 1 cm could give reason for small bowel ileus. Suturing may be in the beginning more difficult and time-consuming, but it produces less pain in comparison to clip or tack closure. *To facilitate tension-free closure, the intra-abdominal pressure may be reduced to 6–8 mmHg.* When using this technique, a tight and safe seal is possible even with scarred peritoneum.

Step 9 Finally the working trocars are removed under direct visualization. Even though blunt trocars are used, bleeding from epigastric vessels may occasionally occur and must be recognized and controlled. Suturing of lateral fascial openings caused by the trocars is usually not necessary, but the incision at the naval when used trocars are equal to or larger than 1 cm should always be closed carefully with suture to avoid trocar herniation in the late postoperative course.

Own results, inclusive "learning curve" in 15,101 consecutively operated on, unselected hernia repairs in the TAPP technique (1993–2007), are operating time, 40 min; morbidity, 2.5%; mortality, 0,007%; reoperation rate, 0.44%; time of disability of work, 14 days; and recurrence rate, 0.7%.

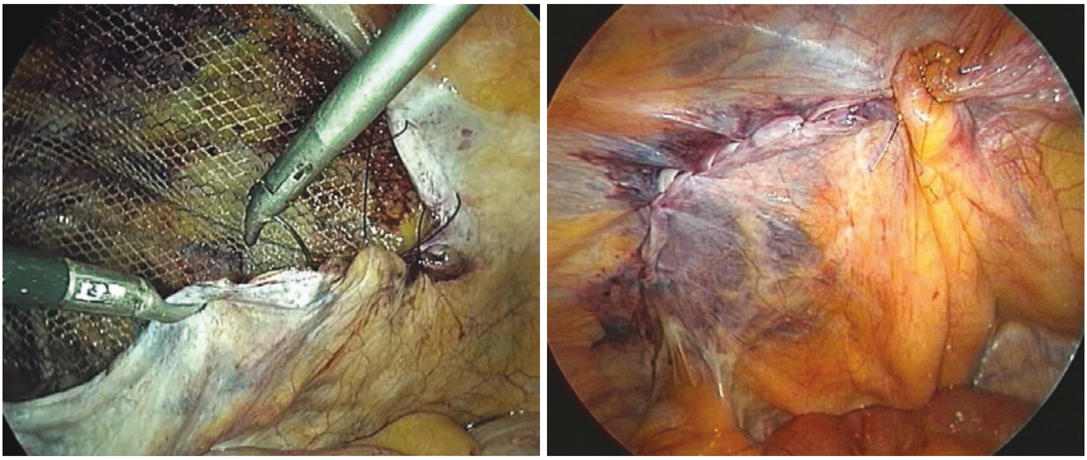


Fig. 9.29 Closure of the peritoneum by absorbable running suture

9.2 Evidence-Based Management in TAPP (J. Kukleta [3, 4])

9.2.1 Preparation of the Patient

When Is the Urinary Bladder Catheter Recommended?

Statements

If the patient does not empty his/her urinary bladder, the operation may be more difficult with a higher risk of bladder injury; however, perioperative catheterization of urinary bladder is very rarely necessary.

Recommendations

- **Grade B (upgraded)**: It is recommended that the patient empty his/her bladder immediately prior to the operation
- **Grade C**: Restrictive pre- and postoperative intravenous fluid administration reduces the risk of postoperative urinary retention

Full urinary bladder can increase substantially the technical difficulty of TAPP repair [7, 8]. In order to diminish the risk of bladder injury, the bladder should be emptied before surgery. Predisposing factors for an injury are a full bladder or a previous exposure of the retropubic space particularly after prostate interventions, irradiation, or preperitoneal mesh/plug implantation [9]. The amount of intravenous intraoperative fluid administered is a significant risk factor for urinary retention [10].

9.2.2 Establishing Pneumoperitoneum

Which Is the Safest and Most Effective Method of Establishing Pneumoperitoneum and Obtaining Access to the Abdominal Cavity?

Statements

- **Level 1A:** There is no definitive evidence that the open-entry technique for establishing pneumoperitoneum is superior or inferior to the other techniques currently available
- **Level 2C**: Establishing pneumoperitoneum to gain access to the abdominal cavity represents a potential risk of parietal, intra-abdominal, and retroperitoneal injury
- Patients after previous laparotomy, obese patients, and very thin patients are at a higher risk
- **Level 4:** The various Veress needle safety tests or checks provide insufficient information about the placement of the Veress needle but should remind that maximal caution is required

- The initial gas pressure when starting insufflation is a reliable indicator of correct intraperitoneal placement of the Veress needle
- Left upper quadrant (LUQ, Palmer's) laparoscopic entry may be successful in patients with suspected or known periumbilical adhesions or after failed insufflation attempts at the umbilicus

Recommendations

- **Grade A**: When establishing pneumoperitoneum to gain access to the abdominal cavity, extreme caution is required. Be aware of the risk of injury
- The open access should be utilized as an alternative to the Veress needle technique in patients after previous open periumbilical abdominal surgery

To create pneumoperitoneum to gain access to the abdominal cavity carries a risk of injury. The safest and most efficient method of access is still controversial.

There are four ways to obtain access to the abdominal cavity: (1) open access (Hasson), (2) Veress needle to create pneumoperitoneum and trocar insertion without visual control, (3) direct trocar insertion (without previous pneumoperitoneum), and (4) visual entry with or without previous gas insufflation.

Among general surgeons and gynecologists, the most popular method is the Veress needle [11]. To increase the safety and minimize the morbidity of this method, several safety tests were proposed by Semm [12, 13]. The literature does not always support the use of these tests as they provide very little useful information about the placement of the needle [14]. The intraperitoneal pressure initially induced by the gas insufflations seems to be more important to control the correct placement of the Veress needle [15]. If the pressure is initially higher than 2–3 mmHg, then the needle is not placed correctly.

Therefore, it might not be necessary to perform various safety checks when inserting the Veress needle, but their routine use may still remind the surgeon of the risk of injury involved in this procedure; however, waggling of the Veress needle from side to side must be avoided, as this can enlarge a 1.6 mm puncture injury to an injury of up to 1 cm in viscera or blood vessels [14]. The angle of the Veress needle insertion should vary according to the BMI of the patient, from 45° in nonobese to 90° in obese patients.

Although the open approach seems to be the safest, especially in patients after previous periumbilical surgery, it does not eliminate completely the risk of injury [16] (Level 2C). In 12,919 cases, access morbidity was in 12,919 cases: Hasson 0.09%, Veress +1st trocar 0.18%, and optical trocar 0.29%.When using open approach palpation through the peritoneal aperture, to exclude adhesions is mandatory before inserting a blunt cannula [17]; however, when using miniaturized instruments (5 mm optic trocars), this is impossible.

There is no evidence that the open-entry technique is superior or inferior to the other entry techniques currently available. One RCT recommends open access as a standard for laparoscopic operations, but the number of only randomized 50 patients is too small to allow definite conclusions [18].

There are few reports suggesting direct trocar insertion without previous gas insufflation [19, 20]. The benefit, it is argued, is to diminish the potential morbidity of the Veress needle and to create pneumoperitoneum faster. The new designs of blunt tip trocars promise to decrease the number of minor injuries (subcutaneous, preperitoneal gas insufflation, needle tip injuries intra- and retroperitoneally) while maintaining the incidence of major injuries equally low as the Veress needle.

The visual entry trocars may offer an advantage over traditional trocars, as they allow a clear optical entry, but this advantage has not been fully explored. They also minimize the size of the entry wound and reduce the force necessary for insertion, but they are not superior to other trocars since they do not avoid visceral and vascular injury completely.

A systematic review of the safety and effectiveness of methods used to establish pneumoperitoneum in laparoscopic surgery (2003) could not demonstrate any significant difference to support one method of choice [21].

The method of approach has to be adapted to patient's condition in case of expected increased risk of injury (BMI, previous surgery, position of scars, suspicion of adhesions, etc.). Implementation of the available evidence should optimize the decision-making process in choosing a particular technique to enter the abdomen during laparoscopy [14].

After an unsuccessful attempt in the umbilical region preferably with safety tests or having a high intraperitoneal pressure when starting gas insufflations [15], "Palmer's" point in left hypochondrium can be chosen [14]. If in any doubt, the Hasson approach is recommended [17].

9.2.3 Trocar Choice, Placement, and Positioning

What Kind of Trocars Should Be Used? Is There Any Relation Between Trocar Type and Risk of Injury and/or Trocar Hernias?

Statements

- **Level 1B**: The radially dilating trocars cause less acute injuries (bleeding at trocar site) and less chronic tissue damage (trocar hernias)

Recommendations

- **Grade A**: The cutting trocars should be avoided

The design of dilating instead of cutting trocars contributed significantly to decrease the risk of port-site bleeding and development of port-site hernias [7, 14, 22–25].

9.2.4 Special Technical Remarks

Cord Lipoma

Statements

- **Level 2C**: Cord lipomas or lipomas in the femoral canal may imitate primary hernia and hernia recurrence or become symptomatic in later course

Recommendations

- **Grade B**: Lipomas of spermatic cord/round ligament and the preperitoneal lipomas of direct and femoral sacs should be removed

Quite often, substantial funicular lipomas or pre- or retroperitoneal fat prolapse into the enlarged hernia orifices ring [26–29]. They should be retracted and eventually resected, as they may become symptomatic or mimic a recurrent hernia [30]. An overlooked lipoma is one of the known reasons of "recurrence" [31]. Although the published data provides low evidence, the search for and exclusion of such masses is an integral part of the endoscopic hernia repair [32, 33].

Large Direct Hernia Sac and Incidence of Seromas

Statements

- **Level 2B**: The incidence of seromas in direct hernias can be significantly reduced when the lax transversalis fascia is inverted
- **Level 2C**: Seroma is a common early postoperative minor complication in endoscopic preperitoneal hernia repair

Recommendations

- **Grade B**: In voluminous direct hernias, the extended transversalis fascia should be inverted and fixed to Cooper's ligament

A prospective nonrandomized study demonstrates significantly lower incidence of postoperative seromas in the group of patients with direct hernias and transversalis fascia inversion, without increase of postoperative pain despite the use of invasive fixation with tacks to the Cooper's ligament [34]. In some expert reports, fixation with sutures is recommended as a less expensive alternative. A cautious use of superficial electrocoagulation to obliterate blood and lymphatic vessels has also been suggested to reduce seroma formation [7, 22].

9.2.5 Mesh Choice, Mesh Size, Mesh Slit, and Mesh Fixation

Does the Use of a Larger Mesh Prevent Recurrence After Laparoscopic Inguinal Hernia Repair?

Statements

- **Level 2A**: A small mesh may be a risk factor for recurrence after laparoscopic inguinal hernia repair
- **Level 5**: Insufficient dissection of the preperitoneal space makes it difficult to place a large mesh properly and avoid folds and wrinkles
- Fixation does not compensate for inadequate mesh size

9

Recommendations

- **Grade A**: A mesh size of at least 10 × 15 cm is recommended
- **Grade D**: Use a bigger mesh (i.e., 12 × 17 cm or greater) for large hernias (direct >3–4 cm, indirect >4–5 cm)

Mesh size may have a greater impact on recurrence than surgical technique [35, 36]. 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, i.e., light- or heavyweight [37].

Data extracted from a recent meta-analysis of open versus laparoscopic hernia repairs provide some information about this issue [38]. A significant trend toward reduced recurrence rates with increasing mesh size was noted (a "large" mesh was most often of 10 × 15 cm size). Indeed, use of a small mesh almost doubled the risk for recurrence [38]. A large retrospective series which included 3017 patients undergoing TAPP inguinal herniorrhaphies showed a 5% recurrence rate using an 11 × 6 cm mesh in 325 repairs and a 0.16% recurrence rate using a 15 × 10 cm mesh in 3205 repairs [39].

There are two large randomized studies from Sweden: one compared TAPP with Shouldice with a 5-year follow-up of 920 patients and showed a recurrence rate of 6.6% when using a mesh size of 7 × 12 cm [40]; the other compared TEP with Lichtenstein with 5-year clinical examination of 1370 patients when using a mesh size of 12 × 15 cm and showed a recurrence rate of 3–5% [41].

Animal data have suggested that a minimum of 3 cm mesh overlap is essential to prevent mesh protrusion through the hernia defect resulting in recurrence [42].

It should be emphasized that 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 [37, 43, 44].

Some surgeons routinely cut the mesh making it curved, i.e., rounding off the edges. This is not necessary, but may diminish the mesh size significantly. 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.

Should the Mesh Have a Slit or Not to Surround the Spermatic Cord?

Current Statements

- **Level 1**: Cutting a slit in the mesh to allow the structures of the funicle to pass through does not compromise testicular perfusion and testicular volume
- **Level 3**: There are no important differences between slitting and no slitting for complications or recurrences (except one study (Bittner)),but the incidence of chronic pain and neuralgia is higher

Current Recommendations

- **Grade B**: In most of the cases, cutting a slit in the mesh to create a new inner inguinal ring should be avoided

9.2.6 Comments

We identified one randomized trial [45]. In this three-armed study including 360 patients, a TAPP procedure was performed. In group A, the mesh was implanted through a central incision, creating a deep inguinal ring by overlapping the two incised sides. In groups B and C, a non-incised mesh was used which was fixed with staples in group B and with nonabsorbable sutures in group C. The authors reported no significant differences between the groups regarding operation times, postoperative complaints, and need for pain killers. Furthermore, they found only one recurrence in group C (no recurrences in group A and B).

Moreover, we found one comparative study with historical controls [46] including 2700 TAPP procedures from a single institution. After a median follow-up time of 26 months, there were 28 recurrences, 9 (0.3%) of which were due to insufficient closure of the mesh slit. From the same institution, a later prospective study involving 8050 procedures without slit in the mesh reported an overall recurrence rate of 0.4% [47].

We identified one new randomized trial [48]. In this trial [1] 40 patients undergoing TEPP were randomized to a slit or no slit. Doppler ultrasound was performed preoperatively, day 5 and after 6 months. There were no significant differences in testicular perfusion and volume.

Finally, one case-control study [49] with a retrospective design compared 78 patients undergoing TEP with a slit mesh with 300 patients undergoing TEP with a no-slit mesh. Number of patients included was not based on a power analysis. Patients had a 12 × 15 cm polypropylene mesh. Clinical recurrences were seen in 0.6% in the slit group and in 6% in the no-slit group ($P < 0.01$), but chronic testicular pain and neuralgia were more often after slit mesh implantation ($p < 0{,}009$). Moreover follow-up after 3 years was either with telephone interview or clinical examination; however, the study quality was questionable since significant bias may have been involved in patient selection for slit versus no slit, e.g., mean follow-up in the non-slit group was nearly double compared to the slit group.

Thus, there is no convincing evidence to support use of a slit in the mesh for laparoscopic inguinal hernia repair.

9.2.7 Peritoneal Closure

Statements

- **Level 3**: Incomplete peritoneal closure or its breakdown in endoscopic preperitoneal hernia repair increases the risk of bowel obstruction

Recommendations

- **Grade B**: A thorough closure of peritoneal incision or peritoneal tears larger than 1 cm should be done
- When suturing the peritoneum, reduction of the intra-abdominal pressure should be done

The bowel obstruction can develop due to adhesions between omentum or epiploic appendices and suture line, between the mesh and the intestines, e.g., by inadequate closure of a peritoneal lesion [50–54]. The peritoneal opening must be thoroughly closed in order to prevent contact of viscera with the prosthetic mesh material and to reduce the risk of bowel obstruction. The closure can be achieved with staples, tacks, running suture, or glue. The last two methods mentioned are more time-consuming but less painful [7, 22].

The reduction of intra-abdominal pressure (e.g., 8 mmHg or even less) facilitates the peritoneal closure during the running suture especially in difficult cases [7, 22].

9.2.8 Port-Site Closure

Statements

- **Level 2A**: Use of 10 mm trocars or larger may predispose to hernias, especially in the umbilical region or in the oblique abdominal wall

Recommendations

- **Grade B**: Trocar sites with fascial defects of 10 mm or larger should be closed

Port-site hernia is a late postoperative complication predominantly reported in TAPP repair. Although, according to general opinion, only 10 mm and bigger trocar site defects should be closed, the development of incisional hernia with consequences was described even with 3–5 mm trocars [55–59].

A review of 63 reports (24 case reports, 27 original articles, 7 technical notes, and 5 review articles) was published in 2004 [60]. The evidence level of these reports varies from 1 to 3. Recommendation B concerns the closure of trocars of 10 mm or bigger.

9.2.9 Conclusion on Technical Key Points in TAPP Repair

The multitude of data published on this subject presents different levels of evidence, but particular technical key points are well investigated [61, 62]. Some expert opinions lack supporting data, but some steps of the TAPP technique are clearly supported by strong levels of evidence. The grade of recommendations varies from A to D.

The proven technical key points should become the pillars of the standardized TAPP repair, transferred to the wide surgical community and emphasized in the teaching and learning environment to guarantee the best possible outcomes.

9

9.3 Specific Risks

Specific risks of TAPP in comparison to open inguinal hernia repair are (1) injuries to the bowel, (2) injuries to the urinary bladder, (3) injuries to the aorta and iliac vessels, (4) bowel obstruction, and (5) trocar hernias.

Ad 1 Creating the pneumoperitoneum and placement of the first trocar are the most dangerous parts of the operation, because both acts are blind procedures. Therefore, some authors recommend an open access to the abdominal cavity (Hasson technique). However, even when using this technique, lesions to the bowel are not completely avoided (Fig. 9.30).
A systematic review of the literature could not show any significant difference between the Veress needle and the open techniques (Kukleta [3, 4]).

In our practice we use the Veress needle but we always do the "safety tests" according to K. Semm. When doing this it is important to develop a specific feeling with your thumb and

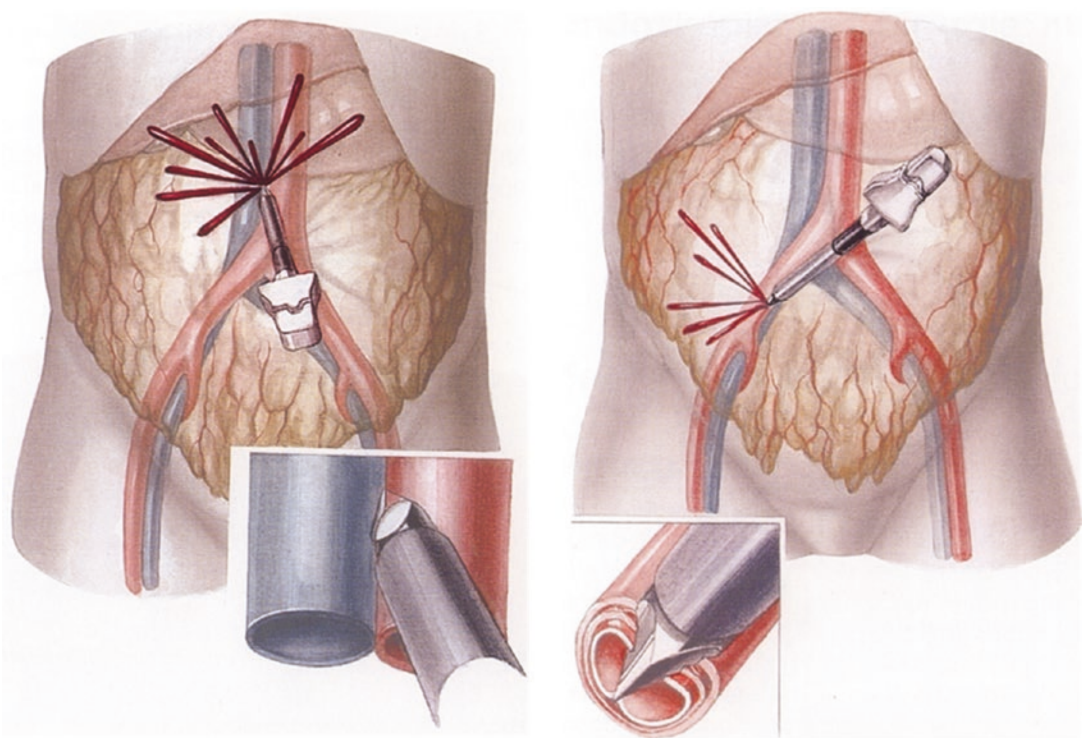


Fig. 9.30 Access-related vascular complication

index finger which hold the needle when perforating the fascia or the peritoneum (snap test). Furthermore it is essential to observe the insufflator very carefully. In the case that when starting with the insufflation the intra-abdominal pressure is high (>2–3 mmHg) and the gas flow is low (<1 ml/min), the needle has to be removed because something may be wrong. In these cases showing difficulties when creating the pneumoperitoneum by the Veress needle, we have two alternatives: (1) use the open technique (Hasson) or (2) choose the "palm point" (below the left costal margin, medio-clavicular line) for the Veress needle.

In patients with previous periumbilical surgery, it should be started at the palm point.

In addition in TAPP injuries to the bowel are possible in patients presenting with extensive adhesions of the bowel to the inguinal region or to the hernia sac. In these cases the indication for TAPP must not be overstressed. The surgeon being not familiar with adhesiolysis should better do an open repair in these cases. But never take down adhesions between the bowel and the hernia sac. This is not necessary and carries a high risk for a bowel lesion. In TAPP the hernia sac inclusive the adherent structures is reduced "en bloc."

The last possibility for an injury of the bowel is accidentally by using monopolar electric for bleeding control. Therefore, when using heat always the whole metallic tip of the instrument must be under view control.

Ad 2 Injuries to the urinary bladder may happen not only in TAPP but also in TEP, as the operating field in the groin is identical. In patients without any history of surgery in the preperitoneal space between the urinary bladder and the pubic bone (space of Retzius), the risk for a lesion of the bladder is very low. A damage of the wall of the urinary bladder may be caused by a rough dissection technique, by excessive use of electric coagulation, or fixing the mesh to the wall of the urinary bladder. In order to avoid this complication, a gentle blunt dissection technique is recommended, and if there is some bleeding, use first a compression with a gauze for some time, and last use bipolar electric but very punctually. Indeed in patients after transabdominal prostate resection, the risk for a lesion of the urinary bladder is clearly increased, but in these patients TAPP should be reserved for specialists.

Ad 3 Injuries to the big vessels are exclusively caused by inadequate rough introduction of the trocars or applying a rough dissection technique. When introducing the trocars, keep in mind that the distance between the back of the abdominal wall and the aorta is only about 3 cm. It is strongly recommended to use blunt trocars and develop a feeling for the resistance strength of the abdominal wall when introducing them and never lose the view control.

Ad 4 Very rarely the postoperative course after TAPP may be complicated by bowel obstruction. An insufficient closure of the peritoneum or inadequate use of some suture material [63] is the cause of this unpleasant sequela in the vast majority of the cases. It must emphasized that a tight closure of the peritoneal incision, best by an absorbable monofilament suture, is an essential step of the operation, because a gap of 1 cm only left may lead to this complication.

Ad 5 In contrast to TEP, more trocar hernias occur in the later postoperative course. At the umbilicus when using a 10 mm optic trocar after 5 years, about 3.2% trocar hernias were seen [2], despite closure of the opening intraoperatively. Therefore it may be helpful for prevention of this late complication to reduce the diameter of this trocar by using a 5 mm optic. Furthermore for introduction of the working trocars, a transmuscular (m. rectus abdominis) route is recommended.

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Check for updates

TAPP: Complications, Prevention, Education, and Preferences

Reinhard Bittner, Jan F. Kukleta, and David Chen

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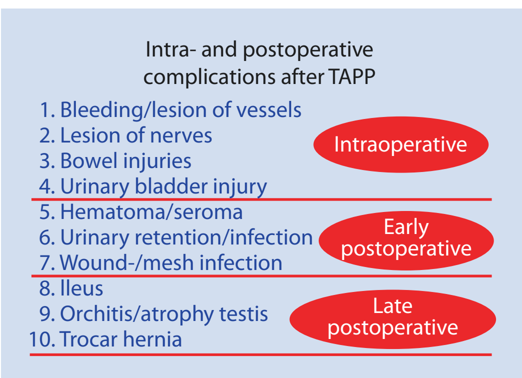
TAPP is a complex technical procedure. There are many possibilities for complications which may occur intraoperatively, early postoperatively, and in the late postoperative course (◘ Fig. 10.1).

10.1 Complications

10.1.1 Ad 1: Bleeding/Lesions to the Vessels

Injuries of the aorta, caval vein, or the iliac/femoral vessels are very rare but life-threatening. In one comprehensive literature overview [1], 3 out of a total of 3503 laparo-endoscopic hernia repairs (0.09%) were observed, in another overview none out of 2997 patients [2], but there may be a larger number unreported. *In most cases, the causes of these severe complications were rough introduction of a trocar or a crude operative technique.* In our own experience with more than 15,000 TAPPs, no injury of the great vessels was seen. Injuries to the epigastric vessels which are caused when opening or closure of the peritoneum in TAPP are more common but rather harmless and easy to treat either with electrocoagulation or by clipping. Some branches of the inferior epigastric vessels may be injured when introducing the working trocars especially when using perforators with a sharp cutting tip (◘ Fig. 10.2a). Using this sharp three-edged perforator, we saw bleeding from the trocar site in 0.9%, but using a perforator with a conical tip and expanding working mechanism, the occurrence of this kind of bleeding could be reduced down to 0.067% (◘ Fig. 10.2b).



◘ **Fig. 10.1** Intra- and postoperative complications after TAPP

Preventive strategies are Deep knowledge of anatomy. Gentle blunt dissection technique and carefully respecting the anatomical layers. Use of blunt perforators with expanding working tips [3]. Removal of the trocars under view and observe the trocar site for some seconds.

10.1.2 Ad 2. Lesions of the Inguinal Nerves

In the literature, the information on violations of the inguinal nerves varies between 0.8% [2] and 3.8% [1]. Most commonly affected is the N. cutaneous femoris lateralis in nearly 60% of the cases (◘ Fig. 10.3) [4]. Nerve injuries are caused by direct trauma to the nerve either due to rough dissection or use of electrocoagulation for bleeding control near to the nerve. Postoperatively, these patients will complain about some numbness or complete loss of sensitivity in the corresponding skin area. Much more worse is the case when a clip or tack for mesh fixation was put to the nerve, because this will result in intractable pain. In our experience, we observed a lesion to the nerves in 0.3% but exclusively a damage to the N. cutaneous femoris lateralis, produced by thermic application [34].

Preventive strategies are Deep knowledge of anatomy. Gentle blunt dissection technique and

◘ **Fig. 10.2** **a** Sharp-edged cutting perforator. **b** Blunt expanding perforator

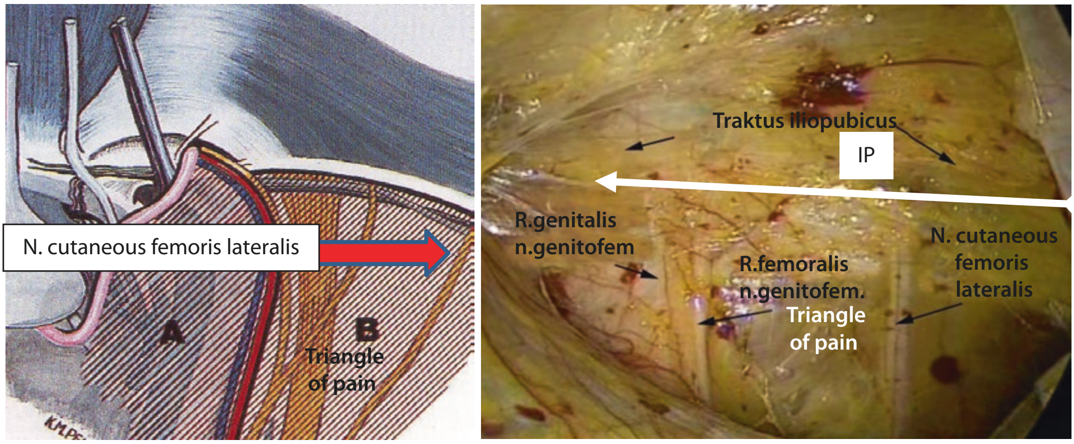


Fig. 10.3 Right inguinal region. Triangle of pain, caudally of the ileo-pubic tract and laterally to the testicular vessels

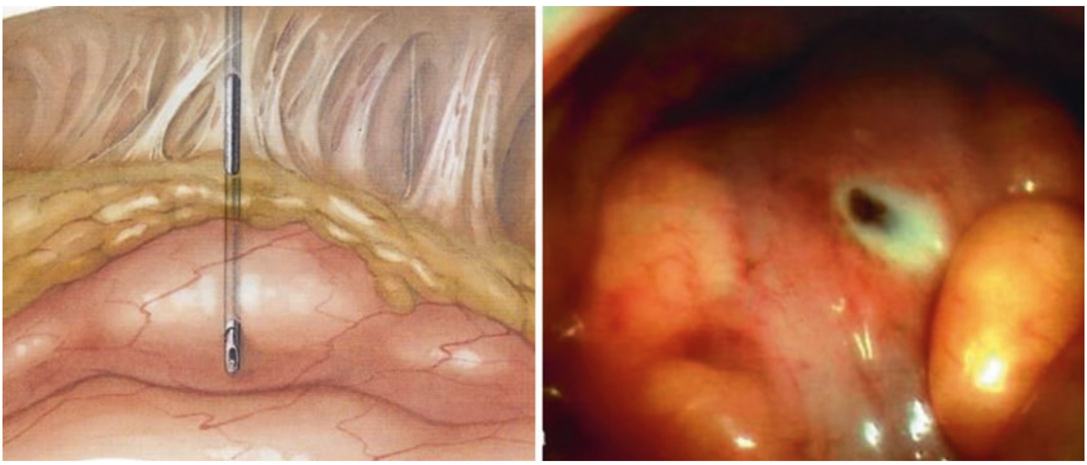


Fig. 10.4 Mechanism of bowel violation by Veress needle or electrocautery

carefully respecting the anatomical layers especially the deep layer of the transversalis fascia. Avoid use of monopolar electric in the region of the “triangle of pain” (Fig. 10.3), and this is a law: Don’t put clips or tacks in this region and up to 1–2 cm above of the ileo-pubic tract.

10.1.3 Ad 3: Bowel Lesion

According to the literature, lesions to the bowel are described between 0% [2] and 0.1% [1]. In our own experience, it happened in 0.1% (47). The cause of this life-threatening complication may be a direct violation by the Veress needle or by electrocautery or during adhesiolysis when keeping down adhesions after surgery in the lower abdominal cavity to gain access to the groin (Fig. 10.4).

Preventive strategies are In patients after previous periumbilical surgery, use open access (Hasson) or the Palm point (see above). Be maximally careful when gaining first access to the abdominal cavity. Adhesions to the groin or to the hernia sac must not be taken down; in these cases the incision of the peritoneum should atypically be carried slightly above the adhesions. Always keep the whole metallic tip of the instruments when using heat under direct vision. In cases with excessive adhesions of the bowel with the anterior abdominal wall, it may be advisable to convert to open surgery.

10.1.4 Ad 4. Urinary Bladder Injury

In literature, damages to the urinary bladder are described between 0.07% [2] and 0.1% [1] of the cases with laparo-endoscopic hernia repair. In our own setting, we saw this complication in 0.1% of TAPP patients [34], nearly exclusively after previous surgery in the preperitoneal pelvic space (e.g., transabdominal prostate resection, preperitoneal mesh) presenting with severe adhesions (Fig. 10.5). Cave, sometimes the urinary bladder, may be part of the hernia sac and can be injured when the surgeon is not aware of this (Fig. 10.5 left). Dissection of the preperitoneal space (Retzius) is quite easy in patients having had no previous surgery (Fig. 10.5, right, above), but may be extremely difficult in patients after previous prostate resection (open and laparoscopically which makes no difference) or after previous TAPP or TEP (Fig. 10.5 right, low).

Preventive strategies are Gently performed blunt dissection of the space of Retzius. In cases in which severe adhesions are to be expected, choose an open repair except great experience in such difficult cases is provided [5].

10.1.5 Ad 5. Hematoma/Seroma

In some clinical reports, it is not differentiated between hematoma and seroma. Moreover, there are no clear definitions of these relatively common complications; in so far the real occurrence is not exactly known. According to the literature after laparo-endoscopic hernia repair, hematomas are observed in between 4.4% [2] and 13.1% [1] of the cases and seromas between 4.4% [2] and 12.2% [1] of the cases. In our own large series, we saw bleeding complications in 0.3% and seromas in 0.1% (reoperated) of our patients [34]. The diagnosis is made by ultrasound (Fig. 10.6a, b).

Prevention strategies Anticoagulation with coumarin derivatives should be stopped and replaced by low-molecular heparin (Quick >60%). Other anticoagulation drugs like aspirin, Plavix, and Xarelto should be finished about 8 days before the operation. Dissection in the anatomical layers and meticulous bleeding control. Furthermore, it is recommended that in large direct hernia the pseudosac should be inverted and fixed to Cooper's ligament in order to reduce the dead space (Fig. 10.7).

10.1.6 Ad 6. Urinary Retention/Infection

According to the literature after laparo-endoscopic hernia repair, urinary retention is reported about 3.5% [1] and 3.8% [2] of the cases, in one single-center study even up to 22.2% (10). In our own large series, we saw urinary retention in 0.5% of our patients and an infection in 0.1% only [34].

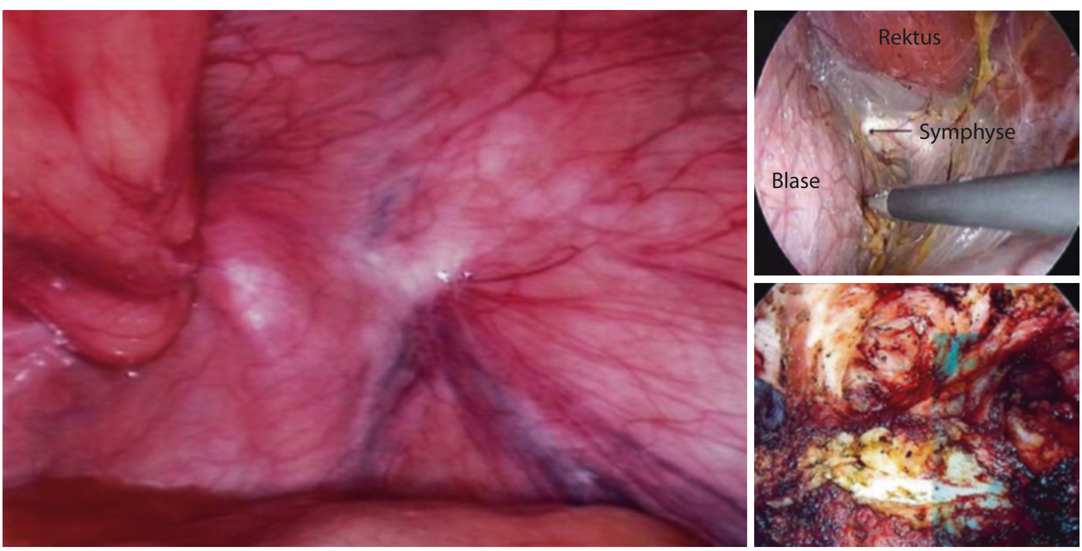


Fig. 10.5 Laparoscopic view of the groin in a patient after transabdominal prostate resection. *Right superior*: Spatium of Retzius in a patient without previous operation. *Right below*: Completely scarred preperitoneal space after previous mesh implantation

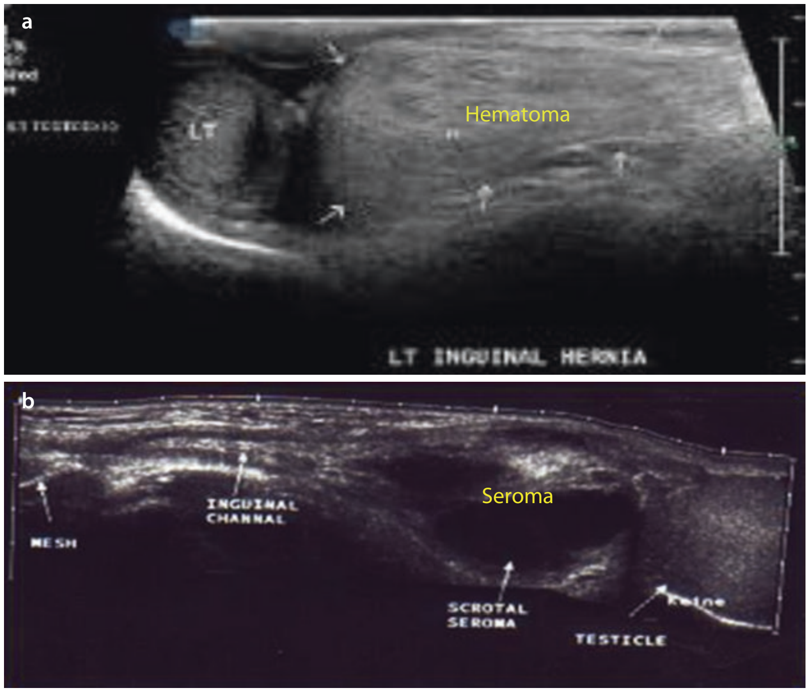


Fig. 10.6 **a** Hematoma along the cord. **b** Seroma within the scrotum after repair of a scrotal hernia

Preventive strategies are Gentle dissection in the space of Retzius to minimize the trauma to the wall of the urinary bladder. Emptying the urinary bladder immediately before the patients leave for the operating theater. Restriction of liquid infusion during anesthesia to a maximum of 500 ml. Routine use of urinary catheters is not recommended.

10.1.7 Ad 7. Wound/Mesh Infection

According to the literature after laparo-endoscopic hernia repair, the occurrence of wound infection is reported between 0.5% [2] and 1.0% [1] of the cases; in our large series, we saw a wound infection in about 0.04% (47). But all of these patients received "one-shot" antibiotic prophylaxis. A mesh infection was seen in 0.1% of the cases. In most of these cases, the infection occurred after a puncture of a seroma.

Preventive strategies are Aspiration of seromas should be avoided. Sometimes absorption of a large seroma needs several months. Adequate guidance of the patients and control by ultrasound are important. Any contact between the mesh and the skin must be avoided. The value of antibiotic prophylaxis is debatable; however, antibiotic prophylaxis should be considered in the presence of risk factors like advanced age, corticosteroid usage, immunosuppressive conditions, and obesity [35–37].

10.1.8 Ad 8: Bowel Obstruction

Bowel obstruction is very rare and reported anecdotically. We saw this complication in three cases (0.03%), who needed a reoperation [34]. The cause was in all cases a reopening of the peritoneal closure.

Preventive strategies are Careful tight closure of the peritoneal incision by an absorbable running suture (see ▶ Chap. 9).

10.1.9 Ad 9. Orchitis/Testicular Atrophy

Orchitis and atrophy of the testis are rare complications after laparo-endoscopic hernia repair; in literature, a frequency of between 0.15% [2] and 0.6% [1] is reported. In our total experience of more than 15,000 TAPPs, we saw an atrophy of the testis in six patients (0.04%), but the last was 20 years back. Four of these six patients suffered from a complex hernia (three recurrent scrotal hernias, one recurrence after TAPP). In all these patients, the hernia sac was very close to the testicle. When trying to completely remove the hernia sac, the blood circulation must have been destroyed near the testicle.

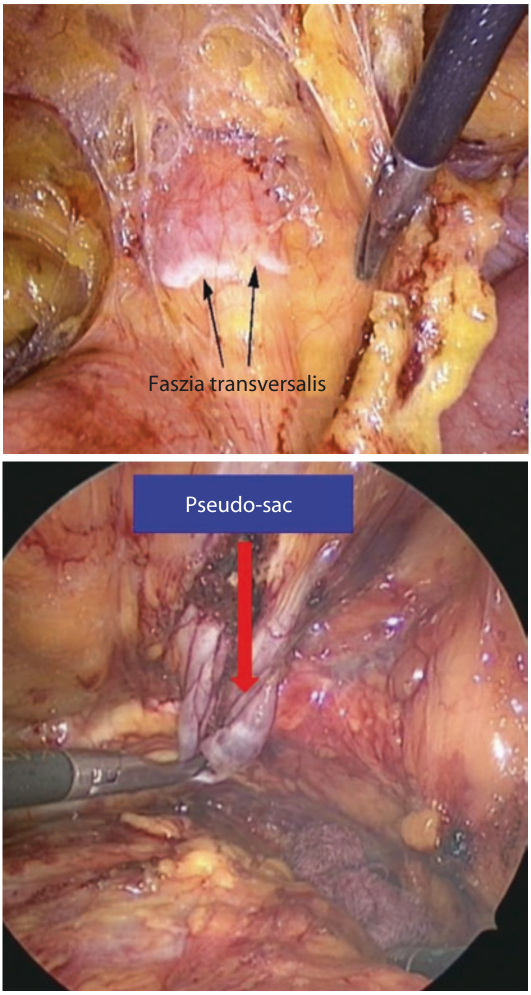


Fig. 10.7 Direct hernia. The enlarged transversalis fascia (hernia pseudosac) is inverted and fixed to Cooper's ligament with suture or tacks

Preventive strategies are Don't dissect too close to the testicle. In case of a long hernia sac showing dense adhesions to the cord, cutting of the hernia sac is recommended (see ▶ Chap. 9). The distal part of the sac should be left open; the proximal part of the sac must be closed by suture. Furthermore, in unclear hernia pathology it is recommended firstly to identify the vessels lateral/caudal near the kidney and then use the vessels as guiding structures to dissect the hernia sac up to the top (see ▶ Chap. 9).

10.1.10 Ad 10. Trocar Hernias

Trocar site hernias (Fig. 10.8) can occur in up to 7.7% [6]. There seems to be a clear relationship between the frequency of trocar hernias and the diameter of the trocar, the shape of the tip of the perforator, and the place the trocar is inserted. Montz FJ et al. [7] could show that in nearly 90% of these patients a trocar with a diameter equal or larger than 10 mm was used in the patients who developed a trocar hernia in the later course. Ridings P and Evans DS [6] reported a frequency of 7.7% trocar hernias when using cutting trocars, but they observed not any hernia when using blunt trocars with a conical tip which is working expanding. Similar results were observed by us: Using sharp trocars the frequency of trocar hernias was 1.27%, but using blunt trocars the frequency was 0.01% only. Furthermore, the risk is significantly increased when the midline is used for inserting the trocars [8]. In our long-term study 5 years after TAPP, we saw in 3.2% of the patients a trocar hernia at the umbilicus and not any at other positions.

Preventive strategies are (1) Use trocars as small as possible. As now 5 mm optics are available; there is no longer a need for 10 mm trocars at the umbilicus. In order to bring in a standard mesh, a 7 mm working trocar (see above) is sufficient. In special cases when using an extra-light mesh, it is possible to insert it through a 5 mm trocar. For the second working trocar, a 3 mm or 5 mm trocar can be used. (2) Insert only trocars with a blunt expanding working tip. (3) For cosmetic reasons the umbilicus is an ideal place for trocar placement, but it should looked for if at the umbilicus some weak tissue is present. In these cases after removal of the trocar, the opening should be closed like it is performed in an umbilical hernia.

10.2 Pitfalls and Prevention

As complications after TAPP can occur with any surgeons, pitfalls are as a rule caused by lack of knowledge of the anatomy or of proper operative technique. Pitfalls are rare and only anecdotally described, however, from such unpleasant mishaps we can learn and better understand the principles of the operative procedure. The following reports some events which actually happened.

10.2.1 Ad 1. Mismatch of Anatomy

First case The surgeon mistook the femoral vein with a femoral hernia sac (Fig. 10.9a). He tried to

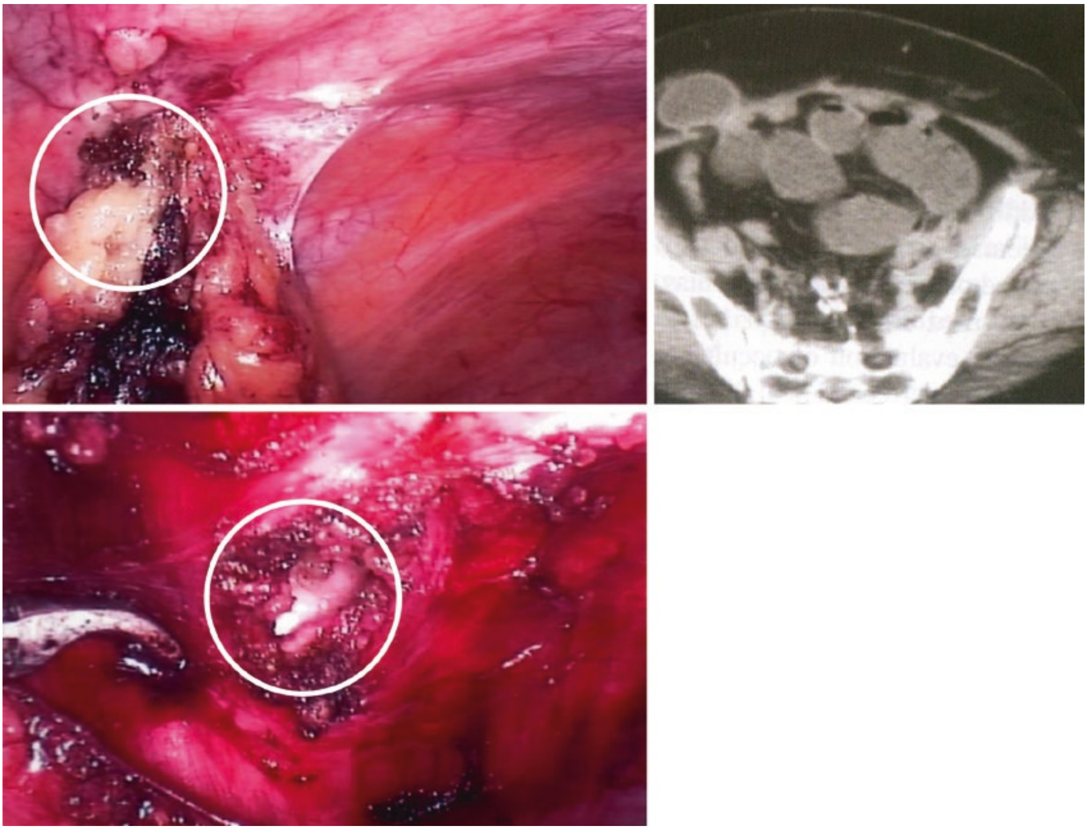


Fig. 10.8 Trocar hernia

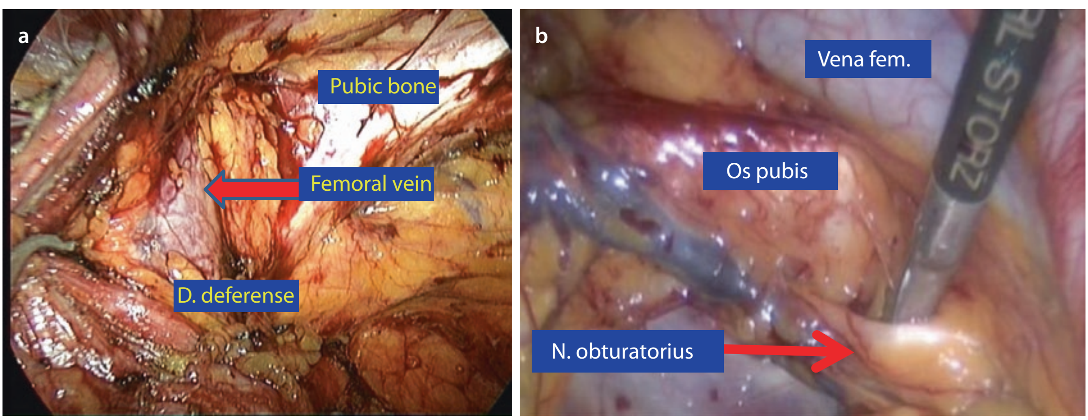


Fig. 10.9 **a** Mismatch of the femoral vein with a femoral hernia sac. **b** Mismatch of the N. obturatorius with the ilioinguinal nerve

reduce the hernia sac, but this was impossible; therefore he decided to cut the sac, and not before doing this he became aware that he had cut the vein.

Second case A female patient complained about intractable pain in the groin after open inguinal hernia repair; therefore he decided to perform a neurectomy of the ilioinguinal nerve. It is unclear why, but he resected the obturator nerve (Fig. 10.9b). After the operation, the patient not only continued to have pain but also difficulties when walking.

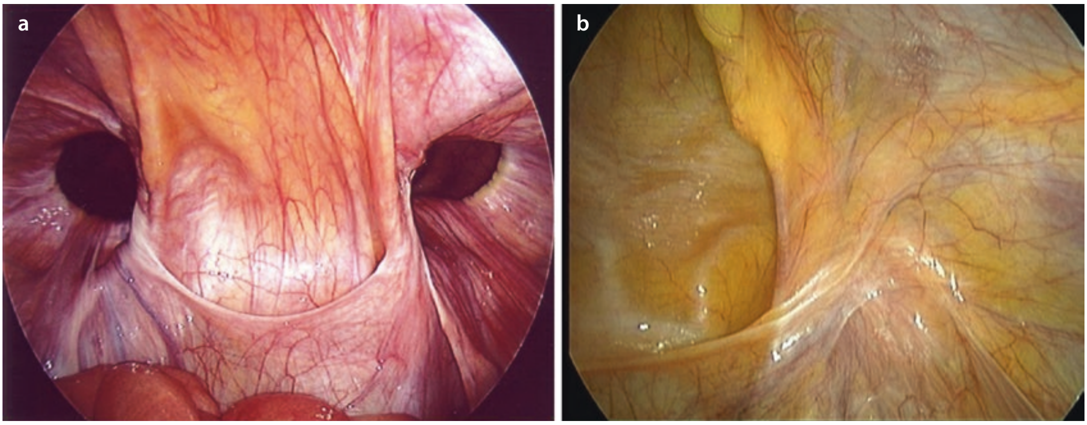


Fig. 10.10 **a** Clear visible large hernia defects on both sides. **b** No defect is visible, but clinically and by ultrasound seen a large lipoma in the inguinal canal mimicking a hernia

10.2.2 Ad 2. Mismatch of the Side of the Hernia

Not always the hernia defect is clearly visible at laparoscopy (Fig. 10.10a). In many cases, despite unequivocal clinical diagnosis no hernia opening can be seen (Fig. 10.10b). In the rule the reason for this may be a large lipoma representing the hernia pathology without any deep hernia sac (Fig. 10.10b). Unfortunately, it can happen that on the contralateral side, some excavation may be visible and then the surgeon operates on that side. Therefore, it is recommended that preoperatively the location of the hernia should be marked.

10.2.3 Ad 3. Adhesions Between Omentum and Bowel with the Hernia Sac

Case report: Male, 49 years, scrotal hernia. *Laparoscopy*: Adhesions between parts of the omentum and of the bowel with the hernia sac. *Procedure:* Firstly sharp adhesiolysis of the hernia content from the hernia sac with scissor, then TAPP. Difficult closure of the peritoneum because of multiple defects due to the adhesiolysis. *Postoperative course:* Pain right lower abdomen and right flank. At third postoperative day urologic consultation – in CT scan – suspected abscess formation. *At fifth PO day reoperation*: Severe peritonitis and abscess due to some lesions in the wall of the small bowel. Next day: Septic shock and death of the patient. Conclusion: Two severe mistakes, (1) unnecessary adhesiolysis and injury to the bowel and (2) too late reintervention.

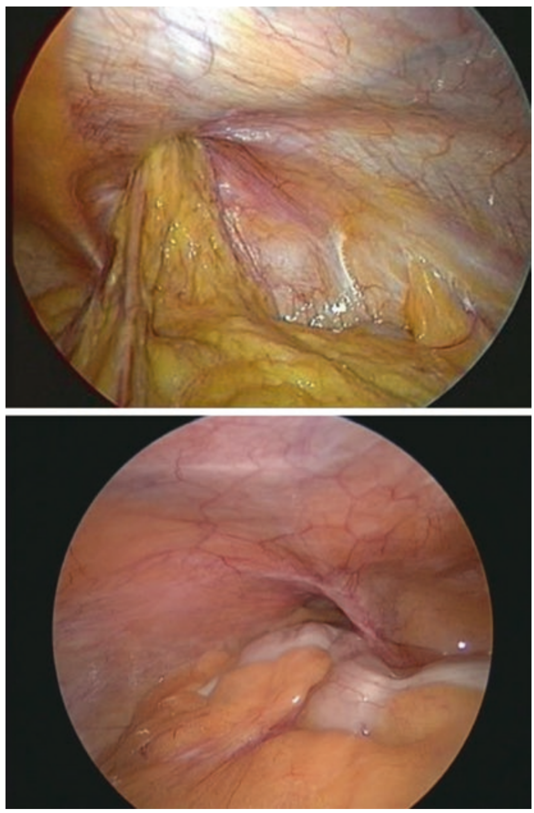


Fig. 10.11 Indirect hernias, omentum, and sigmoid bowel are adherent to the hernia sac

Preventive strategy It is not necessary but dangerous to release adhesions between the hernia sac and the hernia content intraoperatively found (Fig. 10.11). Hernia sac and hernia content should be reduced "en bloc" without touching the content.

10.2.4 Ad 4. Pitfalls Due to Fixation Errors

Case 1

Male, 49 years, 25 clips/tacks for fixation of the mesh and closure of the peritoneum (Fig. 10.12). Postoperatively severe pain in the groin, not possible to walk for 7 days. With painkiller improvement, but under physical stress intensity of pain increased again. Furthermore, suffering of pain when emptying the urinary bladder, with bowel movements, and during sexuality.

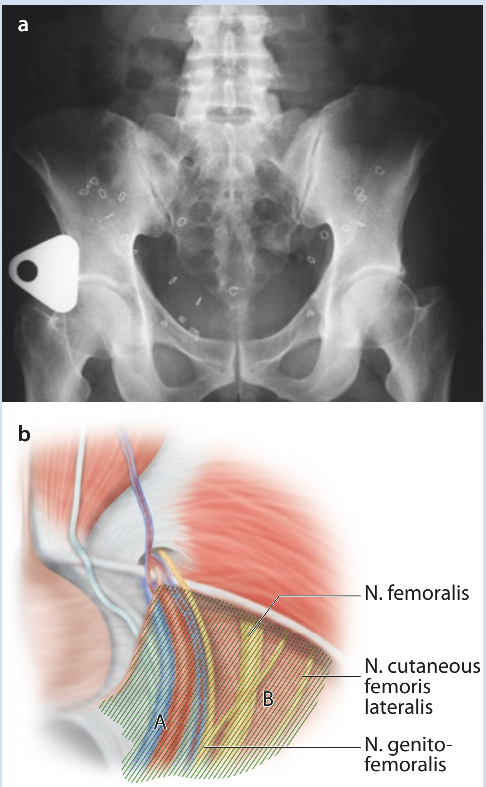


Fig.10.12 X-ray of the groin after tack-fixation

Case 2

Female, 43 years, BMI 20,3: Bilateral TAPP. Twenty-five spiral tacks for fixation of the mesh and closure of the peritoneum. Postoperatively severe pain VAS 7. After 3 month's pain and defense right lower abdominal quadrant, thickening of the wall of the ascending colon. Reoperation: Fistula between one spiral tack and the coecum. Removal of 12 tacks and closure of the fistula. Because of persisting pain 2 months later removal of 13 tacks from the other side and removal of both meshes. Result: Still persisting severe foreign body feeling not being able to do any physical activities.

Case 3

Male, 52 years. Unilateral TAPP. Fixation of the mesh and closure of the peritoneum with staples. Postoperatively intractable pain (Meralgia paresthetica) in the groin and numbness proximal lateral skin of the thigh. Fifteen days later laparoscopic reoperation: Removal of a piece of mesh (2 × 2 cm) lateral/cranial in the region of the spina iliaca anterior superior and removal of six clips. Postoperatively pain and numbness persisted. Seventeen months later open removal by a neurosurgeon of an additional clip which was sticking in the femoral cutaneous nerve. As the neurosurgeon didn't see any mesh in this region, it must be assumed that this clip was placed not to fix the mesh but to close the peritoneum.

Case 4

Male, years. Bilateral TAPP. Fixation of the mesh with glue. Early recurrence on one side. Reoperation after 10 days: Direct recurrence, no mesh medially (dislocation?). Implantation of a second mesh but now fixation with clips. Postoperative course: Urinary retention and hematuria, treated by Foley catheter for 24 h. Three months later while jogging occurrence of hematuria. Cystoscopy verified mesh within the urinary bladder (Fig. 10.13). Open reoperation by a urologist and resection of this part of the wall of the urinary bladder. The pathologist found mesh and clips sticking into the wall of the urinary bladder.

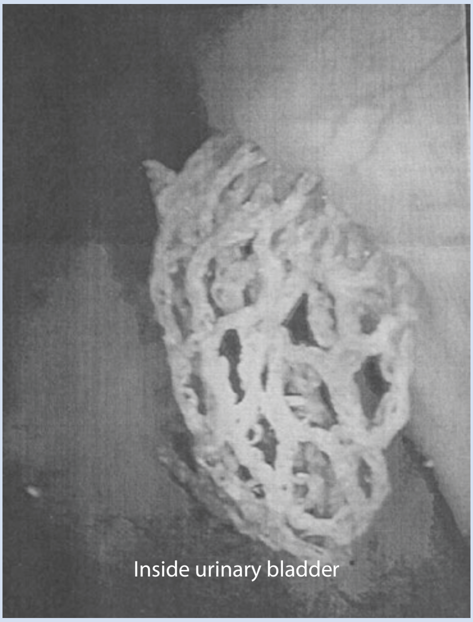


Fig. 10.13 Cystoscopy: Mesh inside of the urinary bladder

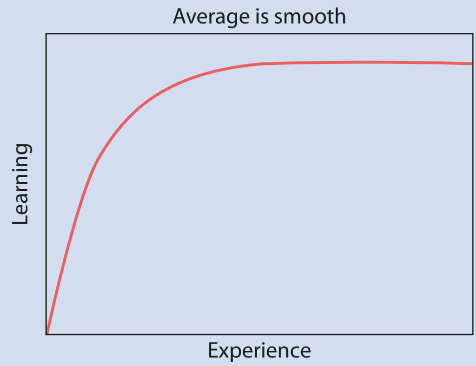


Fig. 10.14 A learning curve averaged over many trials is smooth and can be expressed as a mathematical function

Preventive strategies Laparo-endoscopic hernia repair works according to the principle of Pascal. In so far in the vast majority of the cases, a fixation of the mesh is not necessary if the mesh has an adequate size (at least 10 × 15 cm) and an overlapping of about 5 cm is guaranteed (3,4,9). Fixation is recommended only in patients presenting a hernia defect with a diameter larger than 3–4 cm. In these rather rare cases, an atraumatic fixation with glue should be applied; only in very large direct defects (>4 cm) absorbable tacks may be used. But tacks should only be applied to the rectus muscle and to Cooper's ligament which must be clearly anatomically identified. A mesh fixed by glue or tacks cannot move or migrate but may penetrate if fixed to the urinary bladder or near the bowel.

The peritoneal incision should never be closed by clips or tacks but by an absorbable running suture. Suture closure is less expensive and safer and causes less pain.

10.3 Education and Learning Curve

Laparo-endoscopic hernia repair is considered to be a difficult operation with a long "learning curve" and not suitable as an operation for trainees. The learning curve is defined as the number of TAPPs that is needed to acquire the necessary skills. A *learning curve* is a graphical representation of the increase of learning (vertical axis) with experience (horizontal axis) (Wikipedia) (Fig. 10.14).

The goals in hernia surgery that must be achieved are low morbidity, low recurrence rate, and low rate of acute and chronic pain. Accordingly, duration of learning curve in laparo-endoscopic hernia surgery means number of procedures needed to achieve the average plateau in the rate of complications and undesired side effects which is reported in literature.

The familiar expression "*a steep learning curve*" is intended to mean that the activity is difficult to learn, although a learning curve with a steep start actually represents rapid progress. In order to avoid this rather confusing terminology, it seems to be better the term *learning curve* with meanings of *easy* and *difficult* should be described with adjectives like *short* and *long* rather than *steep* and *shallow* (Wikipedia).

However, the data published that described education and how to overcome the learning curve in inguinal hernia repair are extremely contradictory. Some studies evaluated the learning curve by studying the operation time [9–14], conversion rate [9, 10, 12, 15, 16], or number of recurrences [36, 9, 10, 15–18]. According to these studies, between 20 and 240 procedures are required for the learning curve to reduce operation time, morbidity, and recurrence rate to a stable level in line with experienced surgeons. The cause for the large differences in the number of operations necessary to become familiar with the new technique lies in the remarkable heterogeneity of these studies. Many factors may influence the learning curve, including previous individual and institutional experiences in hernia surgery, and specifically in the laparo-endoscopic technique. Furthermore, the number of hernia repairs in the respective institution performed per year may be important, as may be the selection of patients for laparoscopy, the details of the technique and their standardization, and the structure of the training. In addition individual skill preexisting experience of the trainee with other laparoscopic procedures like cholecystectomy, the number of prestudy camera guiding, and the strictness and duration of supervision by an experienced surgeon may play a role when defining the learning curve. In analyzing the literature, you will not find any study in which all these factors are included when estimating the duration of the learning curve. In this context, it is important to differentiate between the learning curve of surgeons establishing this new technique and the learning curve of young surgeons working in a hospital where TAPP already has been fully standardized and is performed as a daily routine procedure. Our large study [19] about more than 15,000 cases clearly demonstrates that senior surgeons well experienced in open surgery who had started laparoscopic inguinal hernia repair had needed significantly more operations to decrease morbidity and recurrence rate down to today's standard level than did trainees who started not before TAPP was a well-standardized procedure in the hospital. Moreover, the total morbidity in the patients operated on by the trainees was significantly lower than those operated on by the pioneers, which amounted to a level of 3–4% already in their first lot of operations (operations 1–50). Even more strikingly, in the patients operated on by the trainees, we observed a recurrence rate that was less than 1% even from the beginning. Accordingly, our overall results achieved by the 23 individual surgeons included in the hernia program demonstrate that it is just the operation time that demonstrates a significant learning curve. Therefore according to our large experience, TAPP is not just a surgery for specialists but also for young surgeons in training, who can achieve excellent results [19]. Without any doubts, operation time is longer when performed by less experienced surgeons or trainees, but this does not influence long-term results, and the trainees demonstrated a continuous improvement in terms of the operation time. These results are in sharp contrast to the reports in the literature. One study reported a recurrence rate of 14.3% in patients operated on by less experienced surgeons (level 1, 10 procedures performed), but 2.4% for experienced surgeons (level 3, 25 hernia repairs) [20]. A large randomized clinical trial reporting long-term results of 1183 patients operated on in seven surgical centers by a total of 12 TAPP surgeons found the recurrence rate at the different hospitals to range between 5% and 13% and for the individual surgeons 0–23% [38]. A further large randomized controlled trial [39] including 12 hospitals and 22 TEP surgeons demonstrated a 5-year recurrence rate ranging from 0% to 32% for the individual surgeons and 0 and 13.5% for the different hospitals. These extremely large differences in the quality of hernia surgery between hospitals and individual surgeons who had taken part in the abovementioned studies demonstrate clearly that there is an urgent need for strictly standardization of the technique worldwide and a better structured education as well [36, 11, 14, 15, 17, 40]. Learning curve must only be a matter of duration of operating time but not a matter of quality of performance. In our department, in which TAPP is completely standardized, a gradually increasing number of younger surgeons and trainees became familiar with the new technique, but education must be well structured. The preconditions that the trainee will be included in the operation program are: (1) Trainees should do camera guiding for at least 50 times. (2) Trainees should have some previous experience with laparoscopic operations (25 laparoscopic cholecystectomies). (3) The operations should be done under the guidance of experienced surgeons until gaining sufficient proficiency; thus, many pitfalls and intraoperative problems could be anticipated and possible complications prevented. (4) TAPP must be strictly standardized, which made it easier for young trainees to become familiar with the laparoscopic anatomy and the operative strategy. In a similar study regarding the TEP technique, Haidenberg et al. [17] came to the same conclusion. They demonstrated that under structured guidance by an experienced endoscopic surgeon, young trainees benefit from the knowledge of the more senior surgeon. The experience and knowledge that the more experienced surgeons gained when establishing the new surgical technique can be passed on, thus avoiding typical possible problems in operations performed by the trainees.

In accordance with Miserez et al. [21], we advocate a stepwise learning of TAPP. This saves time and is more relaxing for both the trainer and the trainee. In our experience, it is best to start with intra-abdominal suture closure of the peritoneum because there is no danger to the patient. The next step is the opening of the peritoneum, then dissecting the medial compartment, mesh placement and glue fixation, and last, dissecting the hernia sac (most difficult and dangerous). In order to learn more easily and effectively, video recordings of the trainee operation should be created and analyzed in the clinical rounds afterward. In the discussion about making the operation more acceptable, operating time is an important issue, as is shortening the learning curve, e.g., a trainee will need more than 30 min solely to perform suturing the peritoneum for the first time. Considering the economic situation of most hospitals, such long operation times are hard for management to bear. Furthermore, as a result of current restrictions on resident duty hours and the huge increase in bureaucratic obligations, trainees spend less and less time in the operating theater. Thus, there is an urgent need to organize training more efficiently. In this context, training surgeons outside the operating room with simulation-based strategies (computer, video, model) is gaining increasingly more importance [22–27]. Several studies have demonstrated that trainees who practice laparoscopic skills in a simulated environment demonstrate improvement of those skills when tested in the same environment, but Zendejas et al. [28] were the first to demonstrate that a simulation-based mastery learning decreased operating time, improved trainee performance, and decreased intra- and postoperative complications after laparoscopic inguinal hernia repair. Skills training consisted of supervised practice sessions using the Guildford MATTU TEP hernia model [29] and standard laparoscopic equipment. A similar model [19] was developed in our department in cooperation with the company Karl Storz, allowing model simulation training of four steps of TAPP: opening the peritoneum, placing the mesh, and fixing and suturing closed the peritoneum.

In summary, laparoscopic hernia repair is a well-accepted technique in inguinal hernia repair that has significant benefits regarding all pain-associated parameters when compared to open surgery. Moreover, we demonstrated that laparoscopic hernia repair is a safe and promising method even if performed by young trainees. Laparoscopic hernia repair should therefore be an elementary part of the trainee program. Under the precondition that TAPP is well established in the clinic, that the operative technique is strictly standardized, and that there is a well-structured educational program, learning curve does not necessarily have to mean higher complication rates and recurrence rates. The depth of experience presented in this study demonstrates that the learning curve can be reduced to the operating time. In order to shorten the operating time and thereby make the surgery more efficient, model simulation training is strongly recommended.

10.4 Aftercare and Pain Management

Immediately after passing the recovery room, the patient is allowed to drink and to have some light meal. The mobilization starts when the patient needs to empty his urinary bladder. It is important that the patient gets up out of the bed, and when doing this for the first time that he is guided to the toilet by the nurse. After successful first mobilization, the patient can do it by himself next times. Moreover, he will be encouraged to carry his own clothes and walk around as much as possible.

All patients are advised to stay at least one night in the hospital for safety reasons. The morning after the operation, the patient is allowed to have a shower. Then, an ultrasound examination is performed and if there is no pathologic-anatomic peculiarity to be seen, the patient can be discharged home. All patients receive a standardized prophylactic pain medication with ibuprofen 600 mg three times daily plus stomach protection with 20 mg pantoprazole once per day. At the evening and the morning after the operation, pain at rest and physical stress (VAS) is recorded. All relevant patient data are documented in the German hernia registry “Herniamed”. When dismissed home, the patients are asked to fully

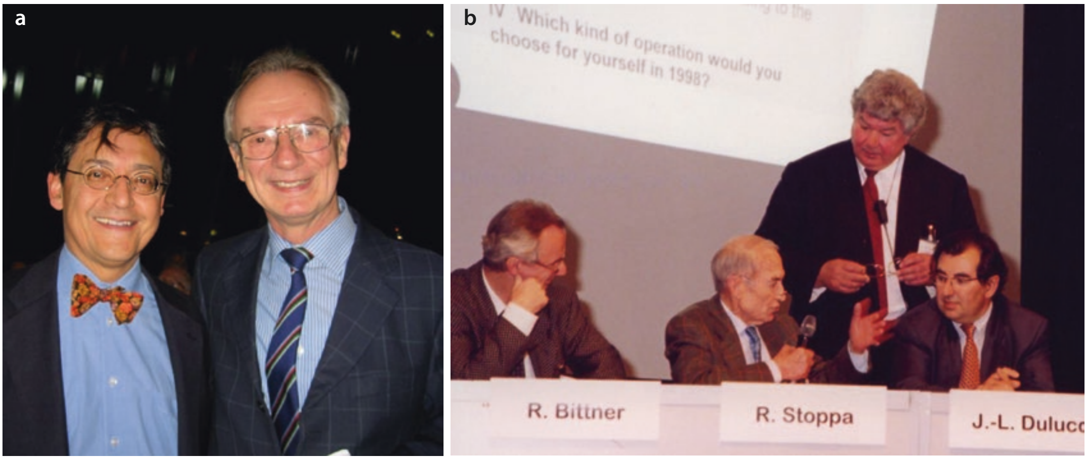


Fig. 10.15 **a** Maurice Arregui with the author of this chapter and **b** Jean L. Dulucq during the EHS meeting in Cologne

mobilize according to their body feeling without any special restrictions; regarding the pain medication the same advice is given. The patients are requested to come back for outpatient visit after 5 days, 4 weeks, and 1 and 5 years. Return to work is recommended about 1–2 weeks after TAPP according to the demands of their work.

10.5 Why do I Prefer TAPP

Maurice Arregui (Fig. 10.15a) was the first who described reliable principles of TAPP in 1992 [41]; Jean L. Dulucq (Fig. 10.15b) was the first who published the TEP technique later in the same year [30]. In both techniques, identical dissection of the groin is done, but the access to the groin is different.

Although I am well aware that with both techniques excellent results can be achieved, in my experience there are 11 reasons to prefer TAPP:

1. *TAPP is easier to learn.*

The transabdominal approach is largely independent on the body conditions of the patient, the course of the epigastric vessels and their branches, and possible difficulties to detach the posterior sheath of the rectus muscle, respectively, the peritoneum from the muscle, e.g., in patients after previous lower abdominal surgery.

2. *TAPP is better to standardize.*

In TAPP from the beginning, the surgeon has a complete and clear view to the anatomical structures and a sufficient large space for dissection of the hernia sac and the cord structures.

3. *Applicability in virtually all types of hernia.*

The analysis of more than 15,000 inguinal hernia repairs shows that in 98% of the patients (Fig. 10.16) and in all types of hernia (Table 10.1), TAPP can successfully be done [42].

4. *In TAPP the dissection area is less.*

Although in laparo-endoscopic hernia repair the space in the groin dissected for placement of the mesh is just the same for both techniques, but in TEP due to the necessary extended access the total wound area is much larger. Therefore, this larger wound area may result in more bleeding complications.

5. *In TAPP rapid assessment of the contralateral side is possible.*

One of the advantages of laparo-endoscopic hernia repair is that in bilateral hernias both sides can be operated simultaneously through the same three small incisions without increasing the rate of complication, or pain, or time of disability of work [5]. In open surgery as well as in TEP occult, hernias may be missed; however, in TAPP these hernias which were not detected in clinical examination are seen with the first laparoscopic view (Fig. 10.17; left side).

6. *In TAPP type of hernia and cause of recurrence immediately recognizable with the first laparoscopic view* (Figs. 10.18a–c and 10.19a–c).

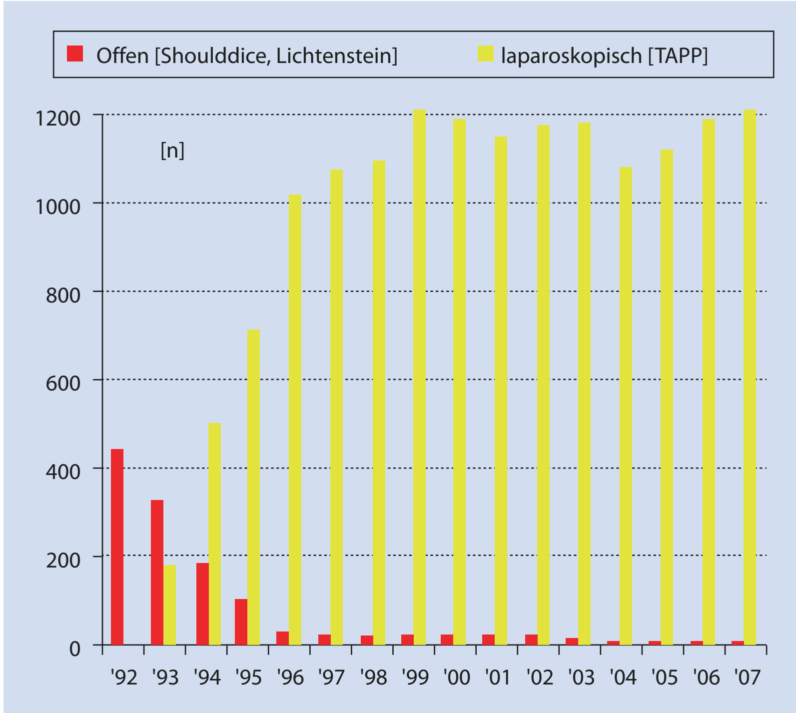


Fig. 10.16 A 15 years of experience with TAPP (1993–2007, Marienhospital Stuttgart)

10

Table 10.1 Types of hernia in 15,000 TAPPs

II (indirect)	4537	32.2%
IIIa (direct)	5594	40.8%
IIIb (ind./komb.)	3096	22.9%
IIIc (femoral)	483	3.6%
IV (Rec. Hernie)	1965	13.0%
Scrotal	807	5.3%
Irreducible	477	3.2%
Strangulated	161	1.1%

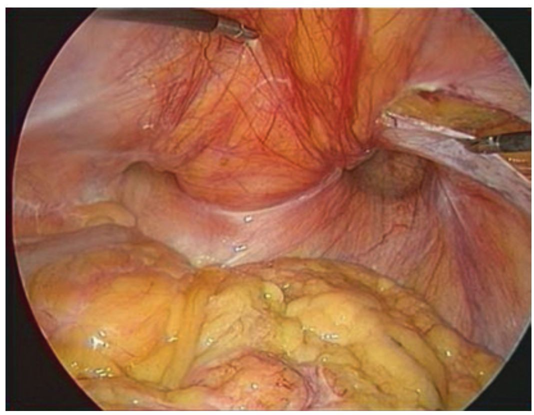


Fig. 10.17 Bilateral hernia, left side detected Intraoperatively

7. In TAPP additional abdominal operations are possible, e.g., cholecystectomy (Fig. 10.20).

8. *TAPP is an excellent operation for strangulated hernias.*

For an expert surgeon in TEP, it might be possible to repair a strangulated hernia but not without doing laparoscopy. It makes more sense to do a TAPP, because during the whole operation it is possible to observe the perfusion of the strangulated bowel and its recovery (Fig. 10.21). Following this concept, frequency of bowel resection in these cases is significantly reduced compared to open surgery [31].

9. *In TAPP repair of scrotal hernias is easier.*

In scrotal hernia (Fig. 10.22), the complete reduction of the hernia sac may be difficult and time-consuming; however, in TAPP dissection is easier due to more clear anatomy from the beginning and the possibility to see the hernia sac not only from outside like in TEP but also from inside. Therefore, it is possible to detect any adhesions between the bowel and the omentum and the hernia sac; accordingly, dissection and use of heat for bleeding control can be adapted.

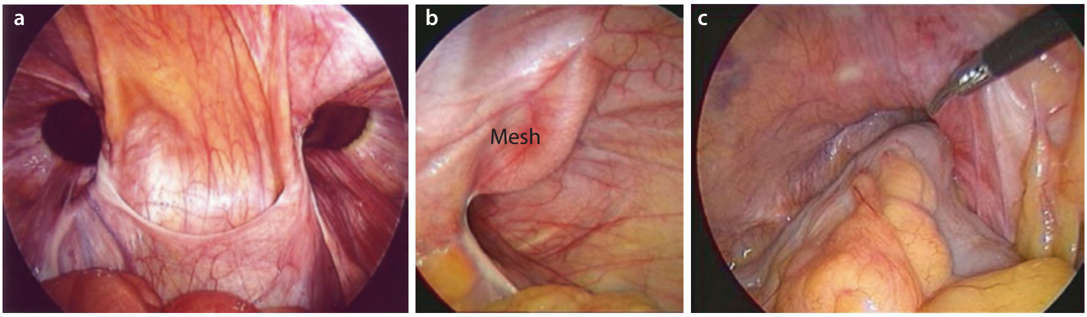


Fig. 10.18 **a** Bilateral hernia. **b** Indirect recurrence due to lateral uprolling of the mesh. **c** Sigmoid sliding hernia

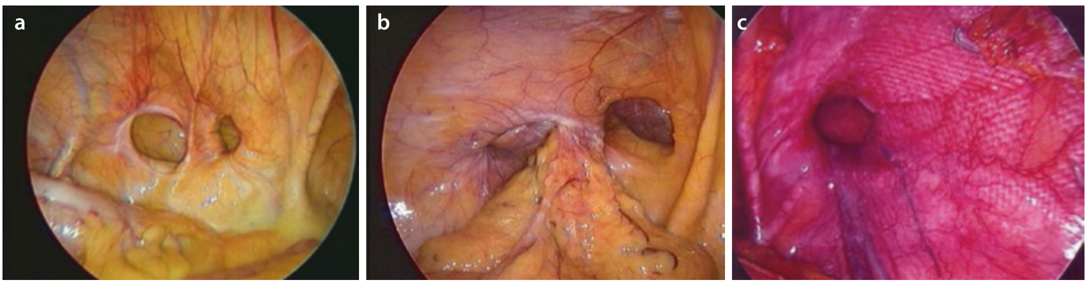


Fig. 10.19 **a** Recurrent hernia after open repair: Two defects, medially and supravesically. **b** Recurrence after open repair: indirect and direct defect. **c** Recurrence after TAPP due to insufficient medial overlapping

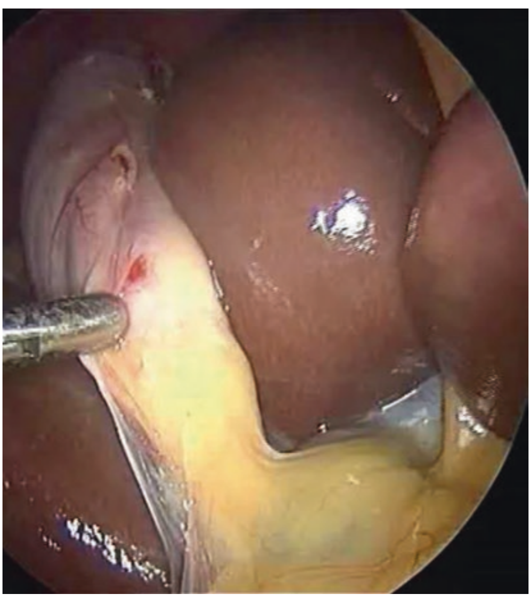


Fig. 10.20 Starting with TAPP, then after closure of the peritoneum additional cholecystectomy

10. *In TAPP inguinal hernia repair in patients after previous preperitoneal groin surgery (transabdominal prostate resection, hernia mesh repair) is easier.*

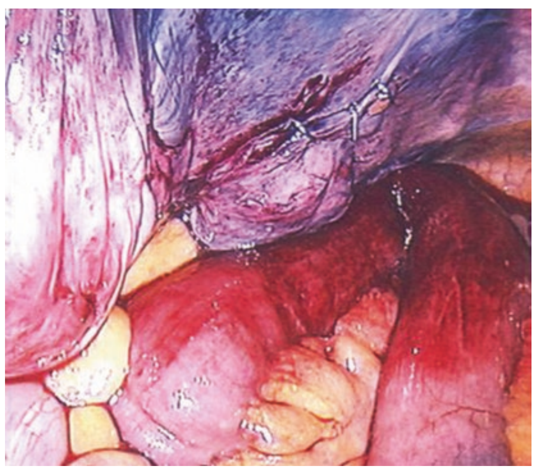


Fig. 10.21 TAPP in strangulated hernia

Surgery in the space of Retzius or Bogros produces more or less scar tissue; therefore, separation of the anatomical layers may be very difficult. However, in contrast to TEP the pathologic characteristics of the hernia as well as the anatomical structures are very clear to identify in laparoscopic repair. Thus, TAPP can successfully be performed even in these difficult cases [32, 33] (Fig. 10.23).

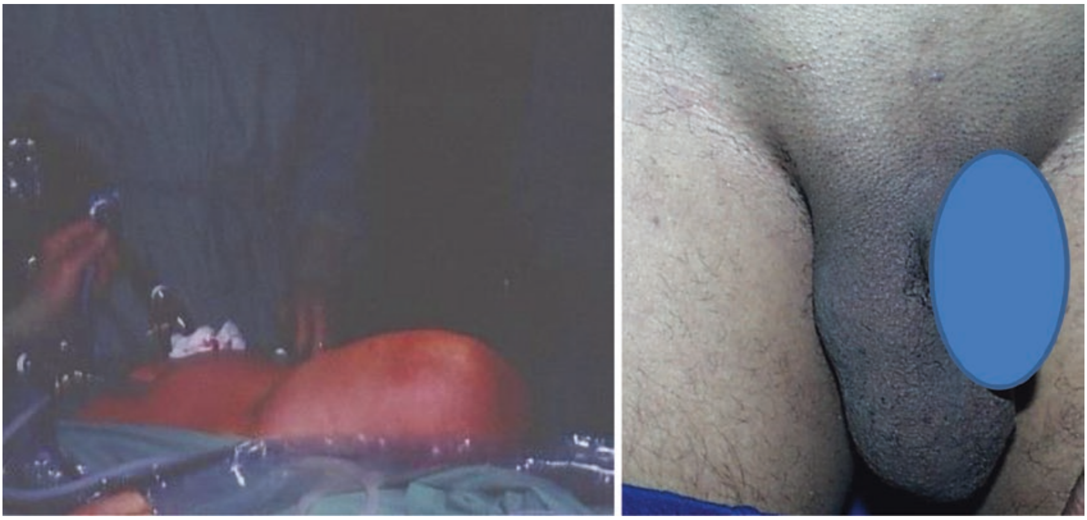


Fig. 10.22 Scrotal hernia

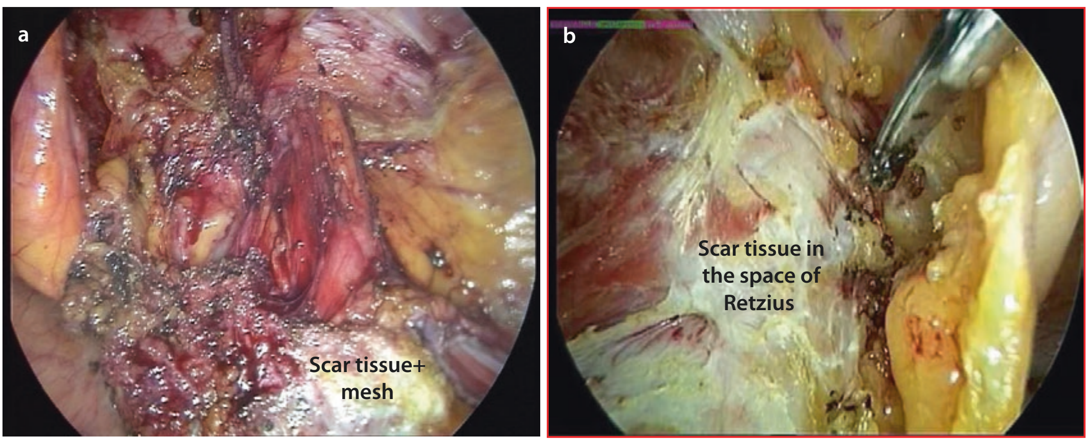


Fig. 10.23 **a** Recurrence after preperitoneal mesh repair and **b** TAPP after previous transabdominal prostrate resection

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Technique Total Extraperitoneal Patch Plasty (TEP): Standard Technique and Specific Risks

Ferdinand Köckerling, Pradeep Chowbey, Davide Lomanto, and Maurice Arregui

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11.1 History

Following the first laparoscopic transabdominal inguinal hernia repair involving the implantation of polypropylene material in the form of a mesh [1] or with plug and mesh [2, 3], the TAPP approach using no additional plugs was established and is now in widespread use [4].

Initial experience with totally extraperitoneal hernioplasty was reported in Europe in 1991 by the French surgeon Dulucq [5] and in the USA by McKernan [6] and Phillips [7]. In 1992 and 1993, Ferzli [8, 9] also published a report on an "endoscopic extraperitoneal hernia repair" (EEPH) technique.

11.2 Standard Technique [10–13]

11.2.1 Patient Preparation

On the day of the operation, the patient is shaved from the costal arch to the pubis.

Immediately prior to being brought into the operating room, the patient is asked to empty his bladder. Routine transurethral catheterization is not indicated on account of the not infrequent complications such as urinary tract infection and urethral stricture, and, anyway, a partially filled bladder hardly impairs preperitoneal dissection. In exceptional cases, a full bladder, however, requires intraoperative insertion of a catheter, which is removed again prior to anesthesia termination.

The guidelines for laparoscopic (TAPP) and endoscopic (TEP) treatment of inguinal hernia of the International Endohernia Society (IEHS) recommend that the patient empty his/her bladder before the operation. Only if technical difficulties are expected (e.g., after prostatic surgery, scrotal hernia) or an extended operating time is the use of a urinary catheter considered during the intervention [12].

11.2.2 Antibiotic Prophylaxis

Analysis of the Herniamed Registry patient group with laparo-endoscopic inguinal hernia repair ($n = 48.201$) did not identify any significant influence of antibiotic prophylaxis on postoperative impaired wound healing and deep infection [14]. In the Consensus Development Conference on endoscopic repair of groin hernias of the European Association for Endoscopic Surgery, a statement is given that there is not enough evidence to support the routine use of prophylactic antibiotics in elective endoscopic groin repair [15].

In the guidelines of the IEHS [12], antibiotic prophylaxis for elective laparo-endoscopic inguinal hernia repair is not universally recommended. Antibiotic prophylaxis should be considered in the presence of risk factors for wound and mesh infection based on the patient (advanced age, corticosteroid usage, immunosuppressive conditions and therapy, obesity, diabetes, and malignancy) or surgical complications (contamination, long operation time, drainage, urinary catheter) [12].

11.2.3 Thromboembolic Prophylaxis

Because thromboembolic complications have been very rarely reported after inguinal hernia surgery, there has been a debate about whether thromboembolic prophylaxis is needed at all in the absence of risk factors [12]. Moreover, the laparo-endoscopic techniques might involve risks from altered venous flow due to CO_2 insufflation and the reverse trendelberg position [12]. The IEHS Guidelines recommend that thromboembolic prophylaxis be given according to the usual routines in patients with risk factors [12].

11.2.4 Patient Positioning

The patient is placed supine on the operating table. Depending on the intraoperative situation, adoption of a Trendelenburg position and tilting of the table toward the surgeon may be useful, since the resulting shift of abdominal contents enlarges the preperitoneal space accordingly and facilitates the dissection. In the event of a unilateral hernia, the patient's arm on the ipsilateral side can be placed at 90°, since the surgeon and his assistant both stand on the contralateral side to the hernia. For bilateral hernias, both of the patient's arms must be placed at his side to permit unobstructed working (Figs. 11.1, 11.2).

11.2.5 Anesthesia

As a rule, we carry out TEP under general anesthesia, since we consider spinal anesthesia to be contraindicated for the following three reasons:

1. In patients in whom general anesthesia is contraindicated for cardiopulmonary reasons, the uncontrollable absorption of CO_2 from the preperitoneal space and from an inadvertent lesion-related pneumoperitoneum, hypercapnia of varying degree is possible, which, in the presence of impaired pulmonary function, might not be compensated via the respiration.
2. A Trendelenburg position necessary to ensure appropriate dissection and mesh placement may cause problems due to the possibility of anesthetic rising within the spinal canal.
3. To maximize the preperitoneal space and enable optimal mesh implantation, we consider muscular relaxation to be necessary.

Fig. 11.1 Positioning of the patient on the operating table for repair of a right-sided unilateral inguinal hernia in TEP technique

11.2.6 Team Positioning

After disinfection of the skin and application of sterile drapes, the surgeon takes up a position on the contralateral side to the hernia, with his assistant on the ipsilateral side. Once the working trocars have been placed, the assistant then changes sides and takes up a position behind the surgeon (Fig. 11.2), enabling unobstructed camera work without coming into conflict with the surgeon's arms. The monitor of the endoscopy unit is positioned at the foot end of the patient on the side of the hernia and in the case of bilateral hernias can easily be moved to the contralateral side. The instrument nurse is on the same side as the surgeon with the instrument table in front of

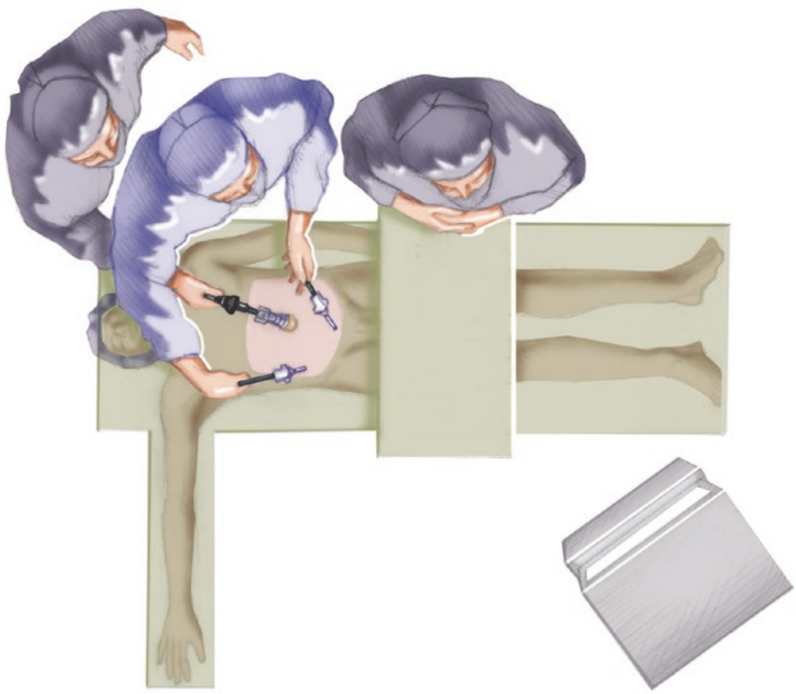


Fig. 11.2 Position of operating team in a unilateral right-sided inguinal hernia

her such that she has an unobstructed view of the operating field and the video monitor. The cables for camera, light, diathermy, and the CO_2 line should be on the contralateral side to the hernia, thus enabling unobstructed access to the working trocars (◘ Fig. 11.1). An irrigation-sucking device is not routinely required. In the event of bilateral hernias, the surgeon, on completion of the dissection of the first side, moves over to the other side.

11.2.7 Instruments

The following laparoscopic instruments have demonstrated their worth in TEP: an atraumatic fine 5 mm grasper, a 5 mm Overholt forceps, and a 5 mm Metzenbaum scissors for dissection, electrocautery hook, a 10 mm swab forceps for punctiform hemostasis and also dissection, a 5 mm needle holder with axial handle, a 10 mm clip forceps for endoclip sutures, and a knot pusher (◘ Fig. 11.3).

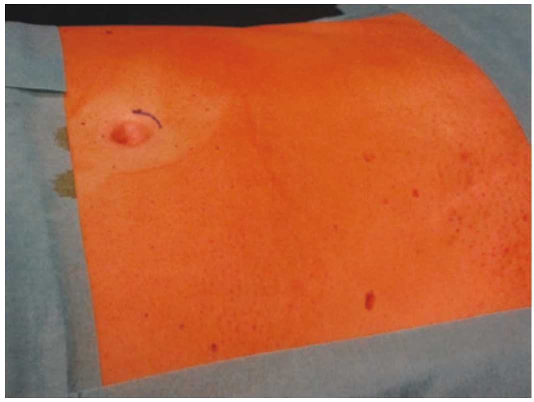
For TEP, we almost always use a 30° optic.

11.2.8 Placement of the Trocars

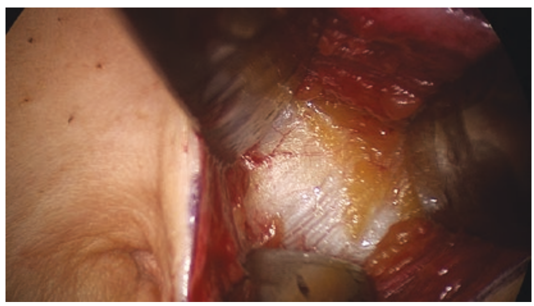
The IEHS Guidelines recommended direct access with the Hasson trocar via a 1–2 cm subumbilical incision on the side of the hernia and opening of the rectus sheath, enlargement of the space between the rectus muscle and the posterior rectus sheath [12]. Balloon dissection should be considered for extraperitoneal space creation, especially during the learning period, when it is difficult to find the correct plane in the preperitoneal space [12].

◘ **Fig. 11.3** Instruments and trocars for TEP procedure

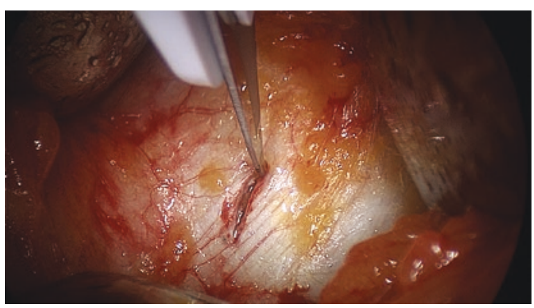
Via a roughly 1–2-cm-long, infraumbilical curved transverse incision (◘ Fig. 11.4) followed by blunt dissection of the subcutaneous tissue using three small Langenbeck hooks (◘ Fig. 11.5), the anterior rectus sheath is incised transversely on the inguinal hernia side. To avoid bleeding from the abdominal rectus muscle, a primary short incision with a No. 11 blade is made (◘ Fig. 11.6) and extended medially and laterally



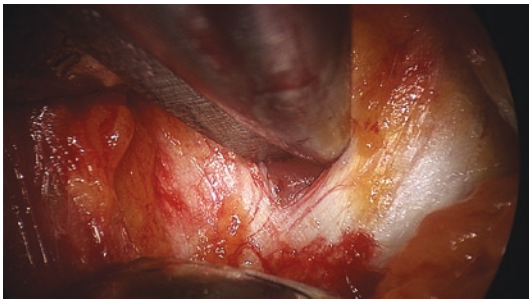
◘ **Fig. 11.4** 1–2-cm-long, infraumbilical curved transverse incision for a left-sided unilateral inguinal hernia



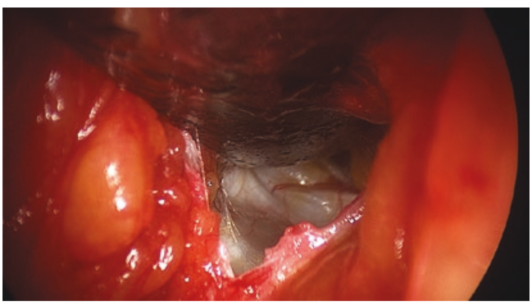
◘ **Fig. 11.5** Blunt dissection of the subcutaneous tissue using Langenbeck hooks (*left side*)



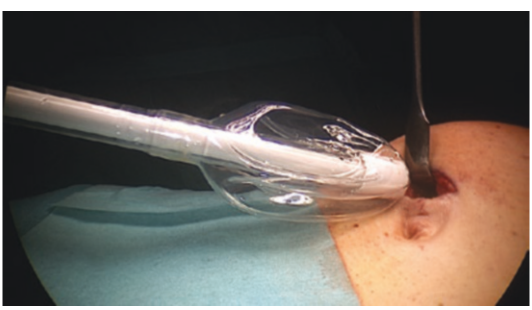
◘ **Fig. 11.6** Transverse incision of the anterior rectus sheath in a left-sided unilateral inguinal hernia using the dissection scissors (◘ Fig. 11.7). After adequate incision in the anterior rectus sheath, the medial margin of the abdominal rectus muscle is displaced laterally using a small Langenbeck hook (◘ Fig. 11.8). Following digital dissection, a dissection balloon trocar is advanced dorsal to the muscle on the posterior rectus sheath (◘ Fig. 11.9) down to the pubis (◘ Fig. 11.10) using a twisting motion and elevation of the trocar tip during the process. The trocar is inserted in the midline to avoid tearing the epigastric vessels or their side branches. Under video-endoscopic control the



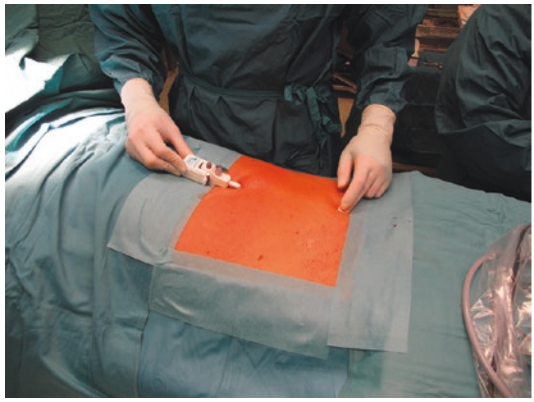
◘ **Fig. 11.7** Extension of the incision in the anterior rectus sheath by using a scissor (*left side*)



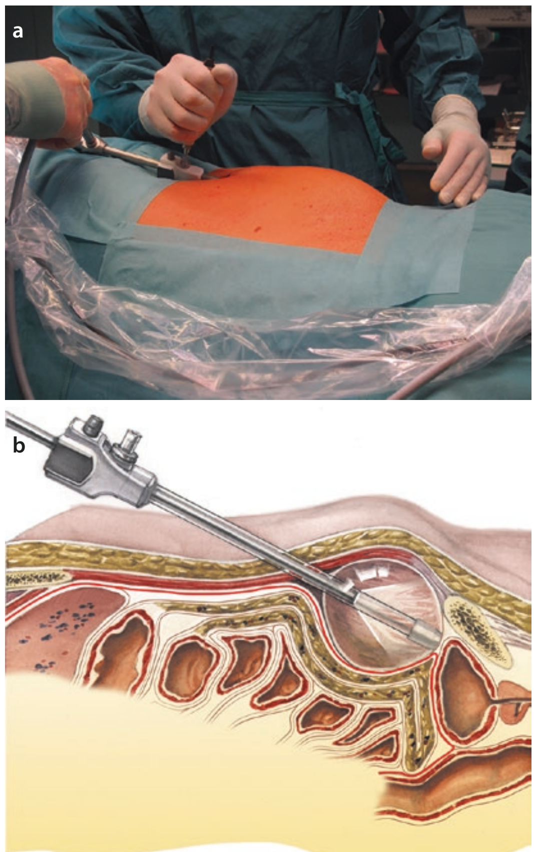
◘ **Fig. 11.8** The rectus muscle is displaced laterally using a small Langenbeck hook, and the posterior rectus sheath becomes visible (*left side*)



◘ **Fig. 11.9** A dissection balloon trocar is advanced dorsal to the muscle on the posterior rectus sheath (*left side*)



◘ **Fig. 11.10** The dissection balloon trocar is pushed down to the pubis using twisting motion and elevation of the trocar tip during the process (*left side*)



◘ **Fig. 11.11** Under video-endoscopic control **a** the balloon is inflated in the preperitoneal space **b** (*left side*)

balloon is inflated within the preperitoneal space (◘ Fig. 11.11) while observing the landmark structures (pubic bone with Cooper's ligament, inferior to the epigastric vessels, abdominal

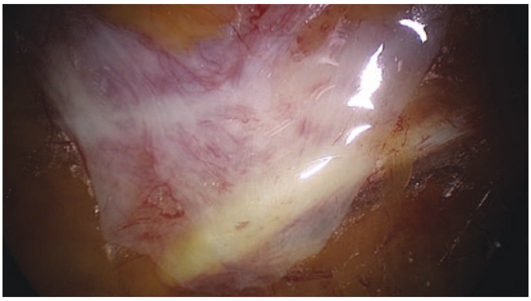


Fig. 11.12 Observing the landmark structures like the pubic bone with Cooper's ligament and the sac of a medial hernia on the left side

Fig. 11.13 A 10/12 mm blunt-tip trocar is advanced to the posterior rectus sheath (*right side*)

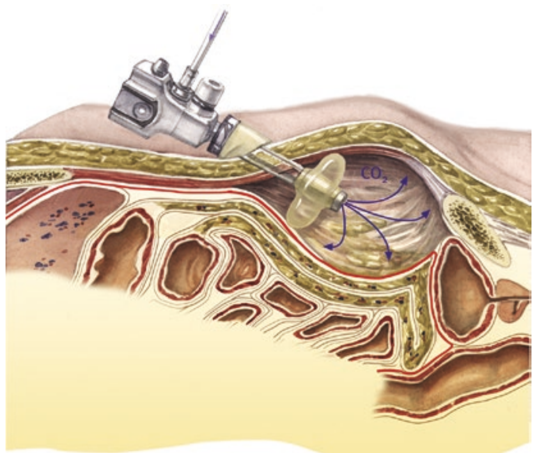


Fig. 11.14 CO_2 insufflation at a pressure of up to 12 mmHg is initiated

rectus muscle) (Fig. 11.12). In particular in the case of older patients, displacement of the epigastric vessels from the rectus muscle in the dorsal direction can be avoided by appropriate maneuvering of the balloon under direct vision. Direct hernias are reduced almost completely by the dissection balloon through which the whitish, transversalis fascia overlapping Cooper's ligament dorsally remains visible (Fig. 11.12). The use of the dissection balloon is, of course, optional, and the preperitoneal dissection can also be effected bluntly with the telescope trocar. In our opinion, however, utilization of the balloon results in an appreciable saving of time and a reduction in bleeding by enabling the early identification of the epigastric vessels. In a Swedish prospective randomized study involving more than 300 patients with unilateral primary hernias operated on utilizing the TEP approach, a significantly lower conversion rate and a significantly shorter operating time were found in the group in which the dissection balloon was employed [16].

In the IEHS Guidelines, it is therefore recommended that balloon dissection should be considered for extraperitoneal space creation, especially during the learning curve, when it is difficult to find the correct plane in the preperitoneal space [12].

After removing the telescope and the deflated balloon, a 10 mm blunt-Tip trocar (Fig. 11.13) is advanced to the posterior rectus sheath or a reusable 10 mm Hasson trocar secured to the anterior rectus sheath with sutures. With the patient in a mild Trendelenburg position, CO_2 insufflation at a pressure of up to 12 mmHg is initiated (Fig. 11.14). 4–5 cm caudal to the umbilicus, a 5 mm blunt-tip trocar is introduced in the midline under vision (Fig. 11.15).

The blunt dissection is then continued, single-handed, toward lateral, with the peritoneal sac being dissected from the transverse abdominal muscle caudally and dorsally to the arcuate line (Fig. 11.16). The arcuate line extending far in the lateral-caudal direction must be incised over a short distance to ensure safe and adequate dissection (Fig. 11.17). If problems are encountered with the lateral dissection, as, for example, in patients after appendectomy, additional placement of a 5 mm trocar suprapubically in the midline is to be recommended.

The lateral, second, working trocar is inserted under direct vision approximately 3–4 cm cranial and 1–2 cm ventral to the anterior superior iliac spine, almost on a level with the telescope trocar (Fig. 11.18a, b). Instead of a 10 mm

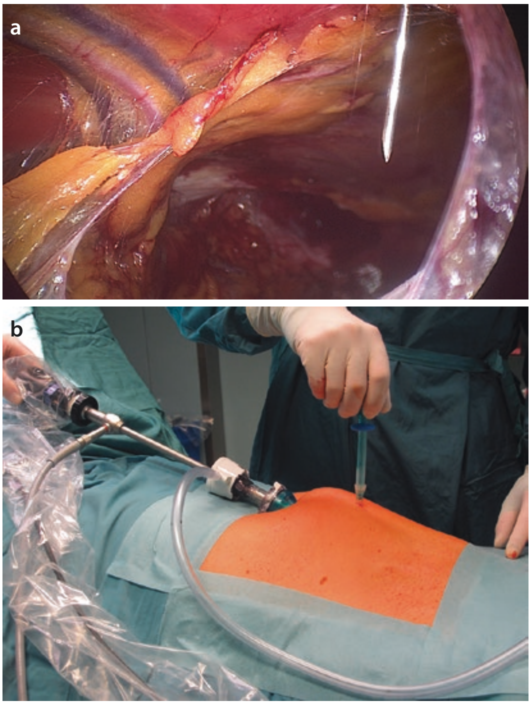


Fig. 11.15 A blunt-tip 5 mm trocar is introduced after control of optimal positioning with a needle **a** 4–5 cm caudal to the umbilicus **b**

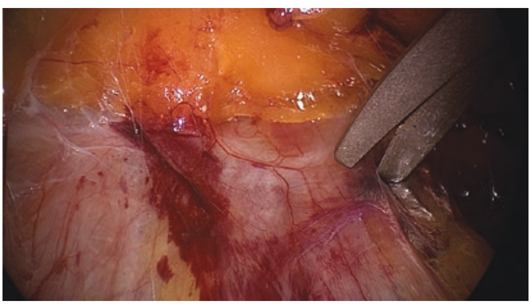


Fig. 11.16 Dissection of the arcuate line (*left side*)

trocar, a 5 mm port may be employed in which case, during the further course of the operation, the polypropylene mesh must be introduced via the infraumbilical trocar. An adequate cranial distance between the anterior superior iliac spine and the lateral working trocar is necessary to ensure the problem-free placement to wrinkled free and 15 × 13 cm, it extends ventrolaterally to the iliac spine.

The abovementioned arrangement of the two working trocars enables a favorable 70–90° instrument angle, while placement of both working trocars in the midline is associated with an unfavorable working angle. Furthermore, in the event of a large lateral hernia sac, axial tension can be applied with the grasper via the lateral working trocar, thus improving dissection and reduction.

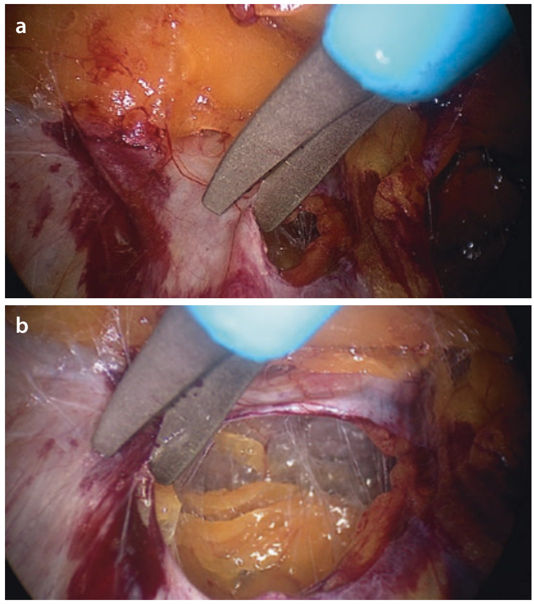


Fig. 11.17 Incision of the arcuate line **a** and the posterior rectus sheath **b**

In the case of bilateral hernias, a bilateral dissection balloon is employed which is introduced into the rectus sheath on the side with the larger hernia. The lateral working trocar cranial to the anterior superior iliac spine is also introduced on the side with the larger lesion, and the contralateral side is dissected via the ipsilateral ports.

In the guidelines of the IEHS, also two alternatives for the trocar placement are recommended: two 5 mm working ports in the midline and in the midway between the camera port and the pubic symphysis. Alternatively, the second working trocar (5 or 10 mm) can be placed after lateral dissection approximately 3–4 cm superior and 1–2 cm anterior to the anterior superior iliac spine [12].

11.2.9 Dissection

If this has not yet been done, the operating table should be tilted toward the surgeon and moved into a mild Trendelenburg position after placement of the trocars as described above, in order to ensure on the one hand optimal utilization of the preperitoneal space and on the other hand

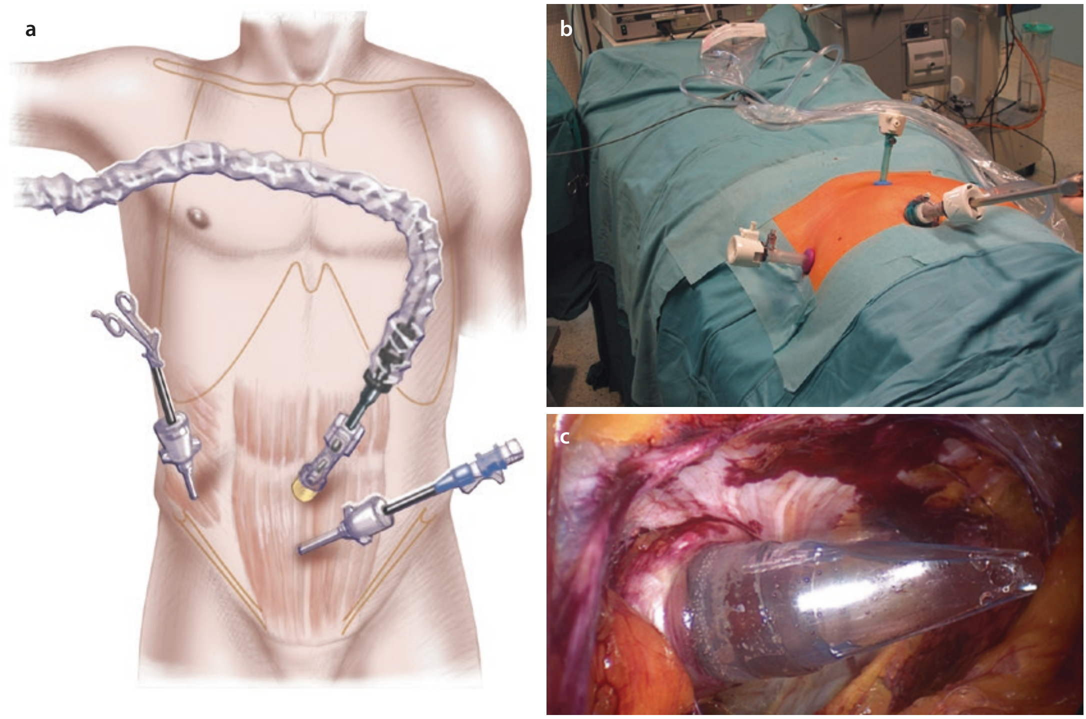


Fig. 11.18 The lateral working trocar is inserted approximately 3–4 cm cranial and 1–2 cm ventral to the anterior superior lilac spine **a**, **b** under direct vision **c** (*left side*)

relaxation of the surgeon's shoulder. Here, in particular the arm of the surgeon operating the lateral working trocar should be relieved by tilting the table appropriately. The zoom should be adjusted such that, to enable good orientation, the maximum possible operating field is covered. That the light source and camera gain should be optimally adjusted goes without saying.

Since the peritoneal sac has already been dissected from the transverse abdominal muscle to a point 4–5 cm cranial to the iliac spine to be able to introduce the lateral working trocar, it makes good sense to complete this dissection caudally. This can be done by bluntly pushing the peritoneal sac (Fig. 11.19) from the lateral abdominal wall and dorsally from the psoas muscle with the aid of two instruments. During this manoeuver, a preperitoneal fascial structure inserted lateral to the inguinal ligament is encountered, and this must be divided sharply to enable subsequent placement of the mesh (Fig. 11.19).

The lateral femoral cutaneous nerve is usually seen beneath very thin transparent fascia (Fig. 11.20). To avoid the subsequent development of neuralgia, this layer should be preserved, and the course of the nerve carefully identified before applying any electrocoagulation that might be necessary.

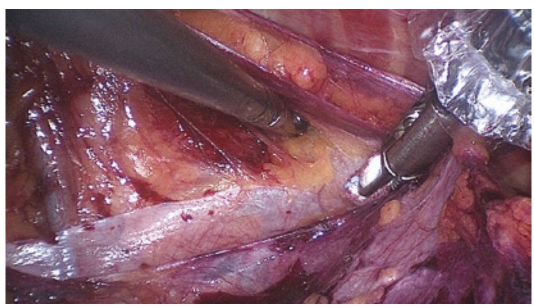


Fig. 11.19 Blunt dissection of the preperitoneal fascial structure inserted lateral to the inguinal ligament (*right side*)

The genitofemoral nerve with its genital and femoral branches courses along the median margin of the psoas muscle and is not always visible (Fig. 11.20). Selective exposure of the nerve appears to be indicated only if electrocoagulation is intended in this area. Since the femoral nerve is covered by the psoas muscle, it is usually not exposed.

To ensure correct orientation, the primary landmarks epigastric vessels (AV epigastrica

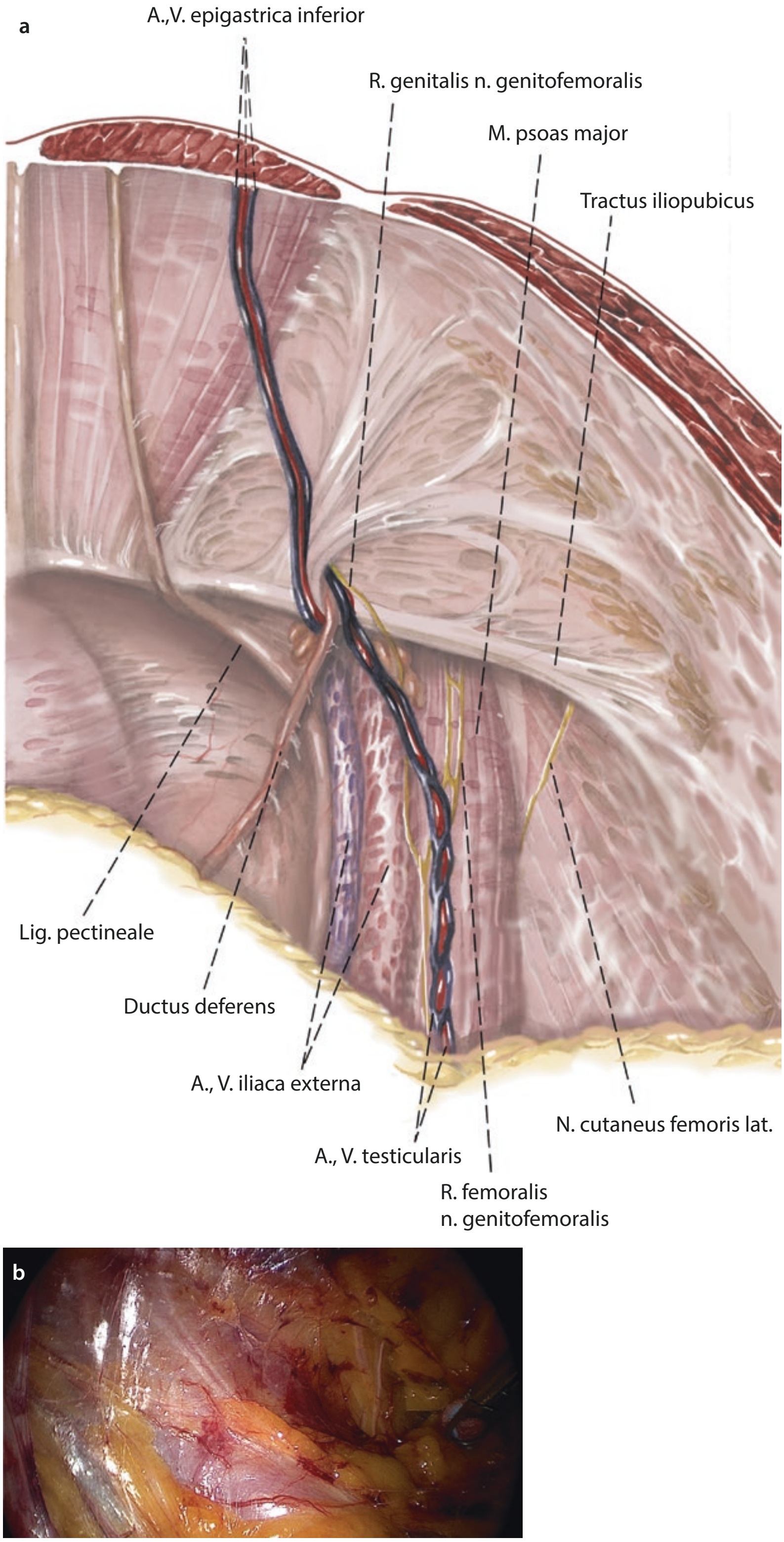
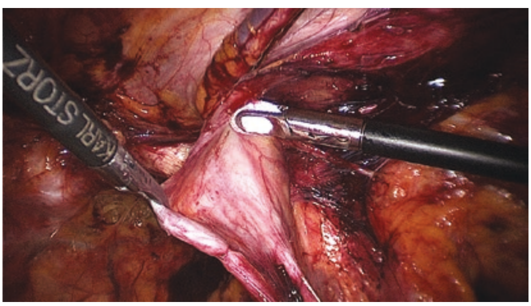


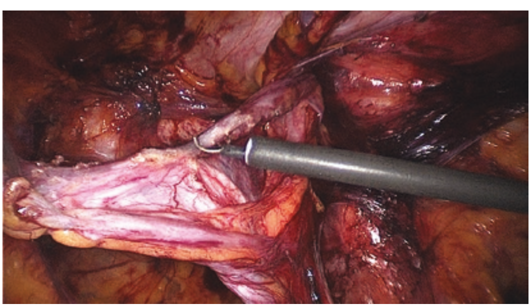
Fig. 11.20 Lateral femoral cutaneous nerve (n. cutaneous femoris lateralis), genitofemoral nerve with its genital (ramus genitalis n. genitofemoralis) and femoral (ramus femoralis n. genitofemoralis) branches (*right side*) (**a** schematic, **b** intraoperative)

inferior), Cooper's ligament (pectineal ligament), iliopubic tract (tractus iliopubicus), and the cord structures of the deferens duct (ductus deferens) and testicular vessels (AV testicularis) should be identified and, if necessary, constantly referred to (◘ Fig. 11.20). Medially, the preperitoneal and prevesicular connective tissue is now bluntly freed bimanually from the pubic bone; in the case of unilateral hernias, dissection should be accomplished some 2 cm to the other side extending the readily recognizable symphysis. When dissecting free the pubic bone and Cooper's ligament, the iliac vessels must be identified. Here, the vein is not always readily and unequivocally identifiable because of its dorsal location (◘ Fig. 11.20).

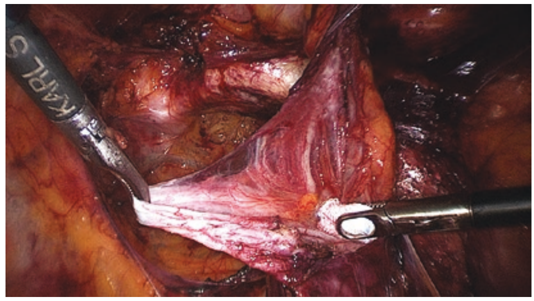
Cooper's ligament should be freed of tissue mainly with the lateral working hand (◘ Fig. 11.21), since the instrument is positioned relatively parallel to the iliac vessels and, in contrast to the instrument introduced via the 5 mm trocar, is not directed to the vulnerable iliac vein. If, in the case of a medial hernia, the peritoneal sac has not already been reduced by the dissection balloon, the sac, which conceals the iliac vessels, must be separated, stepwise, from the transversalis fascia.



◘ **Fig. 11.21** Dissection of Cooper's ligament with a blunt instrument via the lateral working trocar (*right side*)



◘ **Fig. 11.22** Dissection of the indirect hernia sac with the use of the electrocautery hook (*right side*)



◘ **Fig. 11.23** Blunt dissection of the indirect hernia sac from the deferens duct and testicular vessels (*right side*)

On completing the creation of the preperitoneal space laterally and medially, the hernia is dissected out (◘ Fig. 11.22) with exposure of the vas deferens and the testicular vessels (◘ Fig. 11.23) and round ligament and exposure of Hesselbach's triangle, the internal ring, and the potential femoral hernia orifice. Direct grasping of the vas deferens should be avoided. The peritoneum must be separated from the retroperitoneal structures dorsally from the internal ring in the cranial direction for at least 5 cm in order to provide an adequate margin for secure implantation of the prosthetic mesh. An indirect hernia sac is drawn out of the inguinal canal by grasping its ventrolateral margin with a laterally introduced atraumatic grasper and separated from the spermatic cord, stepwise, using a bimanual technique (◘ Fig. 11.23).

In the IEHS Guidelines, the statements advised that the dissection should extend superiorly up to the subumbilical area, inferiorly to the space of Retzius, inferolaterally to the psoas muscle and Bogros space until anterior superior iliac spine is reached, and medially beyond the midline [12].

The landmarks to be visualized are the pubic bone, Cooper's ligament (pectineal ligament), inferior epigastric vessels (AV epigastrica inferior), cord structures (testicular vessels, AV testicularis; deferens duct, ductus deferens), the myopectineal orifice boundaries, and the fascia over psoas muscle [12] (◘ Fig. 11.24).

Complete parietalization of the vas deferens and the testicular vessels needs to be performed [12] (◘ Fig. 11.24b). Complete dissection of the whole pelvic floor (anatomical) should be done for flat placement of the mesh to cover the entire myopectineal orifice and prevent its folding [12].

In the case of an open vaginal process or very large non-reducible lateral hernia sacs (scrotal hernias), transection of the peritoneum can be

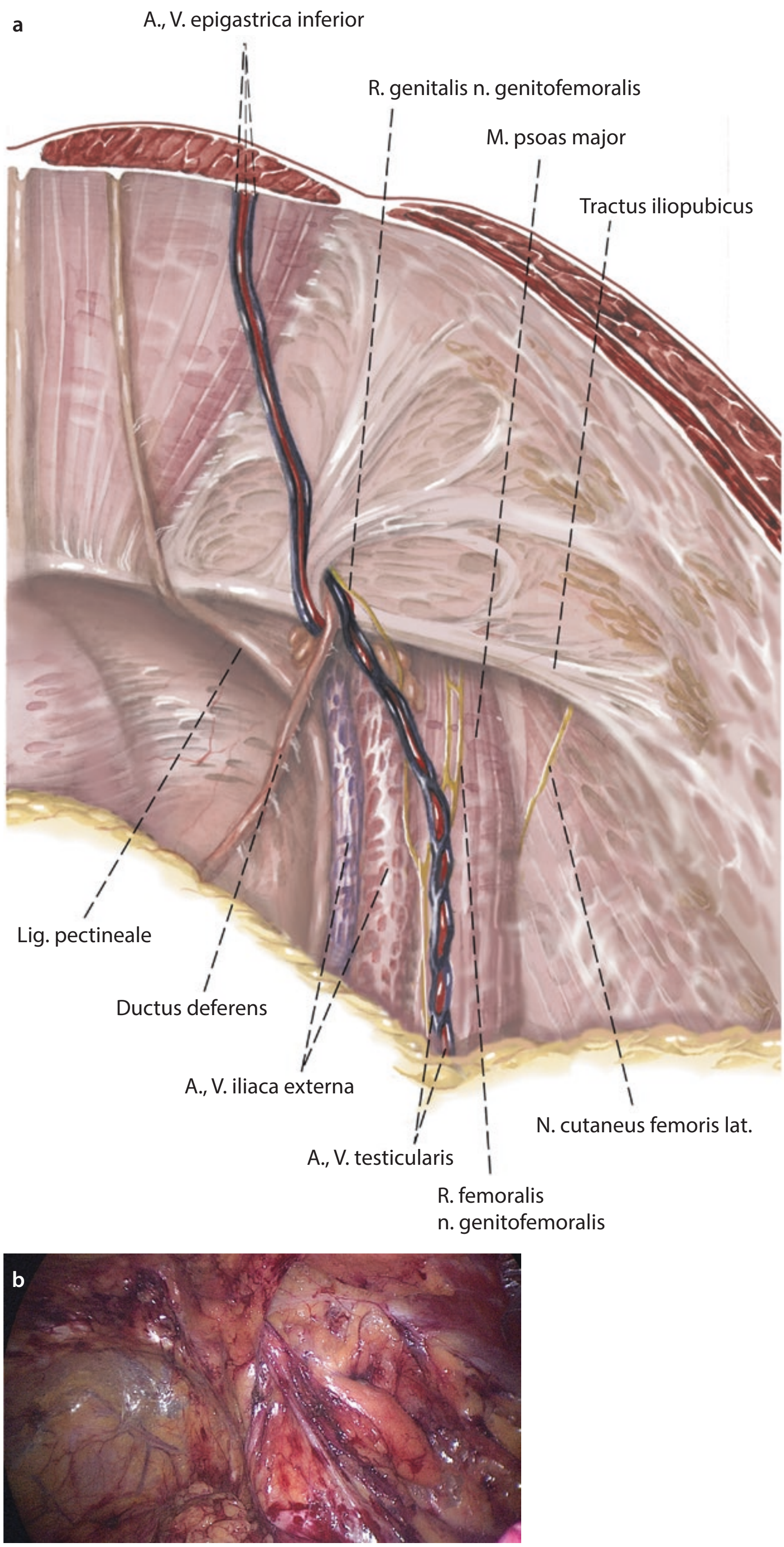


Fig. 11.24 Extent of dissection: superiorly up to the subumbilical area, inferiorly to the space of Retzius, inferolaterally to the psoas muscle and the Bogros space until the anterior superior iliac spine, and medially beyond the midline (**a** schematic, **b** intraoperative)

performed, the distal portion remaining unclosed. The proximal opening is closed with a continuous endoclip suture.

The updated guidelines on laparoscopic (TAPP) and endoscopic (TEP) treatment of inguinal hernia of the International Endohernia Society (IEHS) state that transection of a large indirect sac does not lead to significant differences in postoperative pain, length of hospital stay, and recurrence, but does result in a significant higher seroma rate.

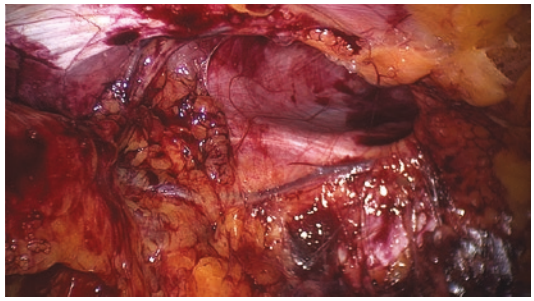
The recommendation in the IEHS Guidelines is that a large indirect sac may be ligated proximally and divided distally without the risk of a higher postoperative pain and recurrence rate, but with an increased postoperative seroma rate [13].

The presence of a peritoneal lipoma in the internal ring must always be excluded, since lipomas left in situ in the inguinal canal present postoperatively as a pseudorecurrence and also carry a risk of necrosis and abscess formation (◘ Fig. 11.25). If the lipoma can be separated from the peritoneal hernia sac, it should be drawn out of the preperitoneal space in toto. When dissecting preperitoneal lipomas, it is important to avoid injuring vessels and postoperative lymphoceles through confusion with the lymph vessel-rich perivascular fat of the pelvic vessels.

The IEHS Guidelines recommend that lipomas of spermatic cord/round ligament and the preperitoneal lipomas of direct and femoral sacs should be removed [12].

In the event of a direct hernia, dissection of the hernia sac from the enlarged transversalis fascia leaves a space ventral to the mesh (◘ Fig. 11.26). To prevent hematomas/seromas in this space formerly filled with hernia sac or a lipoma, we consider tension-free gathering and securement

◘ **Fig. 11.25** Lateral inguinal hernia with an additional lipoma in the inguinal canal (*right side*)



◘ **Fig. 11.26** Large direct inguinal hernia (*left side*)

of the extended transversalis fascia to Cooper's ligament to be indicated. This is accomplished with a nonabsorbable suture (2.0) knotted extracorporeally on a straight needle (◘ Fig. 11.27a–e). As additional effect of this procedure in the case of large medial hernia defects is optimization of mesh placement with prevention of recurrences.

The IEHS Guidelines recommended in voluminous direct hernias that the extended transversalis fascia should be inverted [12]. The direct sac should be inverted and anchored to Cooper's ligament to decrease the risk of seroma and external hematoma formation [12].

Any peritoneal *tear* occurring during dissection should – with the exception of defects smaller than 5 mm – be closed with a continuous suture, in order to prevent adhesions between bowel and prosthesis and the incarceration of small bowel loops. Apart from the training effect, the rigorous closure policy also increases safety since peritoneal lesions appear smaller optically than they actually are on instrumental exposure. According to the IEHS Guidelines, it is recommended that peritoneal tears should be closed whenever feasible to prevent adhesions [12].

Although the round ligament corresponds embryologically to the vas deferens, it is more firmly fused with the peritoneum, and in the case of young women, the latter must be dissected free with the scissors.

Here, again, care must be taken to ensure subsequent peritoneal closure. In older women, severance of the round ligament after placement of absorbable clips has proven valuable for avoiding peritoneal lesions.

Often, a femoral hernia is found to be an irreducible peritoneal lipoma. Here, to avoid avulsion of the lipoma, the hernia ring should be enlarged ventromedially with the aid of a hook scissors.

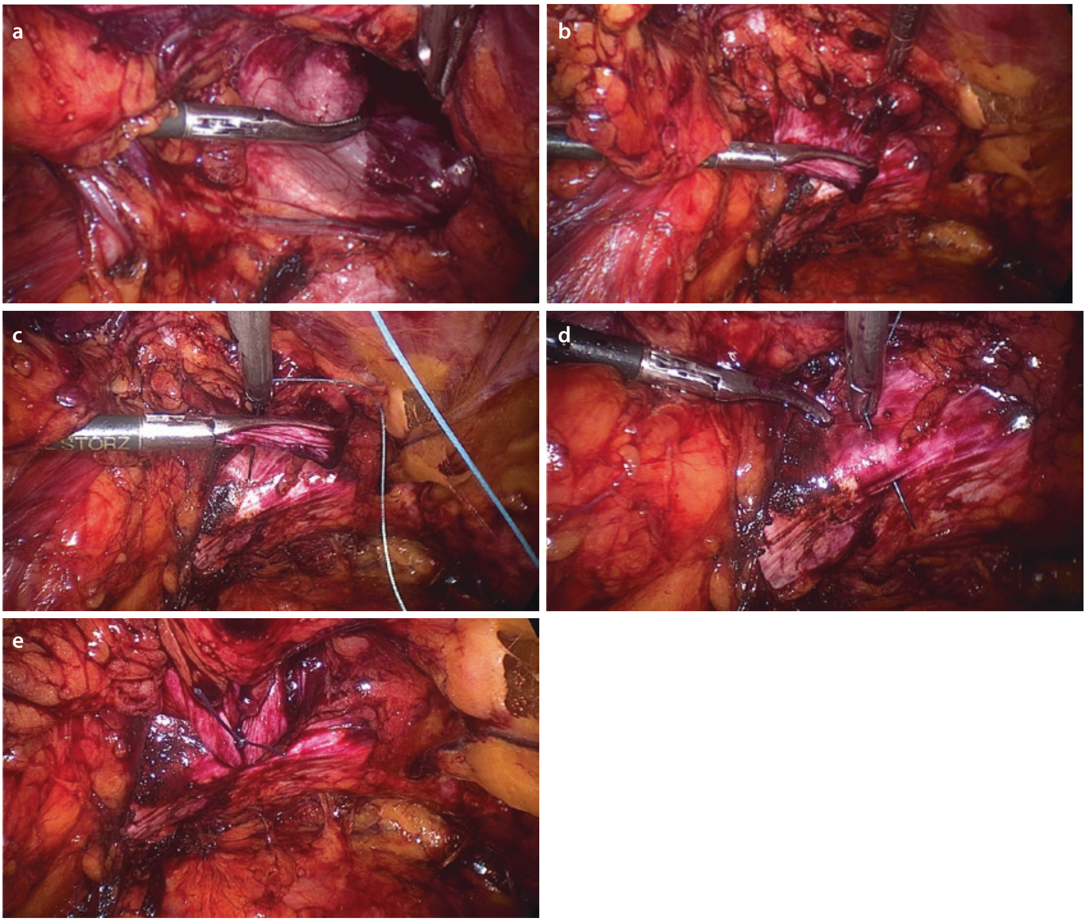


Fig. 11.27 Reduction of the large direct sac (*left side*) with grasping the extended fascia transversalis **a**, complete inversion of the sac **b** and fixation accomplished by a nonabsorbable suture (2.0) with a straight needle **c**, fixed to Cooper's ligament **d** and knotted extracorporeally **e**

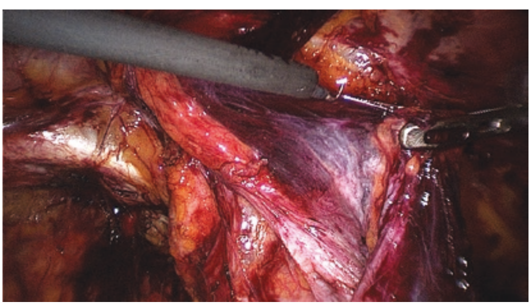


Fig. 11.28 Parietalization of the spermatic cord

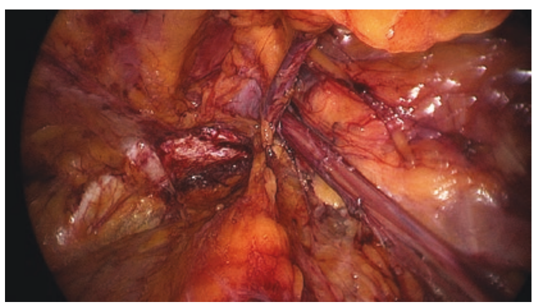


Fig. 11.29 Exposure of the internal ring

11.2.10 Mesh Placement

After reducing the hernia sac, parietalization of the spermatic cord (Fig. 11.28) or the round ligament, and exposure of all true or potential hernia orifices as well as the internal ring (Fig. 11.29), Hesselbach's triangle, and the femoral canal, a careful inspection to ensure the absence of remaining bleeding is made (Fig. 11.30) and a 10 × 15 cm polypropylene mesh introduced (Fig. 11.31) and placed (Fig. 11.32). If the defect size is more than 4 cm in diameter, the size

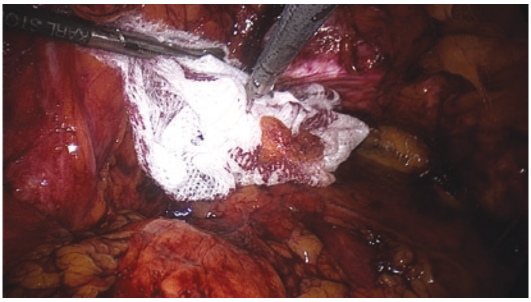


Fig. 11.30 Careful inspection of the preperitoneal space for remaining bleeding with the use of a small compress

Fig. 11.31 Introduction of a polypropylene mesh (TiMesh light) 15 × 10 cm via the lateral 10 mm trocar right trocar (*right side*)

of the mesh must be matched accordingly – for example, 13 × 15 cm, 15 × 15 cm, or 12 × 17 cm.

The IEHS Guidelines recommend a mesh of at least 10 × 15 cm and the use of a bigger mesh (i.e., 12 × 17 cm or greater) for large hernias (direct >3–4 cm, indirect >4–5 cm) [12].

The mesh is folded concertina-like and then introduced into the preperitoneal space via the 10 mm trocar (Fig. 11.31).

We consider it to be unnecessary to slit the mesh, since with adequate preperitoneal dissection, placement of the mesh between the peritoneal sac and abdominal wall poses no problem. Since there is no technical need to slit the mesh, it should be left undone, so as to avoid potential postoperative irritation of the vas deferens or testicular vessels.

The IEHS Guidelines recommend not cutting a slit in the mesh.

The polypropylene mesh is placed parallel to the inguinal ligament, overlaps the symphysis by approximately 2 cm in the contralateral direction, and extends laterally to the anterior superior iliac spine. It covers the medial, lateral, and femoral hernia orifice and should be placed

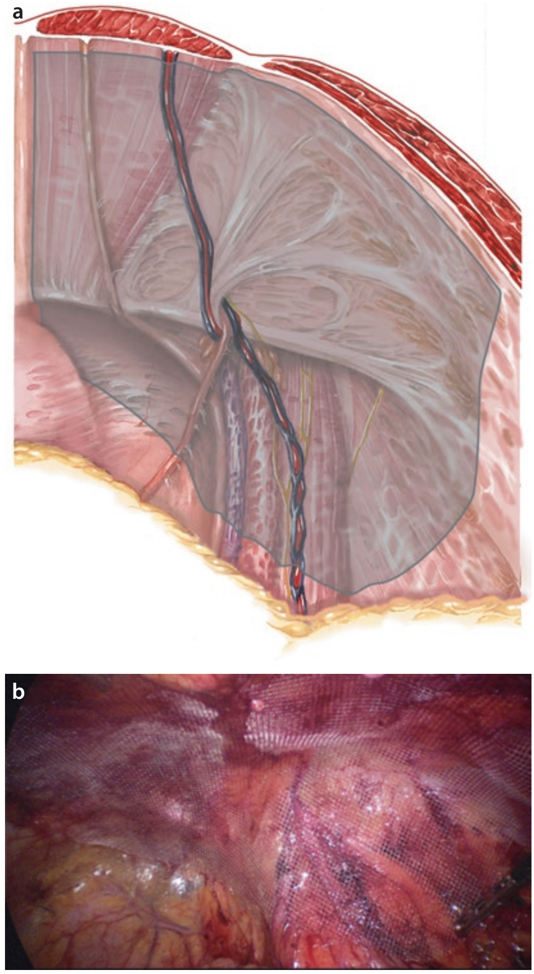


Fig. 11.32 Mesh placement overlapping all potential hernia defects (**a** schematic, **b** intraoperative). Mesh type: TiMesh light (*right side*)

such that the pathological orifice is relatively central (Fig. 11.32). It is important to ensure that the dorsal margin of the mesh is everywhere in contact and runs mediolaterally from dorsal to the pubis over the vas deferens, iliac vessels, and psoas muscle to the transverse abdominal muscle (Fig. 11.32). This margin should be about 5 cm distant from the center of the internal ring. The lightweight large pore polypropylene mesh used can be modeled to the abdominal wall and folds. Thanks to the lightweight and large pores, the mesh adheres well to the tissue. Securement of the mesh with absorbable tacks or glue is technically not necessary and should not be done so as to avoid potential nerve injuries. Only when adequate covering of the hernia orifice, for example, in previously operated patients or large medial

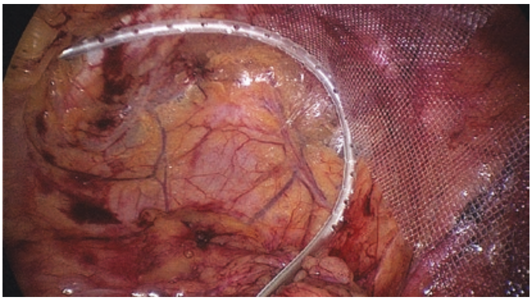


Fig. 11.33 Introduction of a Redon drain via the 5 mm trocar placed in the Retzius space (*right side*)

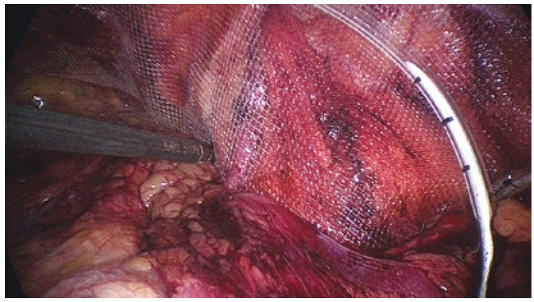


Fig. 11.34 Via the drain in the midline, the CO2 pressure can be released stepwise (*right side*)

hernias, cannot be achieved by adaptation of the mesh dimensions do we use glue for securement.

The IEHS Guidelines recommended, if TAPP or TEP techniques are used, non-fixation could be considered in types LI, II and MI, II hernias. For TAPP and TEP repair of big direct defects (LIII, MIII), the mesh should be fixed; however, fixation does not compensate for inadequate mesh size or overlap [12].

For fixation, fibrin glue should be considered to minimize the risk of postoperative acute and chronic pain [12].

On completion of mesh placement, a drain is introduced via the 5 mm port placed in the Retzius space (Fig. 11.33). With the drain in place, the mesh must be checked for correct positioning, in particular laterally.

We consider routine drainage to be necessary for the following reasons:

1. After removal of the trocars, it enables complete desufflation of the preperitoneal space and thus complete readaptation of the tissue layers with the mesh in between.
2. Despite careful hemostasis with high-frequency diathermy, the release of the CO_2 pressure of 12 mmHg might result in an unpredictable accumulation of blood escaping from microscopic vessels in the relatively large preperitoneal wound. Even when the area appears to be completely dry intraoperatively, up to 50 ml of fluid may accumulate which, in the worst case, may lead to displacement of the mesh.
3. Postoperative preperitoneal hematomas/seromas may result in an increase in mesh infection rates.

In the update of guidelines on laparoscopic (TAPP) and endoscopic (TEP) treatment of inguinal hernia of the International Endohernia Society, a statement is given that a drain after TEP significantly reduces the incidence of seroma formation without increasing the risk of infection or recurrence [13]. Therefore it is recommended that a closed-suction drain can be used to reduce the risk of seroma formation without increased risk of infection.

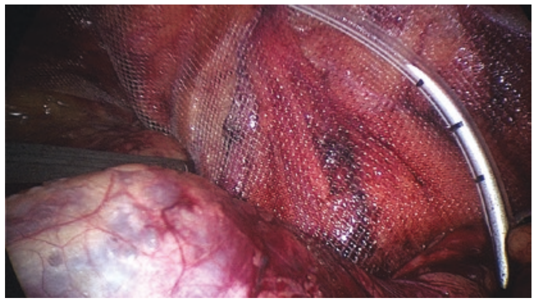


Fig. 11.35 "Grounding" of the peritoneal sac on the mesh (*right side*)

For the critical phase of desufflation regarding vision, CO_2 pressure and anesthesia management and optimal intraoperative conditions must be reestablished. Via the drain in the midline, the CO_2 pressure can be released stepwise (Fig. 11.34) after switching off the insufflator. During this process, in particular the inferior margin of the mesh, which in the midline pressed against the pelvic bone by the bladder and prevesicular fat, must be observed. Laterally in the region of the psoas muscle, the appropriate "grounding" of the peritoneal sac on the mesh (Fig. 11.35) should be clearly observed to avoid any displacement. In some patients foot-down positioning may be helpful. If appropriate visualization is not unequivocally possible, the maneuver must be repeated with the operating table in another position and/or the position of the mesh corrected. If the peritoneal sac causes kinking folding of the mesh, a repeat dissection might become necessary, which can be done after removal of the drain and reintroduction of the medial working trocar. Most cases of "shrunken" meshes reported in the literature may be considered the result of a displacement that has already occurred intraoperatively.

During the desufflation phase, a grasper placed through the 5 mm trocar can be of help, for example, by elevating the ventral part of the mesh to facilitate the repositioning of the peritoneal sac. In particular in the case of young, muscular patients with a correspondingly flat preperitoneal space, it is important that the peritoneal sac should be seen to "unfold" as far caudally as possible to prevent kinking of the mesh.

If there are any intraoperative doubts as to the proper placement of the mesh or of proper closure of the peritoneal lesions, a check laparoscopy can readily be carried out by opening the posterior rectus sheath and peritoneum.

Otherwise, when the optic and trocars have been removed, the fascia at the umbilicus and the skin are sutured.

For logistical reasons, the drain is removed on the morning of the postoperative day but could also be removed in the afternoon or evening of the day of surgery.

11.3 Specific Risks

11.3.1 Bilateral Inguinal Hernias

The proportion of bilateral inguinal hernias using diagnostic laparoscopy is 28.5% [17]. For bilateral inguinal hernias, all guidelines of the international surgical societies recommend laparo-endoscopic repair in TAPP or TEP technique [12, 13, 15, 18, 19]. But to date no randomized controlled trials have been carried out to compare the perioperative outcome of unilateral and bilateral inguinal hernia repair using a laparo-endoscopic technique.

A Swiss registry study compared 3457 unilateral with 3048 bilateral inguinal hernia repairs using TEP technique [20]. The authors identified an intraoperative complication rate of 1.9% for unilateral and 3.1% for bilateral TEP ($p = 0.002$) [20]. Likewise, the postoperative complications for unilateral TEP at 2.3% and for bilateral TEP at 3.2% were significantly different ($p = 0.026$) [20]. The authors concluded that the absolute difference between intra- and postoperative complications of unilateral versus bilateral inguinal hernia repair in TEP technique was small and of minor clinical relevance [20]. In addition, some authors have raised the issue of prophylactic repair of a clinically healthy other side to avoid the second inguinal hernia repair in the future [21–23].

In an analysis of the Herniamed Registry, 9395 patients with a TEP were enrolled [24]. These comprised 6700 patients with unilateral (71.3%) and 2695 patients (28.69%) with bilateral inguinal hernia repair. While no significant difference was found in the overall number of intraoperative complications between the unilateral and bilateral group ($p = 0.310$), a significantly higher number of urinary bladder injuries in the bilateral TEP operation of 0.28% compared with 0.04% for unilateral TEP ($p = 0.008$) were noted [24]. The greater probability of complication-related reoperation (0.82% for unilateral vs 1.78% for bilateral TEP; $p < 0.001$) in the unadjusted analysis was confirmed in the multivariable model (OR 2.35 [1.504; 3.322]; $p = 0.001$) [24]. The authors concluded that a significantly higher intraoperative urinary bladder injury rate and reoperation rate because of postoperative surgical complications constituted a difference in the perioperative outcome between unilateral and bilateral TEP which warranted attention [24]. Based on these results, prophylactic operation of the healthy other groin should not be recommended [24].

11.3.2 Recurrent Inguinal Hernias

The proportion of recurrences in the National Swedish Hernia Registry is 11.2% [25]. Female gender, direct inguinal hernias at the time of the primary procedure, operation for a recurrent inguinal hernia, and smoking are significant risk factors for recurrence after inguinal hernia surgery [26]. In five meta-analyses, the outcome of open repair was compared with that of endoscopic repair of recurrent inguinal hernias [27–31].

In a meta-analysis and review of prospective randomized trials comparing laparo-endoscopic and Lichtenstein techniques in recurrent inguinal hernia repair, patients who underwent laparo-endoscopic repair experienced significantly less chronic pain and returned earlier to normal activities. Operative time was significantly longer in laparo-endoscopic operations. No other difference was found [30].

On the basis of the meta-analyses, the European Hernia Society recommends endoscopic inguinal hernia techniques for recurrent hernias after conventional open repair [18]. Likewise, the International Endohernia Society recommends, with a high level of evidence, TEP and TAPP for repair of recurrent hernia as the preferred alternative to tissue repair and to the Lichtenstein repair after prior anterior repair [12].

In the Consensus Development Conference of the European Association for Endoscopic Surgery, TEP and TAPP are preferred in patients with a recurrent groin hernia after open repair [15]. Repeat endoscopic repair is only feasible when the surgeon has a high level of experience in repeat endoscopic groin hernia repair [15].

To date, there are no prospective randomized studies that compare the outcome of endoscopic repair of primary versus recurrent inguinal hernias [32].

In an analysis of the Herniamed Registry, 20,624 patients with male unilateral inguinal hernia were enrolled. 18,142 (88.0%) had primary and 2482 (12.0%) had recurrent laparo-endoscopic repair [32].

Unadjusted analysis did not reveal any significant differences in the intraoperative complications (1.28% vs 1.33%; $p = 0.849$). However, there were significant differences in the postoperative complications (3.20% vs 4.03%; $p = 0.036$), the reoperation rate due to complications (0.84% vs 1.33%; $p = 0.023$), pain at rest (4.08% vs 6.16%; $p < 0.001$), pain on exertion (8.03% vs 11.44%; $p < 0.001$), chronic pain requiring treatment (2.31% vs 3.83%; $p < 0.001$), and the recurrence rates (0.94% vs 1.45%; $p = 0.0023$). Multivariable analysis confirmed the significant impact of laparo-endoscopic repair of recurrent hernia on the outcome [32]. The authors concluded that laparo-endoscopic repair of recurrent inguinal hernias called for particular competence on the part of the hernia surgeon [32].

11.3.3 Scrotal Hernias

In the guidelines of the European Association for Endoscopic Surgery [15], scrotal hernia is classified as being a complex condition. For scrotal hernia, only highly experienced laparo-endoscopic hernia surgeons should opt for a laparo-endoscopic technique [12]. The challenge in scrotal hernia is ensuring complete dissection of the large hernia sac from the inguinal canal and scrotum. Failure to remove a large section of the hernia sac will generally result in formation of a persistent seroma [12]. Endoscopic control of bleeding during scrotal hernia repair is also often very difficult when dissecting the hernia sac from the spermatic cord structures. Therefore, there is often a higher incidence of postoperative secondary hemorrhage and hematomas [33]. Accordingly, the European Hernia Society Guidelines recommend the open mesh techniques (Lichtenstein, Plug and Patch, and PHS) as the techniques of choice for scrotal hernia [18, 19].

11.3.4 Incarcerated Hernias

In the presence of an incarcerated inguinal hernia, a diagnostic laparoscopy should be performed first of all [12, 15]. The incarcerated bowel or greater omentum can then be withdrawn from the hernia sac, if necessary making an incision into the cranial hernia ring [33]. Next, a decision must be taken as to whether parts of the omentum and/or intestines should be resected. In approximately 90% of cases, the data show that this is not necessary as the organs recover after reposition into the abdominal cavity [33]. Then inguinal hernia repair can be carried out using a TEP or TAPP technique [34–38]. If there is transmural peritonitis, the hernia sac can be first closed with a suture and the inguinal hernia mesh repair performed later [33].

11.3.5 Previous Lower Abdominal, Pelvic, and Urological Surgery, Vascular Operations, and Ascites

Faced with these complex situations, the guidelines of the International Endohernia Society [12] and of the European Association for Endoscopic Surgery [15] also recommend that only very experienced laparo-endoscopic hernia surgeon should opt for a minimally invasive procedure [33]. Following major lower abdominal and pelvic surgery, the European Hernia Society therefore recommends the open mesh techniques (Lichtenstein, Plug and Patch, and PHS) as the preferred techniques [18, 19]. The open mesh approach, no doubt, also presents the least risk in the presence of cirrhosis of the liver with ascites or for patients on peritoneal dialysis [33].

A right-sided or bilateral TEP procedure may be performed safely in patients after previous appendectomy [39]. In a comparative study, the conversion rate after previous open appendectomy was at 10% significantly higher as at 1% in the group without previous appendectomy ($p = 0.005$) [39].

The authors concluded that despite a higher conversion rate, the vast majority of patients could be operated endoscopically [39].

In a comparative study, Le Page et al. [40] found no significant differences in patients with compared with patients without previous prostatectomy in terms of rates of postoperative complications, length of stay, or recurrence. Only the operation time was longer. They concluded that in experienced hands TEP inguinal hernia repair for patients who had previously undergone prostatectomy was safe and had equivalent outcomes to patients who had not undergone prostatectomy and was an alternative to open repair [40].

Chung et al. [41] reported about 23 patients with TEP inguinal hernia repair after previous abdominal surgery compared to 46 patients without such surgery. No difference was observed between the two groups in terms of operative times, analgesic use, hospital stay, return to daily activities, or postoperative complications [41].

In a study by Paterson et al. [42], 35 unilateral and 12 bilateral TEP hernia repairs were performed in the presence of 20 appendectomy, 10 lower midline, 18 suprapubic, and 5 paramedian incisions. There were no major complications and no early or late recurrences [42]. The authors stated that TEP hernia repair could be carried out safely in the presence of scars from previous lower abdominal surgery.

11.3.6 Patients with Coagulopathy or Antithrombotic Therapy

Against a background of a progressively aging population, candidates for inguinal hernia repair are often elderly and have comorbidities. Therefore, it is not uncommon for the patients to be on antiplatelet or anticoagulant therapy [43]. Because antithrombotic agents are associated with longer bleeding time, the risk of postoperative hemorrhage is increased [43]. Prophylactic or therapeutic use of anticoagulants and platelet aggregation inhibitors confronts the treating surgeon with the challenge of protecting patients against thromboembolic complications without inducing bleeding complications [43]. That calls for careful perioperative risk benefit assessment with regard to the use of such therapeutics [43]. If it is possible to suspend platelet aggregation inhibitors for 7 days or discontinue oral anticoagulant therapy and effect bridging with heparin, inguinal hernia surgery can be performed without increased risk of postoperative bleeding [43]. But if, based on multi-disciplinary consensus, antithrombotic medication cannot be dispensed with, a higher risk of bleeding complications must be countenanced [43].

Out of the 82,911 patients from the Herniamed Registry, who had undergone inguinal hernia repair, 9,115 (11%) were operated on while receiving antithrombotic therapy or with existing coagulopathy [43]. The rate of postoperative secondary bleeding, at 3.91%, was significantly higher in the risk group with coagulopathy or receiving antithrombotic therapy than in the group without that risk profile at 1.12% ($p < 0.001$). Multivariable analysis revealed other influence variables which, in addition to coagulopathy or antithrombotic therapy, had a relevant influence on the occurrence of postoperative bleeding. These were open operation, a higher age, a higher ASA score, recurrence, male gender, and a large hernia defect [43].

The authors concluded that patients receiving antithrombotic therapy or with existing coagulopathy who undergo inguinal hernia operation have a fourfold higher risk for onset of postoperative secondary bleeding. Despite the extensive dissection required for laparo-endoscopic (TEP, TAPP) inguinal hernia repair, the risk of bleeding complications and complication-related reoperation appears to be lower compared to open surgery [43].

11.3.7 Patients Older Than 65 Years

Outcome studies demonstrate that morbidity and mortality are increased following surgery in the elderly as compared with the younger population [44].

In the Swedish Hernia Registry, there was a significant and substantial increase in risk of a postoperative complication with laparo-endoscopic and open preperitoneal procedures in older patients (aged > 65 years) [45].

In the Danish Hernia Registry, complications after groin hernia repair were more frequent in patients >65 years (4.5%) compared with younger patients (2.3%) ($p = 0.001$) [46].

In the National Surgical Quality Improvement Program (NSQIP) of the American College of Surgeons, the risk of onset of perioperative complications in patients >65 years is expressed with a significant higher odds ratio of 1.418 [1.206–1.666] [44].

In the Herniamed Registry, 24,571 patients with a primary inguinal hernia operated in TAPP and in TEP technique are documented [44]. 17,214 patients (70.06%) were in the age group ≤65 years and 7357 (29.94%) in the age group >65 years [44].

Unadjusted analysis revealed significantly different results for the intraoperative (1.19% vs 1.60%; $p = 0.010$), postoperative surgical (2.27% vs 4.59%; $p < 0.001$), and postoperative general complications (0.85% vs 1.98%; $p > 0.001$) as well as for complication-related reoperations (1.07% vs 1.37%; $p = 0.044$), which were more favorable in the ≤65 years age group. The age limit for increased onset of perioperative complication rates tends to be more than 80 rather than 65 years. In patients over the age of 80 [44, 47, 48], laparo-endoscopic hernia repair is possible, but preoperative analysis of risk factors and their correction if possible should be mandatory. Moreover, careful intraoperative monitoring by the anesthesiologist is essential, and the possibility to stay for some hours in an ICU should be provided [44].

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Technique Total Extraperitoneal Patch Plasty (TEP): Complications, Prevention, Education, and Preferences

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12.1 Intraoperative Complications

The rate of intraoperative complications in 6833 TEP for primary unilateral inguinal hernia repair in men is 1.17% [1]. The intraoperative vascular injury rate is 0.28% in 6833 male primary unilateral inguinal hernia repairs in TEP technique in the Herniamed Registry.

12.1.1 Injury of the External Iliac Vessels

Injury of the external iliac vessels is an emergency and leads to major bleeding [2–4]. Immediate conversion to open surgery must be done to control the bleeding. An iliac abdominal wall incision is made to immediately convert to open surgery [2]. Pressure is applied to the exposed vessels to control the bleeding. A vascular surgeon, if available, should be called to repair the vessels. Proximal and distal control should be gained before removing compression from the bleeding point, and repair is done using 5–0 Prolene sutures or a patch [2].

12.1.2 Injury of the Epigastric Vessels

In particular in the case of older patients, when creating the preperitoneal space, connective tissue degeneration may result in dorsal displacement of the epigastric vessels from the abdominal rectus muscle. In the majority of cases, this can be seen with the 30° optic in the dissection balloon, so that further use of the balloon is foregone in favor of manual dissection via the 5 mm working trocar. If there is complete displacement of the epigastric vessels, they can be temporarily secured to the rectus muscle with either an endoclip suture or a suture passed transcutaneously, around the vessels, and endoscopically back through the abdominal wall. Clipping of the epigastric vessels is not indicated. The result of displacement is usually minor bleeds from epigastric branches which after identification can be coagulated selectively. Only in the event of bleeding directly from the epigastric vessels is management with absorbable clips justified.

12.1.3 Bleeding

The intraoperative bleeding rate in the Herniamed Registry in 6833 TEP procedures for primary unilateral inguinal hernia in men is 0.72% [1].

12.1.4 Bleeding from the Rectus Muscle

Bleeding of the rectus muscle can occur from muscular branches of the epigastric vessels when the Hasson cannula or blunt-tip trocar is positioned. In this situation, blood flows down along the cannula, stains the camera, and obscures vision [2]. The bleeding vessel should be coagulated using cautery after removal of the cannula. A compress can be inserted along the side of the cannula to achieve hemostasis [2].

12.1.5 Bleeding from Vessels over the Pubic Symphysis

During dissection of the medial preperitoneal space, the veins over the pubic symphysis may bleed and should be controlled properly by monopolar cautery [2].

12.1.6 Bleeding from Spermatic Vessels

Bleeding from spermatic vessels is controlled by using electrocautery [2].

12.1.7 Bladder Injury

Bladder injuries in TEP are extremely rare [5]. In the Herniamed Registry with 6833 unilateral inguinal hernia repair, three cases (0.04%) are reported [1]. In a series of 3868 patients, injuries to the urinary bladder were seen in just eight cases, the majority of whom had previously undergone suprapubic catheterization [5, 11]. Bladder injuries related to balloon dissectors were often limited to only those patients with previous abdominal surgery [5]. In a series of 500 patients, two cystotomies were noted during balloon dissection of the preperitoneal space. Both patients had previous lower abdominal surgery [6]. But this can also happen in patients without any previous, lower abdominal operation or suprapubic catheter placement [5].

Bladder rupture is possible during balloon dissection of TEP even in patients without prior abdominal surgery [5]. But the bladder is especially prone to injury during TEP if the preperitoneal space has previously been dissected [13], e. g., previous preperitoneal hernia repair or prostatectomy. To avoid that complication, the guidelines of the International Endohernia Society recommend that the bladder should be decompressed either by having the patient void immediately preoperatively or by the use of an indwelling catheter [13].

Bladder injury detected during endoscopy should be repaired endoscopically provided the surgeon is sufficiently experienced. This should be followed by bladder drainage for 7–10 days [13].

Bladder injury may present in a delayed fashion with hematuria and lower abdominal discomfort. Contrast-enhanced computed tomography, cystography, and cystoscopy are the primary imaging techniques used to evaluate patients for a suspected injury [13]. Small defects may be managed with postoperative decompression with an indwelling catheter for urinary drainage, whereas large defects necessitate repair.

12.1.8 Bowel Injury

Bowel injury is rare in TEP repair as the procedure is done extraperitoneally. In the Herniamed Registry, four cases out of 6833 unilateral inguinal hernia repairs in TEP technique are reported (0.06%) [1]. In the case of large, irreducible hernias, bowel injury can occur during reduction of the hernia contents. Injury to the sigmoid colon or cecal colon can occur in the case of a large sliding inguinal hernia, when the colon may slide to form a part of the sac [2]. Identification of this situation and prevention of injury are crucial [2].

Also after previous open appendectomy and right-sided inguinal hernias, the lateral dissection needs to be performed very carefully, not injuring the cecal colon which might be adherent to the peritoneum due to adhesions.

In case of a bowel injury, whether problem can be handled laparoscopically depends on the extent of the lesion and the experience of the surgeon. If there is any doubt, conversion is always justified.

12.1.9 Injury to the Vas Deferens

The vas deferens is identified as a thick, white, cord-like structure that enters the deep inguinal ring along with the spermatic vessels. The vas may be injured while dissecting an indirect sac from the cord structures. If the vas deferens is divided in a young patient, it should be repaired immediately by end-to-end anastomosis. In old patients, the cut ends should be clipped to prevent collection of seminal fluid [2].

12.1.10 Conversion

Conversion to either the transabdominal preperitoneal patch plasty (TAPP) or open procedure depends upon the situation and experience of the surgeon [2].

Initially, if there is difficulty in creating an extraperitoneal space, the anatomy is not clear, there is bleeding from small vessels causing a continuous ooze, or dissection of the sac/cord structures is difficult, it is better to convert to the open surgical technique [2]. In case there is an intraoperative complication, it is important to first treat the complication by either the endoscopic or open technique. A decision regarding the approach for repair of the hernia should be taken only after the intraoperative complication has been adequately tackled. Conversion to the TAPP technique may be done, if it is not possible to reduce the contents of the hernia sac [2].

12.1.11 Accidental Tearing of Peritoneum with Pneumoperitoneum

If during manual or balloon dissection a peritoneal tear results in a pneumoperitoneum, single-hand dissection via the medial 5 mm trocar is made appreciably more difficult. In such a case, an additional 5 mm trocar placed suprapubically in the midline may be useful to permit bimanual working. If pneumoperitoneum occurs after placement of both working trocars during dissection of the hernias, it is normally readily manageable.

By steepening the head-down position, adequate exposure of the preperitoneal space is usually achieved. Tiny peritoneal lesions resulting in escape of CO_2 into the abdominal cavity may be problematic. Here, moderate enlargement of the lesion with the Metzenbaum scissors and subsequent suturing may be helpful. We see no need for a Veress needle, since the CO_2 flow is increased, and there is a danger of puncture injuries.

12.1.12 Subcutaneous Carbon Dioxide Emphysema

Subcutaneous emphysema is one of the minor complications associated with endoscopic extraperitoneal repair of inguinal hernia and results in extravasation of carbon dioxide into the subcutaneous tissues [7, 8]. It is a relatively harmless complication as long as hypercarbia is not causing any adverse effect on the respiratory or cardiovascular system, such as pneumothorax, pneumomediastinum, and carbon dioxide (CO_2) embolism [7]. Factors known to be associated with a higher incidence of subcutaneous emphysema are higher insufflation pressure, prolonged operative time, use of more surgical ports, old age, and a BMI < 25 [7].

Some studies have also recognized the importance of the surgical technique. Creation of a false passage during trocar insertion, particularly when multiple attempts have been made, or manipulation of instruments at acute angles causes peritoneal tears and splitting of muscles, leading to subcutaneous emphysema [7]. Development of emphysema may also depend on how well sealed the trocar is at its entry and exit points [7].

In patients with higher risk of developing subcutaneous carbon dioxide emphysema, CO_2 insufflation can be kept at an ideal pressure of 8 mmHg. This reduces the risk of developing subcutaneous emphysema and scrotal swelling [9].

12.2 Postoperative Complications

The postoperative complication rate in 6833 male unilateral primary inguinal hernia repairs in TEP technique is 1.68%, with 0.72% needing reoperation [1]. The most often documented postoperative complications were hematoma/bleeding at 1.16%, seroma at 0.51%, wound healing disorder at 0.07%, and deep infection at 0.06% [1].

12.2.1 Hematoma/Bleeding

In the event of postoperative secondary bleeding in the preperitoneal space with relevant decline in hemoglobin and/or detection of a large hematoma in the preperitoneal space, hematoma removal and hemostasis must be performed by a surgeon with high experience.

A 10 mm suction device is a useful additional instrument for the revision operation. After reopening of the incision at the umbilicus and placement of a Hasson trocar or a blunt-tip trocar, the liquid part of the blood in the extraperitoneal space is suctioned off with the 10 mm suction device. CO_2 gas insufflation is then initiated. This is followed by placement of the 5 and 10 mm trocars in the previous puncture sites under camera vision. Next, the already coagulated blood is removed from the extraperitoneal space using the 10 mm suction device and saline. Likewise, the mesh is removed; this should not present any problem since mesh fixation is generally not used in TEP. Finally, a search for the bleeding site is initiated, and bleeding stopped by means of a clip or electrocoagulation.

Next, after complete hematoma removal and meticulous hemostasis, a new mesh is fitted. Then, a drain is placed again. Meanwhile, the anesthesiologist must monitor the coagulation status, taking any remedial action needed. For patients on platelet aggregation inhibitors, discontinuation of this treatment for a limited period must be discussed by an interdisciplinary team.

12.2.2 Seroma

As already explained for the standard TEP technique, several measures can be taken to prevent seromas. Complete, unlike partial, reduction of an indirect hernia sac results in a lower seroma rate. In the case of a large direct inguinal hernia, the hernia cavity can be completely reduced by gathering and securement of the extended transversalis fascia to Cooper's ligament. Furthermore, drainage of the extraperitoneal space appears to reduce the risk of seromas [13, 14]. If, nonetheless, a seroma is formed, it should not be punctured but left to heal spontaneously. Only if the seroma has not resolved after several months should further surgical measures be contemplated.

12.2.3 Wound Disorders and Deep Infection

Wound disorders and deep infection are very rare complications of TEP operation and cannot be further reduced with antibiotic prophylaxis [15]. Impaired wound healing is seen most commonly at the umbilical access route and generally responds to conservative treatment. For deep infections with mesh involvement, the mesh must be removed. Based on the ultrasound or CT findings, the mesh is removed using an open or laparoscopic route. A new synthetic mesh should not be refitted in such a situation. In contaminated settings, the use of a new mesh can be completely dispensed with or a biological mesh fitted [15].

12.2.4 Postoperative Urinary Retention

The incidence of postoperative urinary retention has been reported to range from 1% to 22% of patients who have undergone laparo-endoscopic inguinal hernia procedures [10].

A history of benign prostatic hyperplasia, age ≥ 60 years, and anesthesia time ≥2 h are significant independent risk factors for urinary retention after laparo-endoscopic inguinal hernia repair. The choice of indwelling or clean intermittent urethral catheterization for postoperative urinary retention remains controversial [10].

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12.2.5 Impairment of Sexual Activity

Painful sexual activity, present in one third of patients with inguinal hernias, improved in the majority of patients following TEP hernia repair [12]. Postoperatively, moderate to severe painful sexual activity occurred in 2.3% of the patients with no history of preoperative complaints [12].

12.3 Pitfalls and Prevention

The absolute contraindications to the TEP technique include patients with preexisting disease conditions such as severe cardiopulmonary insufficiency or liver failure, inability to tolerate general anesthesia, and pregnancy [9].

Relative contraindications are non-reducible or incarcerated inguinal hernia, previous laparoscopic (TAPP) or endoscopic (TEP) herniorrhaphy, massive scrotal hernia, and previous pelvic surgery such as lymph node resection or extraperitoneal prostatectomy, prior groin radiation or midline laparotomy, and central obesity. In these situations, only surgeons very experienced in endoscopic groin surgery should attempt TEP repair if deemed necessary [9].

The surgeon should definitely have a look at the patient before surgery to get a clear clinical picture of the inguinal hernia. If there is any intraoperative discrepancy between the clinical findings available for the inguinal hernia and the size of the hernia sac identified intraoperatively, the possibility of a lipoma in the inguinal canal must be explored. Otherwise, there is a risk of a lipoma being overlooked in the inguinal canal.

Any forceful movement of the balloon trocar can, especially in older patients, lead to a breach of the posterior rectus sheath and of the peritoneal cavity and introduction of the balloon intraperitoneally [9] with possible injury of intra-abdominal organs.

The trocars should be watched carefully as they enter the extraperitoneal space to prevent laceration of the inferior epigastric vessels and their side branches or penetration into the peritoneal cavity.

In a series of 4565 consecutive TEP procedures, Meyer et al. [13] reported about 27 serious complications, 12 bleedings (0.25%), 2 bladder lesions (0.04%), 5 intestinal obstructions (0.11%), 4 intestinal perforations (0.09%), 1 injury to the iliac vein (0.02%), 1 femoral nerve injury (0.02%), 2 lesions of vas deferens (0.04%), and 2 deaths (0.02%) (pulmonary embolism, peritonitis).

The authors concluded that there are contraindications to the TEP procedure. TEP technique must be meticulous to avoid intraoperative complications. Complications can occur even after the surgeon has gained substantial experience [13].

Dulucq et al. [14] reported in 3100 TEP repairs a conversion rate of around 1.2% (n = 36) and an intraoperative complication rate of 2.5% (n = 61). These intraoperative complications were 1 bowel injury (0.04%), 11 inferior epigastric vessel injuries

(0.47%), 1 spermatic cord injury (0.04%), and 48 extensive subcutaneous emphysema (2%). The postoperative complication rate was 2.9% ($n = 69$) with hematoma or seroma in 50 cases (2.1%), neuralgia in 5 cases (0.21%), mesh infection in 1 case (0.04%), port site hernia in 3 cases (0.1%), and urinary retention in 6 cases (0.2%).

Tamme et al. [11] reported in 5203 inguinal hernia repairs in TEP technique in 3868 patients about 12 conversions to Lichtenstein or TAPP (0.31%), clipping of epigastric vessels in 11 cases (0.28%), transection of vas deferens in 3 cases (0.08%), and lesion of urinary bladder in 8 cases (0.21%). Postoperative complications with reoperation were hematoma in 4 patients (0.10%), hemorrhage in 14 patients (0.36%), mesh infection in 1 patient (0.025%), and small bowel obstruction in 2 patients (0.05%). Postoperative complications without reoperation were reported as hematoma in 92 patients (2.38%), trocar site infection in 4 patients (0.10%), nerve irritation in 12 patients (0.31%), and hydrocele in 1 patient (0.025%) [11].

Creation of the preperitoneal space is the most important step for beginners [15]. A wide linea alba may result in breaching of the peritoneum. In such situations, it is best to close the incision and incise the rectus sheath more laterally [15]. Entry into the peritoneum can cause pneumoperitoneum and intra-abdominal organ injury. To avoid this, one must ensure that the correct space is entered by retracting the rectus muscle to lateral and visualize the posterior rectus sheath [15]. Also the balloon trocar should be inserted gently, parallel to the abdominal wall, to avoid puncturing the peritoneum [15]. The balloon must be inflated slowly [15].

For port placement, the skin incisions should be just adequate to grip the trocars and prevent its slipping [15]. The pressure in the preperitoneal space must be such as to offer sufficient resistance during trocar insertion to avoid puncturing the peritoneum [15].

An important and crucial step in TEP procedure is the correct identification of anatomical landmarks [15]. At first the pubic bone should be identified. Once this is seen, the rest of the landmarks are traced keeping this as a reference point [15]. It is advised to keep away from the triangle of doom, which contains the iliac vessels and to avoid placing tacks in the triangle of pain laterally [15].

Bladder injury most commonly occurs during port placement in patients following previous lower abdominal, urological and vascular operations, and interventions [15]. It is absolutely mandatory to empty the bladder prior to TEP repair by voiding the bladder immediately before the operation or catheterization of the bladder [15].

Bowel injury can occur when reducing large hernias, inadvertently opening the peritoneum and causing the bowel to come into the field of surgery and during reduction of sliding hernias [15].

Injury is best avoided in such circumstances by opening the hernia sac as close as possible to the deep ring [15].

Vascular injury is one of the commonest injuries occurring in hernia repair in TEP technique and often a reason for conversion [15]. Most of the bleedings can be controlled with cautery or clips. Iliac vessel injury requires an emergency conversion to control the bleeding and the immediate involvement of a vascular surgeon [15]. Careful dissection and adherence to the principles of TEP repair will help in avoiding most of these injuries.

Injuries of vas deferens occur while dissecting the hernia sac from the cord structures. A complete transection of the vas needs to be repaired in a young patient [15]. An injury to the vas is best avoided by identifying any structure before dividing.

Also the separation of cord structures from the hernia sac must be gentle. Grasping of vas deferens with forceps must be avoided [15].

Bowel obstruction is mainly a result from herniation of the small bowel in an incompletely sutured peritoneal lesion [11]. Any peritoneal lesion larger than 5 mm occurring during dissection should be closed in order to prevent adhesions between bowel and mesh and the incarceration of small bowel loops.

The commonly involved nerves in postoperative neuralgia are the lateral cutaneous and genitofemoral nerves. They are usually involved by mesh-induced fibrosis or entrapment by a tack [15]. The complication is prevented by avoiding mesh fixation or use of glue for mesh fixation, safe dissection of a large hernia sac, and no dissection of fascia over the psoas. Also the use of cautery close to the nerves should be very careful [15].

12.4 Education and Learning Curve

The learning curve for laparo-endoscopic inguinal hernia repair is generally longer than for open. For TEP, in particular, the learning curve is longer than that for open Lichtenstein repair and ranges between 50 and 100 procedures, with the first 30–50 being the most critical [20]. The European Hernia Society recommended in their guidelines that for endoscopic techniques adequate patient selection and training might minimize the risk of infrequent but serious complications in the learning curve [20]. There does not seem to be a negative effect on outcome when the operation is performed by a resident versus an attending surgeon. Specialist centers seem to perform better than general surgical units, especially for endoscopic repair [20].

The Consensus Development Conference on endoscopic repair of groin hernias of the European Association for Endoscopic Surgery has also published statements concerning training and competency in endoscopic groin hernia repair. Endoscopic groin hernia repair is considered to be more complex than open groin hernia repair [16]. Numbers needed to reach competence in TAPP repair appear to be lower than for TEP repair [16]. Numbers needed to reach competence in endoscopic groin hernia repair will decrease when participating in a structured educational program [16]. Broad implementation of a structured educational program in endoscopy is recommended to familiarize surgeons in training with endoscopic surgery and to prevent rare but serious complications of vascular damage or bowel perforation [16].

In a randomized controlled trial, Zendejas et al. [17] showed that a simulation-based mastery learning curriculum compared with standard practice of residents decreased operative time, improved trainee performance, and decreased intra- and postoperative complications and overnight stays after TEP inguinal hernia repair. Furthermore, they demonstrated that surgical trainees, regardless of their level, when adequately supervised by an experienced TEP hernia surgeon, can safely perform the TEP repair and achieve good patient-reported and surgical-related outcomes [18]. Also, surgical trainees can safely perform TEP repair with good long-term outcomes, when they perform their operations under adequate supervision [18].

The curriculum for mastery learning of the TEP repair consisted of two sequential components: an online learning course and skills training. Skills training consisted of supervised, one-on-one practice sessions using the Guilford MATTU-TEP hernia task trainer [19].

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12.4.1 Aftercare and Pain Management

- Since TEP is conducted under general anesthesia, the patient remains for 1–2 h in the recovery room. The patient can be transferred to a normal ward after having completely recovered from general anesthesia, and stable circulatory conditions have been restored.
- The analgesic treatment regimen prescribed postoperatively and tailored to the individual patient's reported pain level should be aimed at assuring a pain-free patient and thus early mobilization. Acute postoperative pain increases the risk of the patient developing chronic pain.
- Severe postoperative pain after TEP must always be viewed as an alarm signal of the likelihood of complications. Therefore, further diagnostic measures should be undertaken if necessary.
- If there is excessive bloody secretion from the drainage, the hemoglobin value must be checked and ultrasonic examination of the operated groin and abdomen carried out.
- If the postoperative course is unremarkable, the patient can be given liquid food and mobilized on the evening of the operation.
- If the drainage is unremarkable 4–6 h after the operation, it can be removed.
- Patient discharge will depend on the individual case and the requirements of the healthcare system.
- Depending on the individual patient's complaints as well as the occupational and physical demands, we recommend reduction of exertion until the wound has healed after 14 days. After that, the patient can gradually resume physical exertion.
- Since the trocar puncture sites are closed with absorbable sutures, there is no need for suture removal.

- In the event of any abnormal developments (fluid secretion from the trocar puncture sites, skin reddening around the trocar puncture sites, inguinal bulging, pain, fever), we ask patients to return to the hospital or visit their general practitioner.
- For more complex procedures with a higher probability of complications, regular clinical follow-up may be needed.
- The patient should in any case be instructed to return to the treating hospital if any complication arises.
- The Consensus Development Conference on endoscopic repair of groin hernias of the European Association for Endoscopic Surgeons states that active encouragement after groin hernia repair is associated with shorter convalescence [16]. Early activity after groin hernia repair does not seem to increase recurrence rates [16]. Quality of life after endoscopic hernia repair is generally excellent in most patients.

Why do I Prefer TEP?

1. One compelling argument put forward for TEP is the use of a purely extraperitoneal access route to the inguinal region. This reduces the risks of intra-abdominal surgical injuries associated with blind insertion of the optical trocar. In particular, it is easier to assist and control the initial access route in the extraperitoneal space compared with the initial blind trocar placement in laparoscopy during the learning curve. In TAPP, too, the initial access route can, of course, also be created through open placement of the optical trocar. This also helps to reduce the risks.
2. The extraperitoneal route is safer after previous abdominal surgery which may have given rise to widespread adhesions. That obviates the need for extensive adhesiolysis, thus also avoiding the risks associated with adhesiolysis.
3. Bilateral inguinal hernias, as seen after all in 30% of the total patient cohort, can be easily operated on using an extraperitoneal space created with a bilateral balloon trocar. Mesh overlap at the midline can be optimally checked and secured.
4. TEP gives an optimum overview of the dissection landmarks.
5. Optimum mesh placement using the instruments is assured to the end of the operation.
6. Therefore, mesh fixation is not needed in more than 95% of TEP procedures.
7. On desufflation of the CO_2 gas, the reduction in the extraperitoneal space and regression of the peritoneum to its former state, while pressing the mesh against the abdominal wall, can be observed and monitored until the end. That helps to identify and still correct any folding of the mesh, which can trigger recurrences.
8. The extraperitoneal space can be easily drained by inserting a Redon drain via a 5 mm trocar before withdrawing the latter.
9. In general, there is no need for peritoneal suturing.
10. The incidence of trocar hernias is lower after using the umbilical route to the extraperitoneal space compared with after the laparoscopic route (10 mm) via the umbilicus.

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Comparison TAPP vs. TEP: Which Technique Is Better?

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13.1 Clinical Comparison of TAPP vs. TEP

TEP and TAPP are the two standard techniques for laparoscopic repair of groin hernia. There have been many studies comparing TEP and TAPP in terms of safety and efficacy; however, there are conflicting reports of advantages of one over the other. TAPP has been reported to be easier to learn but has a higher incidence of visceral injury, postoperative pain, and longer operative time [1]. On the other hand, TEP avoids violation of the peritoneal cavity but is associated with a longer learning curve and a lesser incidence of vascular and visceral injury [1]. The recent guidelines for laparoscopic groin hernia repair published by the International Endohernia Society (IEHS) also could not answer the question of which of the two techniques is better [2]. There have been many systematic analyses comparing TEP and TAPP repairs, and the major differences between the two techniques are as follows (Tables 13.1–13.3):

1. *Access-related complications*

The main difference in TEP and TAPP is in the access to the preperitoneal space. In TEP repair the preperitoneal space is accessed directly in comparison to TAPP where preperitoneal space is accessed via the peritoneal cavity. In an early systematic review which analyzed the results of six comparative studies and three case series, TAPP had a 0.6% incidence of visceral lesions in comparison to 0.2% incidence with TEP [1]. Port-site hernias were more common after TAPP repair (0.4% vs. 0.026%). However a recent systematic review which analyzed eight comparative studies and seven case series found similar results: visceral injuries (0.21% vs. 0.11%), vascular injuries (0.25% vs. 0.42%), and port-site hernias (0.6% vs. 0.05%) [3].

2. *Space creation*

Both TEP and TAPP techniques are based on Stoppa's concept of preperitoneal placement of mesh to cover the myopectineal orifice of Fouchard. It is essential to create an adequate preperitoneal space with proper anatomical delineation for a successful groin hernia repair. The basic difference between TEP and TAPP is in the creation of preperitoneal space. In TEP repair the preperitoneal space is entered directly by creating a plane between the posterior rectus sheath and peritoneum with the use of either balloon or telescopic dissection. In balloon dissection the preperitoneal space is created by inserting a balloon (either indigenous or commercial) into the preperitoneal space and inflating it by saline. In telescopic dissection the space is created by using a 10 mm 30° telescope by moving side to side in gentle fashion dissecting the loose areolar tissue in the preperitoneal space. Balloon dissection is the preferred technique by majority of the surgeons although telescopic dissection is equally effective in space creation [4]. In a randomized study comparing balloon and telescopic dissection in TEP by Misra et al., there was no difference between the two techniques albeit for a slightly higher incidence of inferior epigastric vein drop in balloon dissection group [5]. A recent multicenter study however has shown that balloon dissection was easier and safer [4]. In TAPP the abdominal cavity is entered first, and then after incision of the peritoneum and raising a peritoneal flap the preperitoneal space is approached. The creation of space has been found to be easier in TAPP as the surgeon has more space to work in contrast to TEP where space creation can be difficult because of the limited space in the preperitoneal area and a risk of peritoneal injury and loss of this preperitoneal space. Only few studies have compared ease of space creation between TEP and TAPP, and no difference has been reported with experienced surgeons in ease of space creation [6, 7].

3. *Learning curve*

The concept of a "learning curve" was originally introduced in aircraft manufacturing in 1936 by T.P. Wright. Since then it has been used in many fields outside healthcare. The learning curve describes the time required for a surgeon to learn or master a technique. The learning curve for laparoscopic inguinal hernia repair has been evaluated in three large multicenter trials from Switzerland, the Netherlands, and the United Kingdom [8]. All of these studies documented a significant decrease in operating time, conversion rate, complications, and number of recurrences with increasing surgeon experience. Some studies have evaluated the learning curve by studying the operation time, others by conversion rate or number of recurrences. According to these studies, between 20 and 240 procedures are required for the learning curve to reduce operation time, morbidity, and recurrence rate to a stable level. Many

Table 13.1 Operation time

Author/year	Study design	No. of patients	Grade	TAPP (min)	TEP (min)
Khoury/1995	Observ. prospect.	60 TAPP, 60 TEP	XX00	55	50
Ramshaw/1996	Observ. retrospect.	300 TAPP, 300 TEP	X000	82.5	87.1
Schrenk/1996	RCT	28 TAPP, 24 TEP	X000	46	52.3
Kald/1997	Observ. prospect.	393 TAPP, 98 TEP	XX00	80	80
Cohen/1998	Observ. prospect.	108 TAPP, 100 TEP	XX00	45	70
Bobrzynski/2001	Observ. retrospect.	809 TAPP, 416 TEP	X000	41	46
Papachristou/2002	Observ. retrospect.	60 TAPP, 174 TEP	X000	48	42
Czechowski/2003	Observ. retrospect.	352 TAPP, 324 TEP	X000	100	60
Dedemadi/2006	RCT	24 TAPP, 26 TEP	X000	55	56
Butler/2007	RCT	22 TAPP, 22 TEP	XX00	60	86
Günal/2007	RCT	39 TAPP, 40 TEP	XX00	104.5	57.37
Pokorny/2008	RCT	93 TAPP, 36 TEP	X000	66	78
Zhu/2009	RCT	20 TAPP, 20 TEP	XX00	34.5	32.6
Hamza/2010	RCT	25 TAPP, 25 TEP	X000	96	77
Zanghi/2011	Observ. retrospect.	331 TAPP, 217 TEP	X000	55	110
Gong/2011	RCT	50 TAPP, 52 TEP	XX00	76	79
Shah/2011	Observ. retrospect.	35 TAPP, 76 TEP	X000	70	66
Gass/2012	Registry	1095 TAPP, 3457 TEP	XXX0	59	66.6
Krishna/2012	RCT	47 TAPP, 53 TEP	XX00	72.3	62.1
Mesci/2012[a]	RCT	25 TAPP, 25 TEP	X000	62.4	76
Bansal/2013	RCT	154 TAPP, 160 TEP	XX00	68.6	62.4
Wang/2013	RCT	84 TAPP, 84 TEP	XX00	47.2	50.5
Köckerling/2015	Registry	10,887 TAPP, 6700 TEP	XXX0	52	48
Sharma/2015[b]	RCT	30 TAPP, 30 TEP	XX00	108	121
Jeelani/2015	RCT	30 TAPP, 30 TEPP	X000	75.5	80.8

The grading of the study quality was done according to the sign score: XXXX high quality, XXX0 moderate quality, XX00 low quality, X000 very low quality
[a]Investigation of muscular function
[b]Bilateral hernias, investigation of operative difficulties

factors may influence the learning curve, including previous individual and institutional experiences in surgery, specifically in the laparoscopic technique. Furthermore, the number of hernia repairs performed per year may be important, as may be the selection of patients for laparoscopy, the details of the technique, and the training.

TAPP has been considered to be easier than TEP because of the advantage of the space of peritoneal cavity, but there is no level I evidence to support this. In a meta-analysis, McCormack et al. [1], which included one randomized and nine non-randomized studies comparing TEP and TAPP, have shown that in an inexperienced

Table 13.2 Total complication rate

Author/year	Study design	No. of patients	Grade	TAPP (%)	TEP (%)
Tetik/1994	Observ. retrospect.	553 TAPP, 457 TEP	X000	10.1	17.7
Khoury/1995	Observ. prospect.	60 TAPP, 60 TEP	XX00	6.9	6.9
Felix/1995	Observ. retrospect.	5163 TAPP, 4890 TEP	X000	1.23	1.3
Ramshaw/1996	Observ. retrospect.	300 TAPP, 300 TEP	X000	11.5	7.4
Schrenk/1996	RCT	28 TAPP, 24 TEP	X000	28.6	25
Kald/1997	Observ. prospect.	393 TAPP, 98 TEP	XX00	8.8	8
Cohen/1998	Observ. prospect	108 TAPP, 100 TEP	XX00	20.5	13.4
Lepere/2000	Observ. retrospect.	1027 TAPP, 499 TEP	XX00	10.1	12.5
Weiser/2000	Observ. retrospect.	1216 TAPP, 1547 TEP	X000	6.9	8.7
Bobrzynski/2001	Observ. retrospect.	809 TAPP, 416 TEP	X000	11.7	18.7
Ramshaw/2001	Observ. retrospect.	300 TAPP, 300 TEP	X000	11.5	7.4
Czechowski/2003	Observ. retrospect.	352 TAPP, 324 TEP	X000	7.9	8.7
Dedemadi/2006	RCT	24 TAPP, 26 TEP	X000	41.6	38.5
Günal/2007	RCT	39 TAPP, 40 TEP	XX00	12.8	12.5
Pokorny/2008	RCT	93 TAPP, 36 TEP	X000	39	38
Hamza/2010	RCT	25 TAPP, 25 TEP	X000	16	4
Zanghi/2011	Observ. retrospect.	331 TAPP, 217 TEP	X000	25.7	29
Gong/2011	RCT	50 TAPP, 52 TEP	XX00	12	13.5
Shah/2011	Observ. retrospect.	35 TAPP, 76 TEP	X000	11.4	17.1
Gass/2012	Registry	1095 TAPP, 3457 TEP	XXX0	2.3	5.9
Krishna/2012	RCT	47 TAPP, 53 TEP	XX00	36.9	50.3
Mesci/2012	RCT	25 TAPP, 25 TEP	X000	12%	4%
Bansal/2013	RCT	154 TAPP, 160 TEP	XX00	49	46.9
Wang/2013	RCT	84 TAPP, 84 TEP	XX00	19	20.2
Köckerling/2015	Registry	10887 TAPP, 6700 TEP	XXX0	5.37	2.89
Sharma/2015	RCT	30 TAPP, 30 TEP	XX00	6.7	26.8
Jeelani/2015	RCT	30 TAPP, 30 TEP	X000	6.7	6.7

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surgeon's hand (<20 repairs), both TAPP and TEP would take longer compared to experienced surgeons (30–100 repairs). Voitk demonstrated in his series of 98 TAPP repairs in 1998 that the operating time for the unilateral inguinal hernia repair began to level off after 50 operations [9]. Feliu-Pala et al. showed that the mean operating time was >60 min for first 50 TEP cases, but there was continuous decreasing trend as the level of experience increased (32 min for last 200 cases) [10]. Dulucq et al. in their experience of 3100 TEP cases have reported a recurrence rate of 2.5% in the first 200 cases which decreased to 0.47% for the subsequent 1254 hernias as the learning curve was overcome [11]. Koeckerling et al. reported in a study which evaluated the effect of surgeon volume on laparoscopic inguinal hernia repair outcomes, that

Table 13.3 Recurrence rate

Author/year	Study design	No. of patients	Grade	TAPP (%)	TEP (%)
Tetik/1994	Observ. retrospect.	553 TAPP, 457 TEP	X000	0.7	0.4
Khoury/1995	Observ. prospect.	60 TAPP, 60 TEP	XX00	3.4	0
Felix/1995	Observ. retrospect.	733 TAPP, 382 TEP	X000	0.27	0.26
Schrenk/1996	RCT	28 TAPP, 24 TEP	X000	25	16.7
Kald/1997	Observ. prospect.	393 TAPP, 98 TEP	XX00	2	0
Felix/1998	Observ. retrospect.	5163 TAPP, 4890 TEP	X000	0.46	0.22
Van Hee/1998	Observ. prospect.	33 TAPP, 58 TEP	XX00	2.7	2.8
Cohen/1998	Observ. prospect.	108 TAPP, 100 TEP	XX00	1.85	0
Lepere/2000	Observ. retrospect.	1027 TAPP, 499 TEP	XX00	0.9	0.6
Weiser/2000	Observ. retrospect.	1216 TAPP, 1547 TEP	X000	1.2	0.5
Bobrzynski/2001	Observ. retrospect.	809 TAPP, 416 TEP	X000	2.87	1.92
Papachristou/2002	Observ. retrospect.	60 TAPP, 174 TEP	X000	3.3	0.6
Czechowski/2003	Observ. retrospect.	352 TAPP, 324 TEP	X00	2.3	1.5
Dedemadi/2006	RCT	24 TAPP, 26 TEP	X000	8.3	7.7
Butler/2007	RCT	22 TAPP, 22 TEP	XX00	4.5	4.5
Günal/2007	RCT	39 TAPP, 40 TEP	XX00	2.6	0
Pokorny/2008	RCT	93 TAPP, 36 TEP	X000	4.7	5.9
Hamza/2010	RCT	25 TAPP, 25 TEP	X000	4	4
Belyansky/2011	Observ. prospect.	331 TAPP, 217 TEP	X000	1.34	0.42
Zanghi/2011	Observ. retrospect.	331 TAPP, 217 TEP	X000	0.6	3.7
Shah/2011	Observ. retrospect.	35 TAPP, 76 TEP	X000	5.7	2.6
Bansal/2013	RCT	154 TAPP, 160 TEP	XX00	0.3	0
Wang/2013	RCT	84 TAPP, 84 TEP	XX00	0	0
Jeelani/2015	RCT	30 TAPP, 30 TEP	X000	3.3	3.3

in 16290 operated patients low-volume surgeons (less than 25–30 cases a year) had a significantly higher recurrence rate compared with the high-volume surgeons, although that difference was small (1.03 vs. 0.73%; $p = 0.047$) [12]. Using the conversion rate as an end point, Lal et al. showed that the conversion rate significantly decreases as more experience is gained in TEP repair. In their study the conversion rate was 50% in the first 10 cases and decreased to 2% in the next 51 cases [13].

Bansal et al. evaluated the learning curve in laparoscopic hernia repair using the moving average method [14]. This method has been the most widely used method for calculating the learning curve. It essentially creates an average that "moves" with the addition of new data results in "smoothing" of the process being analyzed, thus reducing the effects of fluctuations. A moving average of 20 was used in this study to reduce variations and accentuate trends. They concluded that 13–15 cases are required initially to become well versed with both TEP and TAPP repairs and there is no significant difference in the learning curve between the two procedures. Similarly no difference in the learning curve of TEP and TAPP was reported by Krishna et al. in their randomized trial including 53 TAPP and 47 TEP repairs [6].

4. *Intraoperative complications*
   The incidence of serious intraoperative complications is very low following laparoscopic inguinal hernia repair whether TEP or TAPP. The incidence of complications reported was higher in the initial years of laparoscopic inguinal hernia repair, but with increasing expertise, the incidence has come down:
   1. *Vascular injury* – Major vascular injury is a very rare complication with a reported incidence of <1% [1]. Incidence is comparable following TEP and TAPP, with a slightly higher incidence following TAPP which is attributed to the access-related complications. The incidence of minor vascular injury like injury to inferior epigastric vessels (IEV), corona mortis, or testicular vessels is not very well reported in literature. An incidence of 2.75% has been reported for bleeding from branches of inferior epigastric, vessels on the pubic bone, or testicular vessels [15]. The available data suggest a slightly higher incidence of these minor vascular injuries following TEP, especially when balloon dissection is used for space creation (Misra et al.) [5]. The injury to IEV is most commonly in the form of dropping of the vessels. This dropping of IEV is seldom seen with TAPP. The injury to corona mortis as well as testicular vessels occurs more commonly with large indirect hernia. The incidence of injury to these structures would be comparable for TEP and TAPP.
   2. *Visceral injury* – The incidence of bowel injury has been reported to the tune of 0–0.06% in laparoscopic hernia repair [1]. In the Cochrane Database Review, two comparative studies reported no visceral injuries, while two reported a higher rate in TAPP than in TEP. In the three case series, the two TAPP series reported similar rates (0.64% and 0.6%) of visceral injuries, while the one TEP series reported a lower rate (0.23%) of visceral injuries [1]. Five studies on TAPP including 2205 patients have reported an incidence of 0.001% of visceral injuries [16–20]. Bittner et al. in their large series of 8050 patients reported visceral injury in nine cases [21]. In comparison 2809 TEP repairs from six case series on TEP repair have also shown an incidence of 0.001% [16–20, 22]. Dulucq et al. in their series of 3100 TEP repairs have reported an incidence of 0.04% [11]. In a German Herniamed database, the incidence of bowel injury was 0.9% in 4583 TEP repairs and 0.8% in 8220 TAPP repairs [23]. Up to 50% of bowel injury occurs during access phase of laparoscopy. Small bowel is the most frequently injured segment (56%). In patients who have previously undergone lower abdominal surgery or suprapubic catheterization, injury to the bladder is the most common visceral complication of TEP (0.06–0.3%) [24]. Bladder injury has also been reported in TAPP specially when it forms a part of the sac or when the peritoneal incision is carried beyond the medial umbilical ligament, but the exact incidence is not known. However recent meta-analysis comparing TEP and TAPP has not shown any significant difference between TAPP and TEP in terms of visceral injuries [3].

5. *Pain*

The major advantage of laparoscopic repair over open repair is the incidence of groin pain both acute and chronic. The International Association for the Study of Pain defines chronic pain as pain persisting beyond the normal tissue healing period, presumed to be 3 months [25].

Poobalan et al. [26] found that prevalence of chronic pain ranged from 0 to 63% following hernia repair in various studies. Aasvang et al., in a review of post-herniorrhaphy chronic pain, reported that the overall incidence of chronic pain after herniorrhaphy was 12% (18% in patients having open surgery [range, 0–75.5%] and 6% in patients treated laparoscopically [range, 1–16%; $p < 0.01$]) [27]. The EU Hernia Trialists Collaboration review of 2003 patients treated by laparoscopic or open-mesh repair showed that a significantly lesser number of laparoscopically treated patients developed a chronic pain state [28].

Most of the non-randomized studies have shown that both TEP and TAPP were comparable in terms of acute pain score. Lepere et al. reported a series of 1972 inguinal hernia repairs with either a TAPP (1290 procedures) or TEP (682 procedures). The pain scores were equivalent in both groups, and chronic groin pain was extremely rare (0.6% vs. 0.7%) [29]. Cocks sequentially compared the results of 148 TAPP repairs in 129 patients with 313 TEP repairs in 254 patients and found no difference in terms of analgesic requirement [30]. In a randomized trial by Bansal et al., TAPP repair was found to have higher pain scores as compared to that of TEP repair in the immediate postoperative period and up to 1-week follow-up, but the incidence of chronic groin pain was similar between TEP and TAPP [7]. The higher incidence of early pain in TAPP was attributable to the peritoneal incision and its closure in TAPP repair. Recent meta-analysis of 10 randomized trials including 1047 patients has failed to show any difference between TEP and TAPP in terms of acute as well as chronic groin pain [3]. The incidence of chronic groin pain was found to be 0.6% and 0.7% in TEP and TAPP repairs, respectively.

6. *Seroma formation*

The incidence of seroma following laparoscopic repair ranges from 1.9% to 11% [31]. Most of the case series have reported a higher incidence of seroma formation following TAPP repair. In a series of 3017 cases of TAPP from two centers over 7 years, the rate of seroma was found to be 8% [17]. A recent comparative study by Koeckerling et al. showed significantly higher seroma following TAPP repair (TEP 0.51% vs. TAPP 3.06%; p value 0.0001) [23]. In a multivariable analysis, a large hernia defect and a scrotal hernia were found to be independent factors associated with higher incidence of seroma formation. Both hernia pathologies were found significantly more often in patients operated on with the TAPP technique; hence, a higher incidence of seroma formation compared with TEP was observed in patients undergoing a TAPP repair.

On the other hand, a multi-institutional retrospective analysis found that local complications, such as seroma, were seen most commonly after TEP repair [32]. A recent meta-analysis comparing TEP and TAPP have shown than there is a slightly higher incidence of seroma formation after TEP repair when compared to TAPP (4% vs. 1%) [3]. However most of this seromas are self-resolving with 98% seromas resolving in 4–6 weeks without any interventions. A large hernial defect, an extension of the hernia into scrotum, and the presence of residual indirect sac are significant clinical factors associated with seroma formation following laparoscopic repair independent of the technique used.

7. *Infections*

The infectious complications following hernia repair range from superficial surgical site infections to mesh infections mandating mesh removal. The wound infection and mesh infection rate have been found to be significantly lower following laparoscopic hernia repair. Wound infection rate of up to 3% has been described with the laparoscopic approach [33]. Schmedt et al. reported 0.07% infections in 4188 unilateral TAPP procedures and 0% in 1336 bilateral procedures [34]. Kapiris et al. reported 0.11% mesh infections in 3017 patients [17], and Leibl et al. reported 3 cases (0.001%) in 2700 patients [35]. Bittner et al. reported 0.1% mesh infections and 0% wound infections in 8050 TAPP procedures in a total of 6479 patients [21]. In the Cochrane Database Review, three comparative studies reported no deep infections, while one reported rates of 0.2% and 0% for TAPP and TEP, respectively [1]. All published case series on TEP and TAPP have reported a wound infection rate of 0.08% (14/16122) and 0.02% (2/10350) in TAPP and TEP, respectively. A recent meta-analysis of 10 RCTs with 1047 patients has shown a low and an equal wound infection rate following both TEP and TAPP (0.08% vs. 0.06%, respectively) [3]. Most of these are superficial surgical site infection and managed easily by local wound care.

8. *Recurrence*

Recurrence after inguinal hernia repair is one of the most important measurable outcomes. The overall recurrence rate for laparoscopic inguinal hernia was reported as high as 25% in early studies [36]. However as the technique has been standardized and more experience has been gained, the recurrence rate after laparoscopic repair has become similar if not better than open-mesh repair. The MRC study has reported a recurrence rate of 1.9% following laparoscopic repair [37]. The reported incidence of recurrence in TEP has been around 1–2% and for TAPP around 0–3% [1]. The recurrence rate in case series reported from 1990 to 1998 including 8761 TAPP cases and 4849 TEP cases ranged from 0 to 5% and 0 to 3.4%, respectively, and has decreased to 0.7% and 0.5%, respectively, in the next decade (1999–2008 17,695 TAPP and 13,562 TEP repairs) (Table 13.3). Recent comparative studies have also reported a recurrence rate of 0.5–0.7% for TAPP and 0.3–0.4% for TEP over a follow-up period of 5 years. In one of the largest series of TAPP (8050 TAPP repairs) by Bittner et al. [21], a recurrence rate of 0.68% has been reported, whereas Dulucq in his series of 3100 TEP repairs has reported a recurrence rate of 0.45% [11]. Recent meta-analysis of 10 randomized trials including 1047 participants have failed to show any difference between TEP and TAPP in terms of recurrence rates over a follow-up period of 6–38 months with majority of recurrences occurring during the first 2 years [3].

9. *Testicular function*

There has been an ongoing debate as to whether there is an alteration in the testicular functions and sexual functions in patients with groin hernia and the impact of surgical intervention. Available surrogates for testicular function include testicular volume, sonographic blood-flow measures, and serum testicular markers. So far the literature is deficient in this regard. Testicular atrophy following hernioplasty is a rare complication with the incidence of 0.5% for primary hernia repair [38]. There are few studies comparing the open and the laparoscopic technique in terms of testicular function. Akbulut et al. in their trial found that there was significant decrease in testicular volume in TEP group in comparison to open-mesh repair group. However postoperative testicular volume remained within normal limit [39]. Singh AN et al. [40] compared testicular parameters following open and laparoscopic repair. They have shown that there was a significant impairment of testicular functions following open-mesh repair as compared to laparoscopic inguinal hernia repair in terms of significant decrease in testicular volume, lesser improvement in resistive index with significant decrease in testosterone, and significant increase in both LH and FSH levels. However, there was no clinically apparent testicular atrophy in any patient. A prospective comparison cohort study comparing the laparoscopic TAPP and open method of inguinal hernia repair by Stula et al. [41] reported a significant increase in the antisperm antibody (ASA) and the mean intratesticular vessels and capsular vessels RI at 3 months; however, this change was statistically nonsignificant 6 months postoperatively. However this change in the testicular parameters was significantly higher in the open method when compared with TAPP technique of inguinal hernia repair. At our institute we have prospectively compared TEP and TAPP in terms of testicular functions. No change in testicular volume and resistive index was observed at 3 months and 6 months follow-up in the study population (p value 0.9 and 0.9, respectively) and between TEP and TAPP repairs (p value 0.79 and 0.72, respectively). We found that there was an overall improvement in the testicular functions in terms of testicular volume and resistive index although not statistically significant, and this change was comparable between TEP and TAPP group. Moreover there was no deterioration in the hormonal levels following laparoscopic inguinal hernia repair, and the outcomes were similar in both TEP and TAPP repairs. Another important observation which has come out from this study is that inguinal hernia repair in general leads to decrease in the vascular impedance of testes and improvement in the testicular vascularity. This implies that the presence of inguinal hernia in itself is associated with some impairment in testicular blood flow which actually improves after laparoscopic repair.

10. *Sexual functions and semen analysis*

While chronic groin pain has been the subject of several studies, little is known about the sexual functions in patients with inguinal hernia preoperatively and following herniorrhaphy. In a nationwide questionnaire study of patients with hernia repair mainly open, 4% patients reported dysejaculation, and 2–3% had moderate to severe pain-related impairment of sexual activity [42]. In ten of the patients, the symptoms were investigated in detail using neurophysiological testing and psychosexual evaluation, and it was concluded that the pain was of somatic origin. Dysejaculation and pain during sexual activity have been described following laparoscopic inguinal hernia repair, but the prevalence and significance have not been assessed in a large cohort. In a Danish study, the incidence of substantial pain during sexual activity was higher with laparoscopic inguinal hernia repair compared with a Lichtenstein repair (12.7 vs. 6.5%) [42]. A study done by Stula et al. showed that 53% of patients undergoing TAPP repair had antisperm antibody (ASA) [41]. ASA are known to cause sperm agglutination, sperm cytotoxicity, poor penetration into cervical mucus, and impairment of acrosomal reaction. In an unpublished study at our institute comparing TEP and TAPP, sexual functions were assessed preoperatively at admission and at 3-month and 6-month follow-up using the Brief Male Sexual Function Inventory (BMSFI) which included parameters such as sexual drive, erection, ejaculation, and overall satisfaction in sexual life. In comparison of sexual functions between TAPP and TEP groups, there was no statistically significant difference preoperatively and at 3-month and 6-month follow-up (p value >0.05). However there is presently no literature comparing TEP and TAPP in terms of sexual function and semen quality.

11. *Quality of life*

Quality of life studies are being used increasingly to evaluate the outcome of surgical care. Quality of life is not measured directly but is commonly sampled by using measurement scales in the form of questionnaires. In view of lower pain scores and early return to activity, LIHR is considered to improve the quality of life of patients with groin hernias. Gholghesaei et al. in their randomized study found better quality of life, less pain, longer operating time, and shorter time to return to activity with laparoscopic hernia repair [43]. In a study by Lawrence et al. assessing quality of life, no significant difference were found between laparoscopic and open group in terms of quality of life at 3 and 6 months postoperatively [44]. Another study identified eight trials that assessed quality of life following hernia repair in 7032 patients and concluded that QOL scores were significantly higher in laparoscopic hernia repair groups than in open hernia repair groups [45]. In a randomized trial comparing QOL between open and laparoscopic groin hernia repairs, Singh et al. reported a significantly better QOL in the postoperative period in terms of physical functions, physical role, bodily pain, and general health after laparoscopic repair [40]. McCormack et al. reviewed the literature in 2005 and concluded that both TAPP and TEP provided better outcomes in terms of quality-adjusted life-years than open repair [1]. However Myers et al. found a significant improvement in all quality-of-life outcome measures following TEP repair except social functioning and mental health [46]. Overall differences in physical and mental quality-of-life measures were significantly improved in the TEP group. There is one randomized study comparing TEP and TAPP conducted from our institute which has shown significant improvement in QOL postoperatively in patients undergoing laparoscopic groin hernia repair, but there was no difference between TEP and TAPP in terms of QOL postoperatively [7].

12. *Return to work or activities*

Complex confounding variables and tremendous subjectivity are incorporated in reporting the amount of time it takes a person to return to work or usual activities. However, recovery time is an important issue in terms of the degree of disruption to a patient's life and the cost to society calculated by days missed from productive work. With few exceptions, the literature has clearly proven that patients have a shorter convalescence and a faster return to work and activities after laparoscopic, compared with open-mesh, inguinal hernia repair. Champault et al. in their study comparing TEP with open Stoppa repair have reported an earlier return to activity in the TEP group (11 days vs. 17 days ($p = 0.01$)) [47]. Similarly Aitola et al. have also reported a significantly earlier return to activity following laparoscopic repair when compared to open groin hernia repair [48]. Most of the comparative studies have shown a similar duration of return to activity following TEP and TAPP. Cohen et al. reported no difference in return to work (TAPP 7 days and TEP 5.5 days) between both techniques [49]. Also Schrenck et al. in a randomized study showed no difference in the time taken to return to work between the two techniques (4.9 days for TAPP and 4.6 days for TEP) [50]. In a randomized trial by Bansal et al., the median duration to return to work was 17.3 ± 5.2 days in TEP group and 15.6 ± 6.4 days in the TAPP group and was comparable in both TEP and TAPP groups [7]. A recent meta-analysis also has failed to show any difference between TEP and TAPP in terms of return to usual activity [3].

13. *Cost*

One of the main issues in LIHR is to justify its cost-effectiveness. However, an adequate analysis of costs and effects is lacking, and it is unclear whether the advantages of laparoscopic repair outweigh its costs. It is plausible that, for management of symptomatic bilateral hernias, laparoscopic repair would become relatively more cost-effective as differences in operation time may be reduced and the difference in convalescence time may become more marked (hence QALYs will increase). For occult contralateral hernias, it has been shown that laparoscopic repair was more cost-effective than open-mesh repair. Greenberg et al. concluded after a systemic review of laparoscopic and open repair of inguinal hernia that a shorter recovery time and shorter off-work period after laparoscopic hernia repair could compensate for the increased hospital expenditures [51]. In a review by McCormack et al., in terms of cost per QALY, the TEP repair was more cost-effective than the TAPP repair [1]. This was found to be related to shorter operative time and decreased hospital stay. In a study by Bansal et al. comparing TEP and TAPP, total cost incurred in both groups was calculated as the sum of the cost of consumables, cost of hospital stay, and the cost of operation theater (OT) time. The difference in cost between the two groups was found to be statistically not significant ($p = 0.23$) [7].

14. *TEP vs. TAPP in large scrotal hernias*

Laparoscopic repair of large scrotal hernias is controversially discussed. There are only few reports in the literature. Ferzli first described laparoscopy for scrotal hernia in 17 patients in 1996 [52]. Bittner analyzed 440 scrotal hernias in their large, single-center series of 8050 TAPP repairs and reported a recurrence rate of 2.7% for scrotal hernias and a higher incidence of sero-hematoma (12.5%) [21]. In our experience large scrotal hernia may be easier to deal with TAPP because the maneuverability for reduction of hernia contents is better because of working space. It is also easier for the bowel to be handled during the reduction of contents because of visibility. However TEP is also feasible in scrotal hernias. In a study by Misra et al., out of 291 groin hernias, 21 were giant scrotal hernias. Out of these TEP repair was successful in 14 (66.6%) with a conversion to TAPP in 4 (19.04%) and open procedure in 3 (14.28%) cases, respectively [53]. Although there is no comparative literature, as per the recent IEHS recommendations [2], both TAPP and TEP are possible therapeutic options in scrotal hernia. TAPP and TEP may be safely used when performed by surgeons with a higher level of experience in either technique.

15. TEP vs. TAPP in incarcerated and strangulated hernias

Incarcerated and strangulated hernias pose a challenge to laparoscopic surgeons. Traditionally laparoscopy was considered to be contraindicated in such situations. However with experience such complicated hernias have been tackled laparoscopically. Both TEP and TAPP techniques have been used in managing such hernias, but there are important differences between the two techniques. In 2001, Leibl et al. [54] published the results of 220 prospectively studied acutely (strangulated) and chronically incarcerated inguinal hernia repairs; 194 of these repairs were accomplished via TAPP. There was no difference in operative time comparing laparoscopic and conventional repair; however, the time of operation was significantly longer compared with elective TAPP repair. Recurrence rate for TAPP repairs of incarcerated hernias were low (0.5%) and was similar to conventional open repair of incarcerated hernias. Other complications, including bleeding, mesh infection (0.1%), organ injury, and death, were similarly low or lower. One advantage of the TAPP technique is that it allows assessment of the viability of the bowel. The time needed for hernia repair allows time for the congested bowel to return to normal or not. Also TAPP gives an opportunity to enlarge the hernia ring, and also resection of the nonviable tissue can be performed intracorporeally or extracorporeally after the repair has been accomplished. TEP can be used for repair of both incarcerated and strangulated inguinal hernias; however, the data on the subject are scant. In 2004, Ferzli et al. described their experience with TEP to repair 11 acutely incarcerated inguinal hernias [55]. Eight repairs were completed via TEP, and three converted to open repairs. They reported no recurrences, a single mesh infection that resolved with continuous irrigation, and a midline wound infection after bowel resection. In a large series of TEP repair, Tamme et al. showed that TEP is particularly advantageous for the treatment of bilateral, recurrent, and strangulated hernias versus open and TAPP repairs with significant reduction in postoperative neuralgia, a reduction in bowel injury, and port-site hernia when compared with TAPP [22]. Saggar and Sarang [56] in the retrospectively analysis of 34 patients (of 286 elective TEP hernia repairs) who underwent repair of chronically incarcerated inguinal hernia using TEP showed that recurrence rate was higher for incarcerated versus non-incarcerated hernias (5.8 vs. 0.35%). Also scrotal hematoma and cord induration also were significantly higher in the incarcerated group. One disadvantage of TEP in comparison with TAPP is that the entire bowel cannot be visualized in TEP. However the umbilical port in TEP can be converted to an

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intraperitoneal port to inspect the bowel when its viability is in question. Thus in setting of incarcerated and strangulated hernia, the conversion rate, recurrence, and complication rates of laparoscopic repair are higher. A drawback to the TEP vs. TAPP approach for the strangulated inguinal hernia is that TEP does not allow inspection of the bowel without laparoscopy.

16. *TEP vs. TAPP for recurrent hernia*

The recurrence of hernia can occur both after an open repair and laparoscopic repair. A question that arises is what is the preferred technique of repair of these recurrent hernias. Recurrence after open anterior repair can be treated with either TEP or TAPP approach which not only provides a mechanical advantage but also a technical advantage of operating through a virgin tissue. Recurrence following laparoscopic repair remains challenging as the preperitoneal space gets obliterated by adhesions and fibrosis, and whether TEP or TAPP approach can be used in such situations remains controversial. The recurrence rate of inguinal hernia after repair is even higher (3.1% vs. 33%) [57] and is attributable to distortion of normal anatomy and replacement of facial strength layer with weak scar tissue.

Most of the TAPP series have shown an equal or significantly better profile compared to open and other repairs in terms of recurrence especially after prior anterior repair. Sandbichler, Felix, and Memon in their single-institution studies have shown a recurrence rate of 0.5%, 0.6%, and 3%, respectively, after TAPP repair [58–60]. Similarly Bittner in his large case series has shown a recurrence rate of 1.1% [21].

A number of studies have also demonstrated equal efficacy of TEP for recurrent inguinal hernia especially after failed anterior approach with recurrence rate ranging from 0% to 20%. Ramshaw's large single-institution study has reported a recurrence rate of only 0.3% after TEP repair [61]. One disadvantage of TEP repair is that the scarring and sutures from previous repair can result in inadvertent peritoneal breach and loss of working space.

In a population-based analysis of prospective data on 1309 patients undergoing endoscopic repair for recurrent inguinal hernia by Gass M et al. [62], intraoperative complications were significantly higher in patients undergoing TEP (TEP 6.3% vs. TAPP 2.8%, $p = 0.0225$), and also TEP technique was associated with longer operating times but a shorter postoperative length of hospital stay. Nonetheless, the absolute outcome differences were small, and thus, on a population-based level, both techniques appeared to be safe and effective for patients undergoing endoscopic repair for unilateral recurrent inguinal hernia.

According to the IEHS guidelines [2], it is generally agreed that an open anterior approach seems to be better after a failed posterior repair. There is good amount of data on TAPP following failed TEP or TAPP repair. Bittner et al. have shown a recurrence rate of 0.74% [21] following TAPP repair for failed TEP or TAPP repairs. However the data on TEP repair for failed posterior repair is lacking. The recent IEHS guidelines recommend that both TAPP and TEP can be used successfully after failed anterior approach and both TEP and TAPP can be attempted after a failed posterior approach provided it is attempted only by experts in field of laparoscopic hernia surgery.

17. *Bilateral inguinal hernia and occult hernias*

Laparoscopic/endoscopic repair of bilateral inguinal hernia has been recommended by the European Hernia Society, the International Endohernia Society, the European Association of Endoscopic Surgery, and the Royal College of Surgeons of England (RCS – Commissioning guide: groin hernias 2013) and is now considered as the gold standard for bilateral inguinal hernia, and both TEP and TAPP approach can be used. The controversy arises for occult contralateral hernias which are not evident on clinical examination. When the laparoscopic technique is used to repair a clinically diagnosed unilateral inguinal hernia, it is possible to also explore the contralateral side. In 10–25% of cases, an asymptomatic, preoperatively inapparent, occult inguinal hernia is identified on the other side [63]. A similar proportion of 28.5% bilateral inguinal hernias is given in the Herniamed Registry for inguinal hernias repaired using a laparoscopic approach [23]. A prospective randomized trial demonstrated that a significant proportion of incidental defects will progress to a symptomatic hernia if left untreated (28% within 15 months) [64]. Therefore, incidental hernias should be simultaneously repaired if the patient has agreed. TAPP repair has a major advantage of allowing the surgeon to explore both the sides simultaneously. A large case series of 2880 bilateral TAPP operations from a high-volume center has shown that morbidity and reoperation rates were only marginally higher compared with 7240 unilateral TAPP operations. The intraoperative complication rate was 0.36% after unilateral and 0.49% after bilateral TAPP repair. The postoperative complication rate was 0.77% after unilateral and 1.4% after bilateral inguinal hernia repair in TAPP technique [21].

In contrast to TAPP, during TEP detection of occult hernia requires dissection into the contralateral side. Hertz and Holcomb performed a laparoscopic transabdominal exploration before performing a TEP inguinal hernia repair and reported an incidence of incipient contralateral hernias as high as 20%. Laparoscopic TAPP repair allows easy identification of the hernia sacs without any need to dissect the spermatic cord. The advantage of contralateral exploration is that an unsuspected contralateral inguinal hernia can be diagnosed at the time of initial surgery, and if treated, the patient can avoid reoperation, exposure to a second anesthesia, another period of work loss, and containment of costs to the healthcare system. The disadvantages would be the violation of a virgin space, difficulty in the event of a requirement for surgery at a later date, and the additional time and morbidity associated with the procedure. In the light of this observation, another question arises: "once dissected, is there a need or advantage in placing a contralateral mesh?" TAPP definitely has an advantage over TEP in terms of diagnosing occult contralateral hernias.

13.2 Comparison of TAPP and TEP: Critical Evaluation of the Studies, Statements, and Recommendations Given by the Guidelines [2, 100, 101]

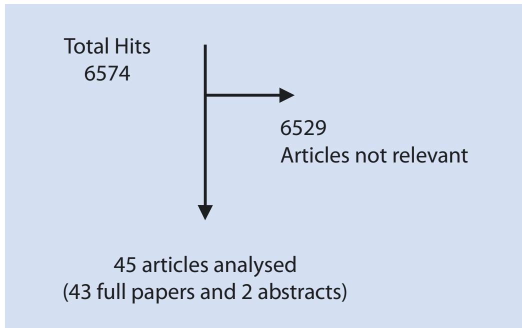
„Search Terms" and „Hits" (PubMed) „laparoscopic inguinal hernia repair" (2101 hits), „laparoscopic hernioplasty" (1861 hits), „laparoscopic herniorrhaphy" (1534 hits), „total extraperitoneal inguinal hernia repair" (289 hits), „total extraperitoneal inguinal hernia repair and laparoscopic inguinal hernia repair" (245 hits), „TAPP and TEP" (143 hits), „laparoscopic herniorrhaphy" and „clinical trials" (212 hits), „meta-analysis" and „inguinal hernia repair" (76 hits), „TEP" and „learning curve" (49 hits), „TAPP" and „learning curve" (31 hits), „systematic reviews" and „inguinal hernia repair" (5 hits), „TAPP" vs. „TEP" (17 hits), and „transabdominal preperitoneal patch plastic" (8 hits).

Search machines PubMed and Cochrane Database

Search period 1994–2015

Total number of hits 6574

Flowchart for Inclusion of Relevant Studies



Six thousand five hundred and twenty-nine papers were found not to be relevant for any comparison of TAPP and TEP; 45 papers seemed to be useful. Forty-three full papers and two abstracts could be analyzed, but the quality of these studies was drastically heterogeneous:

Randomized controlled trials (RCTs): 14. *Comment*: Only five are focused on the comparison of TAPP and TEP directly as the primary objective of the study [6, 7, 78, 80, 81]. The other nine studies have an additional third arm [50, 72, 74, 75, 90], or a third and a fourth arm [76, 79], or additional third, fourth, and fifth study arms [77]. Furthermore two of the three papers mentioned above describe the same study [6, 7], and two papers are related to inflammatory response [76] or hemodynamic and respiratory parameters only [78], and one analyzes muscular function [80].

Meta-analysis and systematic reviews: 8 [1, 3, 60, 91–95]. *Comment*: In four meta-analyses/systematic reviews, the primary objective was comparison between "open and laparoscopic"; comparison between TAPP and TEP is a subgroup analysis [60, 91–93]. One additional study compares the data of one RCT, five observational studies with concurrent comparators and one with nonconcurrent comparators, and three case series (1); one study is a "network analysis" [94] which includes five RCTs having 3 study arms, 11 comparisons of TEP and open and 7 comparisons of TAPP and open. *Only two studies show a direct comparison of TAPP* and *TEP*; one of the two meta-analyses includes seven RCTs [95] and one ten RCTs (3).

Registry studies (population based): 3 [23, 62, 96]

Observational studies: 18 [15, 29, 32, 49, 65–71, 85–89, 97–99]. *Comment*: Only 6 out of 18 are prospective [46, 66, 69, 70, 86, 88], and the other 12 are retrospective.

Guidelines: 2 [2, 100, 101]

Most of the randomized studies have not calculated the statistical power [6, 74, 75, 77–81, 83, 90]. The level of the surgeon's experience with both the techniques was not studied. In addition a variety of confounding factors which might have an impact on the results were not mentioned or taken into account and were not identified by multivariate analyses. Moreover, after analyzing carefully the quality of all the published comparative studies, a lot of bias were found: (1) In five studies surgeons started laparoscopic hernia repair first with TAPP and after gaining experience switched to TEP. Thus the level of experience in laparoscopic surgery was not the same at the beginning of the study [61, 65, 68, 69, 71]. (2) High early recurrence rate (>25%, [50]) and long operation time (>80 min) [15, 68, 69, 75, 76, 79, 99] demonstrated that the surgeons have not yet overcome the learning curve. (3) Methods of patient allocation to one of the two techniques were not clearly stated [32, 77, 99]. (4) Details of technique (type of meshes, type of fixation) having an influence on postoperative pain or recurrences were not given [29, 32, 50, 65, 68, 69, 72, 74, 77, 79, 85, 87–90, 97, 98]. (5) The use of too small meshes (<10 × 15 cm) or meshes of different sizes for TAPP and TEP [61, 68, 69, 72, 76, 97, 99]. (6) Duration of follow-ups was different for TAPP and TEP groups (24–42.5 months versus 9–28.8 months) [29, 49, 50, 65, 72, 74, 75, 78, 79, 84, 86]. (7) The number of patients per intervention group was inadequate (<30) [50, 74, 75, 77–81].

13.3 Results: Operation Time (◘ Table 13.1), Complication Rate (◘ Table 13.2), Recurrence Rate (◘ Table 13.3), Pain (◘ Table 13.4), and Costs

Because of the heterogeneity and limitations of the studies comparing TAPP with TEP, the results showed great variations. The operative time in 24 comparisons varied between 34.5 min and 104.5 min (median 57 min) for TAPP and for TEP between 32.5 min and 110 min (median 62.3 min). In 25 studies complication rates varied between 1.23% and 49% in TAPP (median 11.4%) and between 1.3% and 50.3% in TEP group (median 12.5%). In 24 studies the recurrence rate after TAPP varied between 0% and 25% (median 2.3%) and after TEP between 0% and 16.7% (median 0.6%). Interestingly an analysis of the literature published between 1990

◘ Table 13.4 Chronic pain

Author/year	Study design	No. of patients	Grade	TAPP (%)	TEP (%)
Czechowski/2003	Observ. retrospect.	352 TAPP, 324 TEP	X000	No difference	
Pokorny/2008	RCT	93 TAPP, 36 TEP	X000	3.5%	9%
Bright/2010	Observ. retrospect.	1916 TAPP, 198 TEP	X000	1.15%	3.03%
Zanghi/2011	Observ. retrospect.	331 TAPP, 217 TEP	X000	No difference	
Shah/2011	Observ. retrospect.	35 TAPP, 76 TEP	X000	11.4%	10.5%
Belyansky/2011	Observ. prospect.	331 TAPP, 217 TEP	X000	5.8%	7.1%
Gong/2011	RCT	50 TAPP, 52 TEP	XX00	No difference	
Krishna/2012	RCT	47 TAPP, 53 TEP	XX00	No difference	
Bansal/2013	RCT	154 TAPP, 160 TEP	XX00	1.29%	1.25%
Wang/2013	RCT	84 TAPP, 84 TEP	XX00	0%	0%

and 1998 (TAPP 13 studies, TEP 13 studies) showed a recurrence rate of 1.33% for TAPP and 0.6% for TEP; between 1999 and 2008 (TAPP seven studies, TEP eight studies), the rates were 0.77% after TAPP and 0.54% after TEP [2, 101]. This reduction of recurrence rates demonstrates an improvement of technical performances over the years.

Unanimously a qualitative systematic review of 71 studies showed no difference in intensity and duration of acute pain when TAPP and TEP were compared [92]. For similar chronic pain, six studies showed no difference [6, 7, 89, 90, 97, 99], but two studies showed better results after TAPP (1.15% vs. 3.03% [98]; 3.5% vs. 9% [77]).

Regarding costs a large population-based study performed in German hospitals couldn't find any significant difference between TAPP and TEP [96].

The most recently published meta-analysis (3) of ten RCTs could not prove any significant differences between TAPP and TEP with respect to operative time, total complication rate, hospital stay, recovery time, pain, recurrences, and costs.

13.3.1 Access-Related Complications (Table 13.5a–d)

The frequency of access-related complications may be different. Indeed, an early systematic review analyzing the results of six comparative studies and three case series showed that when using the

Table 13.5 a Access-related complications – visceral

Author/year	Study design	No. of patients	Grade	TAPP (%)	TEP (%)
McCormack/2005	Systematic review	9141 TAPP, 5803 TEP	XXX0	0.6	0.2
Misra/2011	Systematic review	16604 TAPP, 12009 TEP	XXX0	0.21	0.11
O'Reilly/2012	Meta-analysis	In total 4200	XXX0	No difference	
Bracale/2012	Systematic review	395 TAPP, 1209 TEP	XXX0	None	None
Gass/2012	Registry	1095 TAPP, 3457 TEP	XXX0	No information	
Antoniou/2013	Meta-analysis	267 TAPP, 226 TEP	XXX0	No information	
Wei/2015	Meta-analysis	557 TAPP, 500 TEP	XXX0	No difference	
Köckerling/2015	Registry	10887 TAPP, 6700 TEP	XXX0	0.27	0.1

Table 13.5 b Access-related complications – vascular

Author/year	Study design	No. of patients	Grade	TAPP (%)	TEP (%)
McCormack/2005	Systematic review	9141 TAPP, 5803 TEP	XXX0	0.28	0.41
Misra/2011	Systematic review	16604 TAPP, 12009 TEP	XXX0	0.25	0.42
O'Reilly/2012	Meta-analysis	In total 4200	XXX0	No difference	
Bracale/2012	Systematic review	395 TAPP, 1209 TEP	XXX0	No information	
Gass/2012	Registry	1095 TAPP, 3457 TEP	XXX0	No information	
Antoniou/2013	Meta-analysis	267 TAPP, 226 TEP	XXX0	No information	
Wei/2015	Meta-analysis	557 TAPP, 500 TEP	XXX0	No difference	
Köckerling/2015	Registry	10887 TAPP, 6700 TEP	XXX0	1.13	1.39
Sharma/2015	RCT	30 TAPP, 30 TEP	XX00	3.3	9.9
Jeelani/2015	RCT	30 TAPP, 30 TEP	X000	0	3.3

Table 13.5 **c** Access-related complications – port-site hernia

Author/year	Study design	No. of patients	Grade	TAPP (%)	TEP (%)
McCormack/2005	Systematic review	9141 TAPP, 5803 TEP	XXX0	0.4	0.026
Misra/2011	Systematic review	16604 TAPP, 12009 TEP	XXX0	0.6	0.05
O'Reilly/2012	Meta-analysis	In total 4200	XXX0	No difference	
Bracale/2012	Systematic review	395 TAPP, 1209 TEP	XXX0	No information	
Gass/2012	Registry	1095 TAPP, 3457 TEP	XXX0	No information	
Antoniou/2013	Meta-analysis	267 TAPP, 226 TEP	XXX0	No information	
Wei/2015	Meta-analysis	557 TAPP, 500 TEP	XXX0	No difference	
Köckerling/2015	Registry	10887 TAPP, 6700 TEP	XXX0	No information	

Table 13.5 **d** Access-related complications – conversion

Author/year	Study design	No. of patients	Grade	TAPP (%)	TEP (%)
McCormack/2005	Systematic review	9141 TAPP, 5803 TEP	XXX0	0.26	0.47
Misra/2011	Systematic review	16604 TAPP, 12009 TEP	XXX0	0.16	0.66
O'Reilly/2012	Meta-analysis	In total 4200	XXX0	No difference	
Bracale/2012	Systematic review	395 TAPP, 1209 TEP	XXX0	0.75	1.57
Gass/2012	Registry	1095 TAPP, 3457 TEP	XXX0	0.2	1.0
Antoniou/2013	Meta-analysis	267 TAPP, 226 TEP	XXX0	No information	
Wei/2015	Meta-analysis	557 TAPP, 500 TEP	XXX0	No difference	
Köckerling/2015	Registry	10887 TAPP, 6700 TEP	XXX0	No information	
Sharma/2015	RCT	30 TAPP, 30 TEP	XX00	0	6.6
Jeelani/2015	RCT	30 TAPP, 30 TEP	X000	0	6.6

transabdominal approach (TAPP) to the groin, visceral lesions occurred in 0.6% (54/9141), but after TEP this happened in 0.2% (12/5803) of the patients only [91]. On the other hand, after TEP vascular lesions occurred more often compared to TAPP (0.41% vs. 0.28%). Similar observations were reported in two recently published RCTs [80, 81].

Port-site hernias were more common after TAPP (0.4% vs. 0.026%). The conversion rate in TEP was higher than in TAPP (0.47% vs. 0.26%). A recently published systematic review (100) analyzed eight comparative studies and seven case series and found similar results: visceral injuries TAPP 0.21% vs. TEP 0.11%, vascular injuries TAPP 0.25% vs. TEP 0.42%, port-site hernias TAPP 0.6% vs. TEP 0.05%, and conversion rate TAPP 0.16% vs. TEP 0.66%. Whereas in two recently published RCTs [80, 81] after TAPP no conversion was seen, after TEP the frequency was 6.6%; however, the number of procedures done in both techniques was very low ($n = 30$).

In a large German hernia registry (Herniamed), TAPP-related visceral injuries (bowel, urinary bladder) were seen in 0.27% cases (29/10887) but in TEP in 0.1% cases (7/6700) only, and the difference was not statistically significant. Correspondingly to the literature, vascular complications were seen in 1.39% cases after TEP and in 1.13% after TAPP. Difference was significant ($p = 0.03$). However, reoperation rates were not significantly different (TAPP 0.9% and TEP 0.2%) [23]. Interestingly, the overall complication rate as reported by the Swiss hernia registry [62] after TAPP was lower than after TEP (1.7% vs. 4.2%), whereas the German registry [23] showed more complications after TAPP (5.37% vs. 2.89%).

13.3.2 Learning Curve

There are no studies comparing the duration of the learning curves to become familiar with TAPP or TEP, but one systematic review [91] showed a difference with respect to the operative time: For performing a TAPP, unexperienced surgeons (≤20 procedures) needed 70 min but for TEP 95 min, and experienced surgeons (30–300) needed for TAPP 40 min and for TEP 55 minutes. The authors concluded that TAPP may be easier to learn. In three recently published RCTs [80–82], the operation time for TAPP was shorter in each of these studies, but the differences were not statistically significant. Sharma et al. [81] evaluated the operative difficulties of both procedures using an indigenous method and found that TAPP was rated as an easy technique by 100% of the surgeons but TEP by 6.6% of the surgeons only. In conclusion there are some data showing that TAPP may be easier to perform, but more studies are needed to prove it.

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13.4 Summary of Available Evidence

Mainly due to the limited quality of most of the comparative studies inclusively the meta-analyses and systematic reviews, it must be considered that there is no sufficient evidence available to recommend the use of one technique over the other.

Insofar the following statements and recommendations can be given (for details, see Ref. no. [100, 101]):

Statement		
TAPP and TEP have similar operative time. overall complication, postoperative acute, and chronic pain and recurrence rate.	XXXX	Strong

Statement		
Although very rare, there is a tendency in TAPP for more visceral injuries		
Although very rare, there is a tendency in TEP for more vascular injuries		
Although very low, in TAPP the frequency of port-site hernias is higher	XXX0	Strong
Although very low, in TEP the conversion rate is higher		

Statement		
TEP has a longer learning curve and may be more difficult to perform.	XX00	Weak

Recommendation		
In laparoscopic inguinal hernia repair, TAPP and TEP have comparable outcomes; hence it is recommended that –the choice of the technique should be based on the surgeons' skills, education, and experience.	XXX0	Strong

References (In Parenthesis Level of Evidence of the Studies According to the Oxford Classification and Grading of Study Quality Rated by the Sign Score)

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Complex Inguinal Hernias

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14.1 Introduction

Complex hernias can be defined as those with multiple recurrences, infected mesh, strangulation, previous surgeries, and large size. The approach to these hernias involves a great deal of preoperative preparation and decision-making that is carried through the operation and post-op period. The laparoscopic approach in these cases is feasible and with good outcomes provided that the surgeon adheres to the three M's: mastery of the anatomy, meticulous dissection, and modus operandi. A practical approach to the laparoscopic complex hernia repairs is presented along with the available evidence to support it.

14.2 Inguinoscrotal Hernias

14.2.1 Preoperative Considerations

Absolute contraindications include patients with prior groin irradiation, prior pelvic lymph node, and incarcerated massive scrotal hernias. Incarcerated inguinoscrotal hernias and prior laparoscopic herniorrhaphies are considered relative contraindications depending on the operating surgeon's expertise [1].

Conditions such as constipation and prostatism that lead to straining should be addressed preoperatively. A colonoscopy should be offered if the patient has not been screened previously or is due for one. Mechanical bowel prep is often needed in patients with large bowel-containing hernias. Smoking cessation 2 weeks preoperatively improves wound healing and minimizes postoperative cough and pulmonary complications. Other lifestyle modifications such as exercise and weight loss are as crucial in the morbidly obese patient. In addition, careful examination of the skin should be undertaken looking for carbuncles, panniculitis, areas of skin maceration, rashes, or candidiasis. When present, especially in the morbid obese patients, these conditions should be addressed and treated preoperatively. Candidiasis is treated with antifungals; carbuncles and panniculitis should be treated with appropriate antibiotics especially with the increasing prevalence of MRSA.

When obtaining informed consent from patients with large inguinoscrotal hernias, they need to be aware that they are at increased risk for complications and recurrence. These complications include seroma formation, chronic groin pain, vas deferens and bladder injury, and ischemic orchitis. Placement of a Foley catheter in this patient population may be helpful to minimize the risk of bladder injury.

14.3 Technical Considerations in TEP

Three trocars are placed in the midline in a standard fashion [2]. In TEP, the umbilicus-pubis distance and panniculus thickness are critical for trocar placement such that in obese patients with a thick pannus and a lower umbilicus, inadequate placement of the trocars can lead to a decreased working space and excessive torque (see ◘ Fig. 14.1). Insertion of an additional fourth 5 mm trocar may be needed to facilitate the exposure (◘ Fig. 14.2). Dissection is initiated in the midline with identification of the pubic symphysis and Cooper's ligament. The space of Retzius is developed and extended into the space of Bogros. At this point, the epigastric vessels are identified and preserved (◘ Fig. 14.3). Dissection and reduction of cord lipomas when present will help delineate the extent of the hernia sac and create more room to work (◘ Fig. 14.4). In the case of large and incarcerated hernias, the transversalis sling is divided with hook cautery at the 10 o'clock position (if necessary division of the epigastric vessels may be done) to allow complete reduction of the sac (◘ Fig. 14.5). If a testicle and tunica vaginalis are present in the space, it is preferable to divide the sac rather than reduce it to minimize devascularization (◘ Fig. 14.6). The mesh is then placed and tacked only to Cooper's ligament and held in place by the peritoneum. A closed suction drain is inserted to prevent the inevitable incidence of post-op seroma.

14.3.1 Post-op Care

Application of ice packs and administration of NSAIDs will help decrease the swelling in addition to providing analgesia without increasing bleeding.

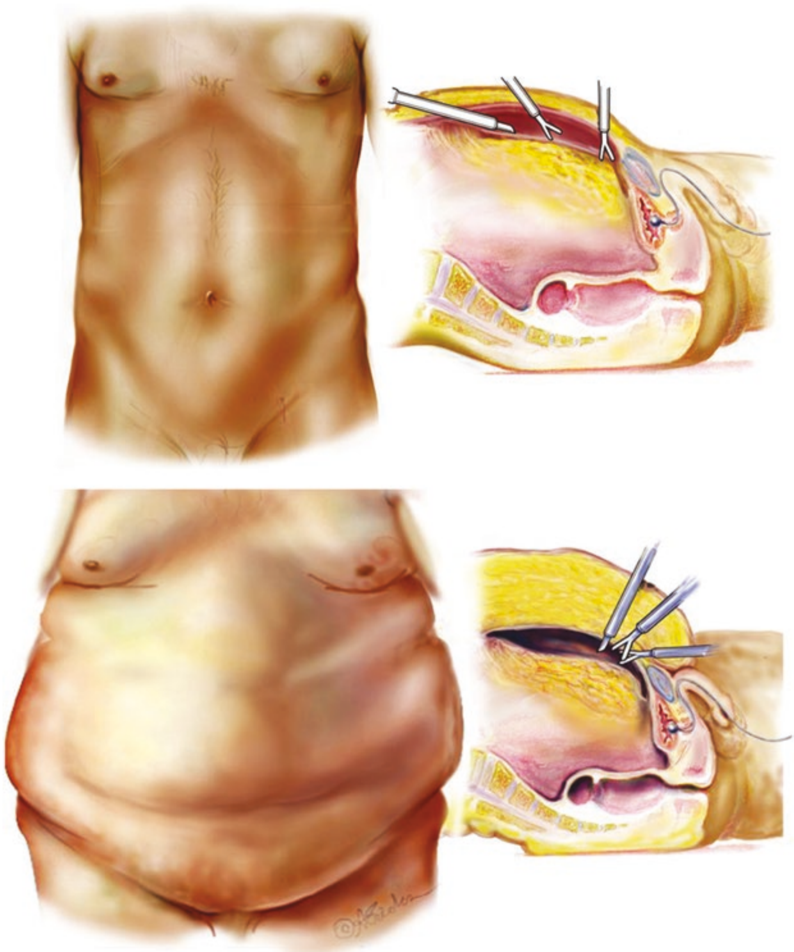

Fig. 14.1 In TEP, the umbilicus-pubis distance and panniculus thickness are critical for trocar placement

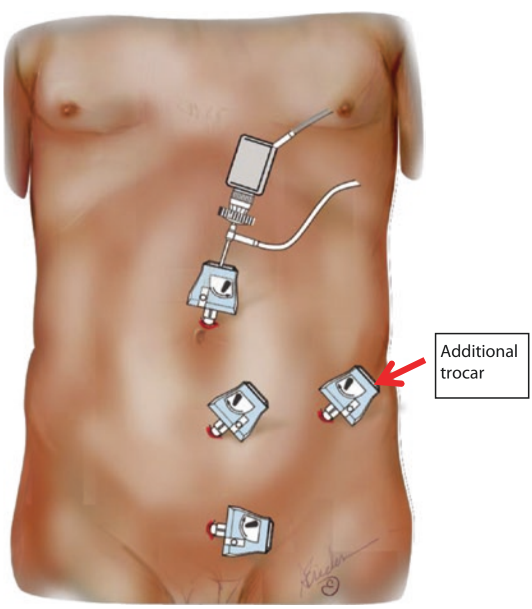

Fig. 14.2 Trocar placement in TEP

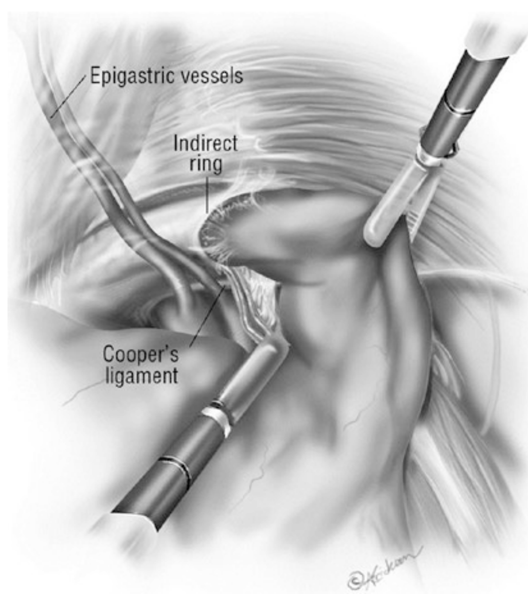

Fig. 14.3 Anatomic relationship of epigastric vessels and hernia

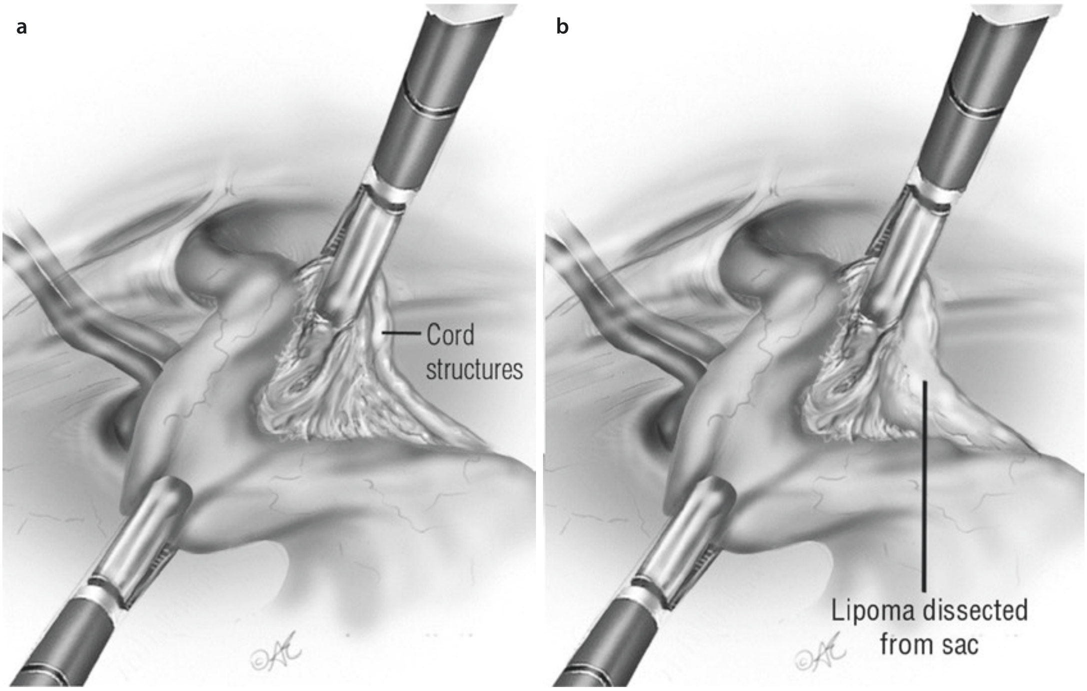

Fig. 14.4 **a** Dissection of hernia sac and cord and **b** dissection and reduction of cord lipoma

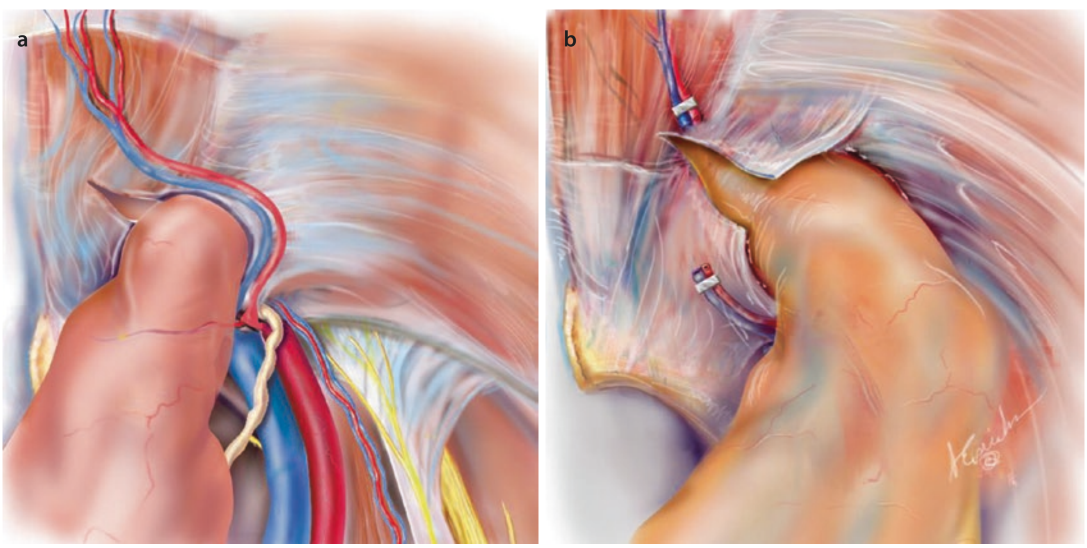

Fig. 14.5 Relaxing incisions in transversalis sling at the 10 o'clock position for incarcerated **a** direct and **b** indirect hernias

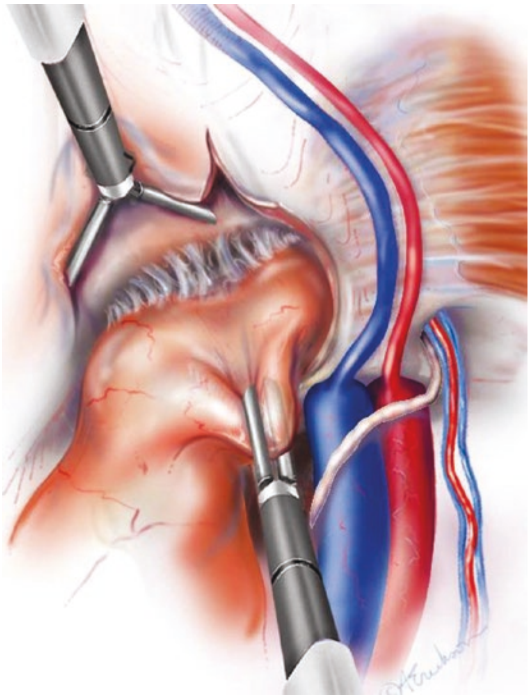

Fig. 14.6 Presence of the testicle and tunica vaginalis in the indirect space should be approached by division of hernia sac

14.4 Technical Considerations in TAPP (See ▸ Chap. 8)

14.4.1 Evidence [3, 4]

Level 3

TAPP and TEP are possible therapeutic options in scrotal hernia. Operation time, complication rate, and frequency of recurrences are higher than in normal hernia repair. Sero-hematoma formation is the most frequent complication. Results will improve with gaining experience. Complete reduction of hernia sack is possible.

TEP inguinal-scrotal hernia repair remains an advantageous approach during the difficult scrotal hernia that requires "conversion" to an open repair, because the preperitoneal dissection performed laparoscopically allows for reduction of the hernia and optimal mesh placement once the hernia repair has been converted and is performed from the anterior approach.

Level 5

The higher recurrence rate may result in some of these cases (large hernia openings), because the standard mesh size (10 × 15 cm) was too small. In large hernia openings, a mesh with less flexural stiffness (lightweight) or insufficient overlapping may be pushed into the defect.

Recommendations

- **Grade C**: TAPP and TEP may be safely used when performed by surgeons with a higher level of experience in either technique. TEP approach for the large, difficult scrotal hernia may serve as an adjunct to dissection and definition of the preperitoneal space allowing for easier hernia and mesh placement once the case is "converted" to open repair.
- **Grade D**: In large hernia openings (3–4 cm), a larger mesh may be used (12 × 17 cm). In large direct defects (3–4 cm), a stapled fixation of the mesh to the symphysis, Cooper's ligament, and rectus muscle may be done. In large indirect defects (4–5 cm), the overlapping of the mesh has to reach approximately 1–3 cm lateral to the spina iliaca anterior superior. In addition, fibrin fixation to the psoas muscle can be performed. In large hernia defects, a mesh with greater flexural stiffness (heavyweight) or a well-fixed lightweight mesh with adequate overlapping may be used. Meticulous hemostasis is essential to reduce the frequency of hematomas and seromas.

14.5 Incarcerated and Strangulated Inguinal Hernias

Incarcerated hernias may be repaired either by TAPP or TEP, but TAPP has the advantage of allowing the surgeon to inspect the bowel to ensure its viability [5]. If a TEP is performed, the umbilical port can be moved from a preperitoneal to a peritoneal location to examine the bowel in question. Occasionally, incarcerated hernias reduce spontaneously or with gentle pressure when paralysis has been achieved with induction of general anesthesia. The key step to the operation is the reduction of the sac and its contents. The hernia ring can be enlarged (while preventing injury to the femoral or epigastric vessels) through a ventromedial incision in the case of direct hernias and through a ventrolateral incision in the case of indirect hernias. If resection of nonviable tissue is required, it can be done intraperitoneally (for the omentum or appendix) or extraperitoneally (for small bowel) after the repair has been accomplished.

The use of TAPP has been described for the treatment of incarcerated femoral hernias [6–8]. A relaxing incision in the medial border of the iliopubic tract as it recurves to form the medial border of the femoral canal may be made to aid in the reduction of the hernia sac.

14.6 Evidence: TAPP for Incarcerated and Strangulated Hernias [3, 4]

14.6.1 Level 3

Operation time is longer than in uncomplicated hernia. Complication rate and recurrences are similar to uncomplicated cases. Advantage of laparoscopy is that bowel viability can be observed during the whole time of procedure. Frequency of bowel resection is less compared with open hernia surgery.

Level 5 Reduction of hernia content or cutting the hernia ring if necessary for reduction may be safer when overlooking both peritoneal and preperitoneal spaces.

Recommendations

- **Grade C**: TAPP may be used for the repair of incarcerated or strangulated inguinal hernias, but the technique should be reserved for surgeons with extensive experience in the TAPP technique.
- **Grade D**: Compromised bowel that is encountered during TAPP repair of strangulated hernia may be resected after the completion of the TAPP repair (after allowing time for the bowel to declare its viability). The resection should be performed extracorporeally for the intestine or may be performed intracorporeally for the omentum or appendix.

14.7 Evidence for TEP in Incarcerated and Strangulated Inguinal Hernia [3, 4]

14.7.1 Level 3

The conversion rate in the acute setting is high. Recurrence and complication rates are higher than in the non-incarcerated hernia.

14.7.2 Level 5

A drawback to the TEP vs. TAPP approach for the strangulated inguinal hernia is that TEP does not allow inspection of the bowel without laparoscopy.

Recommendations

- **Grade C**: TEP may be used for repair of both incarcerated and strangulated inguinal hernias; however, additional laparoscopy for inspection of bowel viability is necessary.
- **Grade D**: The umbilical port can be converted from a preperitoneal port to an intraperitoneal port to assess bowel viability when it is in question.

14.7.3 Evidence for Incarcerated Femoral Hernias

Level 5

There are only few reports of successful treatment of incarcerated femoral hernia. Reduction of hernia contents requires incision of the lacunar ligament.

Recommendations

- **Grade D**: Incarcerated femoral hernia may be safely repaired via the TAPP or TEP; however, in TEP, additional laparoscopy for inspection of the incarcerated hernia content is necessary. Although in some cases a plug repair was done, the general opinion is that a flat mesh having usual size should be inserted.

14.8 Recurrent Inguinal Hernias

Recurrence rates after open primary hernia repair with mesh range between 1% and 5%. Recurrence rates after laparoscopic repair can be as high as 10% [9] or as low as 1% in experienced high-volume centers [10]. However, it is estimated that 17% of inguinal hernia repairs are done for recurrent hernias [11]. Re-recurrence rate after repair of recurrent hernias can be as high as 15%–20% [12–14]. Therefore, laparoscopic repair of recurrent inguinal hernias should be performed in high-volume centers where surgeons are over the learning curve to select the best approach and provide the best possible repair with minimal morbidity. Before an operation for a recurrent hernia is scheduled, it is imperative to review the operative report in detail from previous procedures focusing on the type of hernia that was present, the use of a mesh, and, if so what type and size, the use of tacks/sutures.

Recurrent hernias after a primary open repair can be approached by either TEP or TAPP. Initially most recurrences were done via the TAPP approach, but as surgeons became more familiar with TEP, it became the predominant procedure. Data from multiple nonrandomized studies show re-recurrence rates ranging from 0.5% to 11% with similar outcomes between TEP and TAPP [12, 13, 15, 16].

14

Repair of recurrent inguinal hernias after a prior laparoscopic procedure can be approached either open or with a redo TEP or TAPP. A number of studies have looked at TAPP repair for recurrence after TAPP as the primary repair modality (TAPP after TAPP). In a large series of TAPP after TAPP by Bittner ($n = 135$), the overall re-recurrence rate was 0.74%. This study emphasized the learning curve and experience needed to achieve good outcomes [17].

TEP after TEP is a challenging procedure requiring proficient knowledge in anatomy and meticulous dissection. The challenges arise from adhesions, leading to obscuring of normal anatomical landmarks and loss of working space with difficulty in developing the spaces of Retzius and Bogros. The key features of a TEP after TEP are as follows:

- Development of the working space should be done in a plane between the old mesh and the anterior abdominal wall to keep the peritoneum intact.
- Identification of the epigastric vessels will lead to the identification of the hernia. Hernias don't normally have adhesions, and subsequently the presence of dense adhesions means that there is probably no hernia.
- Ligation of the epigastric vessels or their branches is done routinely to achieve adequate hemostasis because bleeding will compromise the exposure.
- Dissection of the hernia sac is done sharply without electrocautery, whereas in primary hernias, most dissection is blunt with traction and countertraction.
- External palpation and pulling of the testicle will aid in the identification of the cord structures.
- Although the working space is limited and may only allow placement of a smaller-sized mesh, every attempt must be made to place a large mesh. Failing to place a large mesh increases recurrence rates, and in that case, an anterior approach is preferred [18].

In our own experience, TEP after TEP was attempted in 21 patients [19]. Five were converted to open because of inability to open the space of Retzius (3) or bleeding obscuring the operative field (1) and peritoneal violation leading to loss of working space(1). Mean OR time was 47 minutes (31–120 min), and there were no blood transfusions or complications. All patients were discharged home the same day.

14.8.1 Evidence: TAPP for Recurrent Inguinal Hernia Repair [3, 4]

Level 2

TAPP is advantageous in terms of defining anatomy and providing improved mechanical strength. Re-recurrence rate is equal or improved when compared with open techniques. Complication rate at 1 week after surgery is less, and sick leave is shorter compared with the Lichtenstein repair. Acute and chronic pains are less compared with open mesh repair.

Level 3

Effectiveness of TAPP repair in recurrent hernia is equal compared with TAPP repair in primary hernia.

Recommendations

- **Grade A**: TAPP for repair of recurrent inguinal hernia is the preferred alternative to tissue repair and to the Lichtenstein repair for recurrence after prior anterior repair.
- **Grade B**: TAPP for recurrent hernia should only be performed by surgeons with extensive experience in the TAPP technique.

14.8.2 Evidence TEP for Recurrent Inguinal Hernia Repair [3, 4]

Level II

TEP is advantageous in terms of defining anatomy and providing improved mechanical strength. Re-recurrence rate is equal or improved compared with open techniques.

Level IIC

Reoperation rate is less compared with open techniques.

Recommendations

- **Grade A**: TEP for repair of recurrent inguinal hernia is the preferred alternative to tissue repair and to the Lichtenstein repair for recurrence after prior anterior repair.

14.9 Femoral Hernias

Femoral hernias are more common in women and account for 2%–4% of groin hernias [20]. When diagnosed, femoral hernias should be repaired electively even if asymptomatic due to the high risk of strangulation and associated morbidity. Information regarding laparoscopic treatment of isolated femoral hernias is limited to small case series. However, the laparoscopic repair has the advantage of covering the entire myopectineal orifice with a mesh to avoid complications associated with plug placement in the femoral canal in the open repair. Such complications include plug migration and venous thrombosis. Therefore, the authors advocate for all femoral hernias to be repaired laparoscopically [1].

14.10 Obturator Hernia

Obturator hernias are rare and account for less than 0.1% of all hernias, such that limited data on laparoscopic repair exists and is mostly in small case series [21]. They typically occur in older emaciated females. The usual presentation is that of obstruction without a bulge on exam. Pain in medial thigh with extension, abduction, and medial rotation of the hip, the Howship-Romberg sign, is pathognomonic but rarely present. Imaging with CT scan is needed to make the diagnosis, and prompt surgical treatment is necessary to avoid strangulation and the high mortality rate in this elderly population. And considering that up to 20% of obturator hernias are bilateral, it is mandatory to explore the other side. Laparoscopic repair offers the advantage of exploring both sides and covering the whole myopectineal orifice with mesh. Both TEP and TAPP can be done keeping in mind that in TEP, the viability of the bowel should be assessed with conversion of the umbilical port from a preperitoneal into a peritoneal position.

14.11 Hernias in Women

Hernias in women deserve special attention as they follow a different pattern than in their male counterparts. It is more common to have small femoral hernias in women and very rare to have large direct hernias. This difference in presentation stems from the anatomical differences of the female and male inguinal canals, mainly the defect in the external oblique aponeurosis in males [22]. The diagnosis of hernias in women can be challenging depending on the location of the hernia and the presenting symptom. If the presentation is associated with a bulge, then the management is straightforward. More often than not, when a female patient presents with groin pain, the physical exam is non-revealing, and the differential diagnosis is wide and involves many organ systems such as musculoskeletal, genitourinary, gastrointestinal, and vascular to name a few. The risk of occult hernias in women is not to be undermined. Imaging is necessary to make a diagnosis in the absence of a bulge, and MRI can be very helpful in diagnosing potential causes of groin pain besides hernias [23]. Forty-one percent of recurrent groin hernias in women are attributed to femoral hernias that were not present at the initial operation [20]. This high frequency argues for a laparoscopic repair in all women to cover the inguinal and femoral spaces simultaneously.

14.11.1 Evidence [3, 4]

Level 4

Women are at increased risk of having an occult synchronous femoral hernia.

Grade C

When performing inguinal hernia repair in women, extra effort should be undertaken to reveal and treat occult synchronous femoral hernia.

14.12 TEP and TAPP After Previous Radical Prostatectomy and Lower Abdominal Surgery

An almost fourfold increase in the incidence of groin hernia repair was observed after retropubic and minimally invasive prostatectomy compared with a control cohort, and men who underwent radiation had an almost twofold increase in incidence [24].

These observations suggest that in addition to postoperative changes in the abdominal wall, increased vigilance for groin hernia also contributes to the observed increase in the incidence of groin hernia repair in men with prostate cancer. In general an anterior open approach would be the preferred treatment for of inguinal hernias in patients that had undergone prostatectomies. However, both TEPP and TAP have been described for such hernias. It is generally accepted that an anterior approach seems to be the best choice after previous preperitoneal surgery.

Only two studies report the results of TAPP [26] and TEP [25] in hernia patients after previous transabdominal radical prostatectomy. During a 1-year period, Dulucq operated on a total of ten patients after prostatectomy with TEP. Operation time was longer than in uncomplicated repairs, and two patients were converted to TAPP, but overall complication rates and outcomes were similar. Wauschkuhn et al. reported approximately 264 patients who underwent surgery during a 10-year period. They found a longer operation time and a higher morbidity (5.7 vs. 2.8), but time of sick leave and recurrence rates were similar. Analysis of subgroups with respect to the time period during which they were operated on showed a steep learning curve.

Patterson also described 47 TEPs in patient with a variety of lower abdominal scars including appendectomy and paramedian and Pfannenstiel incisions [27]. There were two conversions to open procedure without any significant complications.

14.12.1 Evidence [3, 4]

Level 3

TAPP and TEP are possible treatment options. Operation time is longer and morbidity higher compared with repair of primary hernia, but time of sick leave and re-recurrence rate are similar. There is a steep learning curve. In TEP, there is a significant conversion rate to TAPP. Level 5 TAPP seems to be easier to perform.

Grade D

TAPP or TEP repair may be performed, but it should only be attempted by experts in TAPP or TEP inguinal hernia repair.

14.13 Bilateral Hernia

In comparison to open surgery in patients presenting a bilateral inguinal hernia, laparo-endoscopic repair offers the possibility of repair of both sides without any increase of the access trauma to the abdominal wall. Furthermore a large prospectively documented case series could show that short-term and long-term outcome was equal to the repair of a unilateral hernia [28], except operation time was about 20 min longer. The incidence of bilateral hernias is high. In a prospective study of 1010 hernia repairs consecutively performed with a long follow-up, the rate of bilateral hernias was 28%, but in the patients operated on because of a unilateral hernia, 13.8% of these patients developed a contralateral hernia after 5 years [29]. To grant the advantages of laparo-endoscopic repair, it is recommended to always carefully evaluate both sides clinically and when in doubt by ultrasound. Furthermore, it is recommended to get informed consent for repair of both sides in the case that intraoperatively (esp. in TAPP) a contralateral (clinically occult) hernia is found.

14.13.1 Evidence [3]

Statement

- **Level 5**: In a significant number of cases, unsuspected hernias are found on the contralateral side at surgery

Recommendations

- **Grade D**: The patient with unilateral groin hernia should be asked to give his/her consent to allow simultaneous repair if a contralateral occult hernia is found and he/she wishes it

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Mesh Technology at Inguinal Hernia Repair

Ferdinand Köckerling, Dirk Weyhe, Rene H. Fortelny, and Bruce Ramshaw

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15.1 Biocompatibility

15.1.1 Synthetic Nonabsorbable

In a meta-analysis of Currie et al. [1], eight trials were included in the analysis of 1667 hernias in 1592 patients. Mean study follow-up was between 2 and 60 months. There was no effect on recurrence or chronic pain. Lightweight and heavyweight mesh repair had similar outcomes with regard to postoperative pain, seroma development, and time to return to work.

The authors concluded that both mesh options appear to result in similar long- and short-term postoperative outcomes [1].

In a systematic review and meta-analysis, Sajid et al. [2] studied 11 randomized controlled trials (RCTs) encompassing 2189 patients. In a fixed-effects model, operating time, postoperative pain, and recurrence rate were statistically similar between lightweight mesh and heavyweight mesh. Lightweight mesh was associated with fewer perioperative complications and a reduced risk for developing chronic groin pain. There was also a reduced risk for developing other groin symptoms, such as foreign body sensations, but it was not statistically significant.

In conclusion, the use of lightweight mesh for laparoscopic inguinal hernia repair is not associated with an increased risk for hernia recurrence. Lightweight mesh reduces the incidence of chronic pain, groin stiffness, and foreign body sensation [2].

Therefore, Sajid et al. [2] recommended to use lightweight meshes routinely in laparoscopic inguinal hernia repair. In the update [3] with level 1 studies of the European Hernia Society guidelines on the treatment of inguinal hernia in adult patients [4], it is pointed out that insufficient data are available on the potential advantage of lightweight meshes in laparo-endoscopic inguinal hernia repair. Advantages of lightweight meshes have not been shown in endoscopic repair [3].

In the update [5] of the guidelines on laparoscopic (TAPP) and endoscopic (TEP) treatment of inguinal hernia of the International Endohernia Society [6], a statement on level 1A is made that the statistical significance about lighter meshes with larger pores results in improvement of quality of life is not consistent in the published meta-analyses. Subset analysis revealed no higher risk of recurrence after using lightweight meshes in laparoscopic inguinal hernia repair [5].

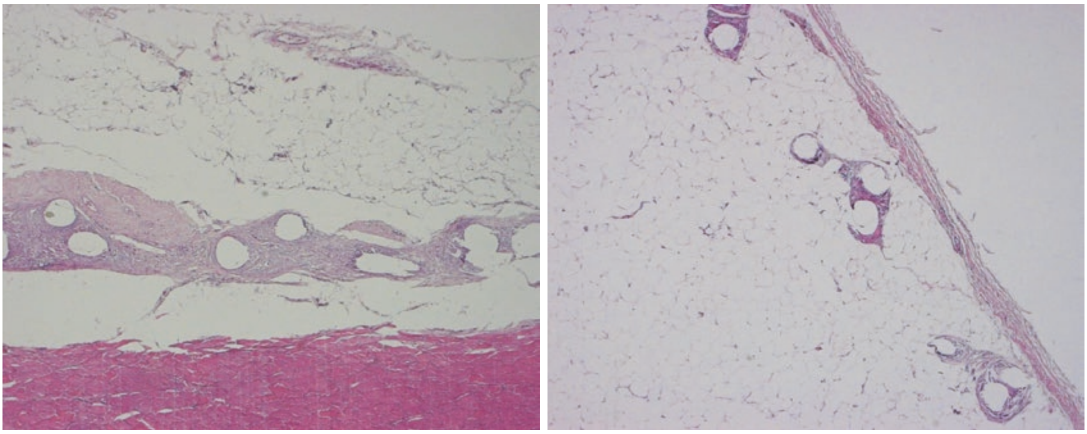
Table 15.1 Meshes on the market for inguinal hernia repair

	PP (g/m^2)	Rigidity
Prolene	108	++++
Marlex	95	++++
Surgipro	95	++++
Atrium	83	++++
Premilene	55	+++
Parietene light	38	++
Optilene mesh LP	36	++
TiMesh light	35	++
Vypro II (multifil.) + polyglactin	31	+
Ultrapro + polyglecaprone	28	++
TiMesh extralight	16	+

On evidence-level grade B, the guidelines of the International Endohernia Society recommend the use of a monofilament synthetic nonabsorbable implant (polypropylene) with a pore size of at least 1.0–1.5 mm (usually meaning low weight) (Table 15.1, Figs. 15.1, 15.2, and 15.3) consisting of a minimum tensile strength in all directions of 16 N/cm appeared to be most advantageous [5, 6].

The consensus development conference on endoscopic repair of groin hernias of the European Association of Endoscopic Surgery (EAES) has made the statement with a level of consensus of 86% that there is currently not enough evidence supporting the general use of lightweight mesh over heavyweight mesh in endoscopic groin hernia repair [7].

In 2016 the long-term results of a randomized double-blinded prospective trial of a lightweight (Ultrapro) versus a heavyweight mesh (Prolene) in laparoscopic total extraperitoneal inguinal hernia repair (TULP-trial) were published [8]. Between March 2010 and October 2012, male patients who presented with a primary, reducible unilateral inguinal hernia who underwent day-case TEP repair were eligible. During the study period, 950 patients were included. One year postoperatively the presence of relevant pain (Numeric Rating Score 4–10) was significantly higher in the lightweight mesh group (2.9%)



Heavy-weight, small-pore polypropylene mesh

Light-weight, large-pore polypropylene mesh

Fig. 15.1 Histological appearance of heavyweight, small-pore polypropylene mesh with bridging effect vs lightweight, large-pore polypropylene mesh

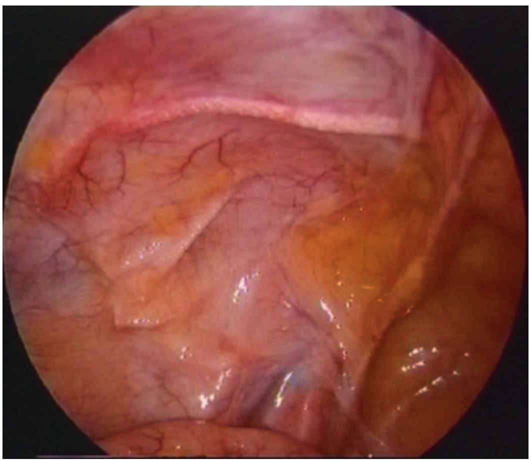


Fig. 15.2 Heavyweight, small-pore polypropylene mesh (83 g/m^2) 5 years after endoscopic implantation

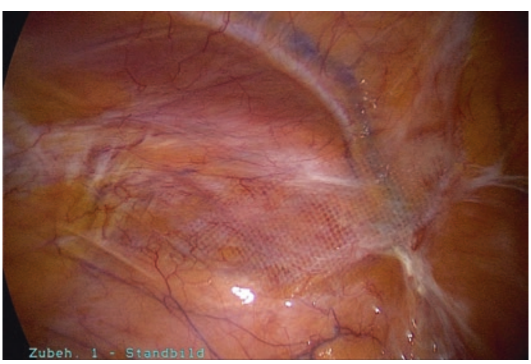


Fig. 15.3 10 years after bilateral TEP repair with titanized, lightweight, large-pore polypropylene mesh

compared with the heavyweight mesh group (0.7%) (p = 0.001), and after 2 years this difference remained significant (p = 0.03). There were 4 (0.8%) recurrent hernias in the heavyweight group and 13 (2.7%) in the lightweight group (p = 0.03). No difference in foreign body feeling or quality of life scores was detected.

The authors concluded that, in TEP hernia surgery, there was no benefit of lightweight over heavyweight meshes observed 2 years postoperatively [8].

15.1.2 Synthetic Absorbable

The guidelines of the European Hernia Society state, based on evidence-level 1A, that operation techniques using mesh result in fewer recurrences than techniques, which do not use mesh [4]. Although mesh repair appears to reduce the likelihood of chronic pain rather than increase it [4], mesh can cause considerable pain and stiffness around the groin and affect physical functioning [1]. This had led to various types of mesh being engineered, with a growing interest in absorbable and biological meshes [9]. To avoid complications, the use of absorbable meshes – such as those made of lactic acid polymer or lactic and glycolic acid copolymers – has been proposed. This exposes the patient to inevitable hernia recurrence because the inflammatory response, through a hydrolytic reaction, completely digests the implanted prosthetic material [9–11].

In a pilot study ten patients underwent open inguinal hernia repair with the use of a plug and patch out of an absorbable polyglycolic acid/trimethylene carbonate mesh (BioA). Three years after the procedure, three patients (37.5%) were diagnosed clinically with a recurrence [12].

A novel approach is to use long-term resorbable implants like TIGR Matrix surgical mesh. In a pilot study at two sites in Sweden, 40 patients with primary inguinal hernias were enrolled for Lichtenstein repair using this new device. None of the patients with an isolated lateral inguinal hernia had developed a recurrence, but 4 (44%) with medial and 4 (33%) with combined hernias have recurred at 36 month follow-up [13].

In conclusion of the very limited number of availably studies, the use of absorbable meshes in laparo-endoscopic inguinal hernia repair is not justified on a routine basis outside of a trial.

15.1.3 Biological

Another potential alternative to the synthetic meshes is biological mesh which, unlike absorbable meshes, is not completely degraded; instead, these induce a remodeling process, i.e., the biological mesh is incorporated into the host through the reproduction of new site-specific tissue [9].

In three retrospective case series [9, 14–17] with 10–38 patients, inguinal hernias were repaired in a laparo-endoscopic technique (TEP, TAPP) with Surgisis. During a mean follow-up period of 12–14.5 months, a recurrence rate of 2 and 9.1% was observed [14, 15]. However, for reliable estimation of long-term recurrence rate after implantation of a biological mesh, a follow-up period of more than 24 months is necessary. No improvement in symptoms was seen in one patient with a sports hernia following TEP operation with Surgisis [16]. In another study, the biological meshes (Surgisis) were used successfully even in a potentially contaminated setting, i.e., with incarcerated/strangulated bowel within the hernia or coincident with a laparoscopic cholecystectomy/colectomy as well as in a grossly contaminated field (i.e., gross pus or fecal spillage) [9, 17].

In conclusion, inguinal hernias can be repaired in laparo-endoscopic technique with biological meshes with reasonable recurrence rate in short term, also as an alternative in a potentially contaminated field [9]. But the higher costs do not justify the routine use in inguinal hernia repair.

15.2 Size

Mesh size may have a greater impact on recurrence than surgical technique [5, 6]. 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, i.e., light- or heavyweight mesh [5, 6].

In the guidelines of the International Endohernia Society, the recommendation on an evidence-level grade A is to use a mesh of at least 10 × 15 cm for TEP and TAPP inguinal hernia repair. On evidence-level grade D for larger hernias (direct >3–4 cm, indirect >4–5 cm), a bigger mesh (i.e., 12 × 17 cm or greater) is recommended [5, 6].

Insufficient dissection of the preperitoneal space makes it difficult to place a large mesh properly and avoid folds and wrinkles [5, 6]. Therefore, 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 [5, 6]. Fixation does not compensate for inadequate mesh size [5, 6].

In the EAES consensus development conference on endoscopic repair of groin hernias, it was stated that sufficient overlap of the mesh is more important than fixation of the mesh (level of consensus: 82%). The mesh in groin hernia repair measures minimally 15x10 cm (level of consensus: 89%) [7]. The use of a heavyweight mesh, larger mesh size, mechanical fixation, and reduction of dead space (i.e., fixation of the transversalis fascia to Cooper's ligament) could be considered in patients with a large medial (i.e., direct) hernia (level of consensus: 85%) [7].

15.3 Slit: Yes or No?

There is no convincing evidence in the literature to support use of a slit or to use no-slit in the mesh for laparo-endoscopic inguinal hernia repair [5, 6]. Therefore, the International Endohernia Society give a recommendation on evidence-level grade B in the guidelines that based on the available evidence, a slit should not be cut in the mesh, although cutting does not compromise testis perfusion [5, 6].

15.4 Fixation (René H. Fortelny)

15.4.1 Non-fixation

The systematic review of Sajid et al. [20] including 1386 patients of 8 RCT with a follow-up of 6–36 months revealed no significant differences in the rates of recurrence or postoperative pain between permanent tack fixation and non-fixation in either TEP or TAPP.

Recurrence

Neither six randomized controlled trials (RCTs) nor three case control studies could demonstrate a significant risk of recurrence following mesh non-fixation in TEP repair (◘ Table 15.2). One RCT by Smith et al. [47] showed no significant difference in recurrence rates comparing tack fixation with non-fixation in TAPP repair. All these RCTs contain limited information on hernia defect size and type especially regarding the

◘ **Table 15.2** Meta-analyses, systematic reviews, randomized control trials, and clinical control studies on recurrence comparing fixation to non-fixation in endo-/laparoscopic mesh repairs

Bibliographic citation	Type of study	Type of repair	Follow-up	Recurrence		Level of evidence	Quality rating
				Fix	Non-fix		
Sajid et al. 2012 [20]	MA	TAPP/TEP	6–36 months§ (8 RCT)	n.s.	n.s.	1++	Moderate
Teng et al. 2011 [21]	MA	TEP	6–36 months§ (8 RCT)	n.s.	n.s.	1++	Moderate
Tam et al. 2010 [22]	MA	TEP	6–36 months§ (8 RCT)	n.s.	n.s.	1++	Moderate
Garg et al. 2011 [31]	RCT	TEP	26,2 (25–29) months*	0/41	0/43	1++	Moderate
Garg et al. 2009 [34]	CCS	TEP	17 (6–40) months§	1/61	2/1692	2–	Low
Taylor et al. 2008 [35]	RCT	TEP	8(6–13) months*	1/247	0/253	1+	Moderate
Koch et al. 2006 [41]	RCT	TEP	19 (6–30) months*	0/20	0/20	1+	Low
Parshad et al. 2005 [49]	RCT	TEP	23.2 ± 9.3 month∞	0/25	0/25	1+	Low
Moreno-Egea et al. 2004 [44]	RCT	TEP	36 ± 12 months∞	0/118	3/111	1+	Moderate
Lau et al. 2003 [45]	CCS	TEP	1 year#	0/100	0/100	2–	Low
Khajanchee et al. 2001 [46]	CCS	TEP	15(1–23) months§	2/67	4/105	2–	Low
Smith et al. 1999 [47]	RCT	TAPP	16(1–32) months*	3/273	0/263	1+	Moderate
Ferzli et al. 1999 [48]	RCT	TEP	8 months#	0/50	0/50	1+	Low

#Mean
*Median (range)
§Mean (range)
∞Mean ± SD
n.s. not significant

percentage of large direct hernias (type M3, EHS classification).

In addition to the results of the RCTs, a Herniamed registry study published by Mayer et al. [51] based on the results of a multivariate analysis of 11,230 cases after TAPP repair detected a significant risk of recurrence in cases of direct hernias as well as combined hernias (combined versus medial, OR 1.137 (95% CI 0.656-1.970); lateral versus medial, OR 0.463 (95% CI 0.303–0.707); p <0.001) in the group of non-fixated meshes.

According to the IESH guidelines for the endoscopic repair of groin hernias by Bittner et al. [55] published in 2011, mesh fixation in TEP is not necessary apart from large medial defects (recommendation grade A). For TAPP repair, non-fixation is feasible for medial and lateral hernias up to a diameter of 3 cm (grade II in EHS classification). In case fixation is required, an atraumatic glue application should be preferred (recommendation grade B) (Fig 15.4).

Acute and Chronic Pain

In all three meta-analyses [20, 21, 22] including eight RCTs [21, 22, 31], no significant differences whether in acute nor in chronic postoperative pain were detected. Only in the TEP repair study of Taylor et al. [35] a significant reduction of chronic pain in the non-fixation group was reported. The only RCT on TAPP repair of Smith et al. [47] detected no significant difference regarding chronic pain in the non-fixation group. However, all studies lack the detailed quantification of preoperative pain, which would be helpful for the identification of high-risk patients for the development of postoperative chronic pain.

Fig. 15.4 TAPP-fibrin glue fixation

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15.4.2 Glue Fixation

Permanent Versus Nonpermanent Fixation (Staple/Tack Versus Glue)

Recurrence

Regarding TEP repair, two meta-analyses [18, 19] found no significant difference in recurrence rates between staple and glue fixation methods. The results of three RCTs [23, 29, 42] included in the meta-analyses by Sajid et al. [18], as well as four case control studies [25, 40, 43, 50], confirmed these findings (Table 15.3).

For TAPP repair, one meta-analysis addressed glue versus staple fixation [18] including four RCTs [32, 36, 38, 39] and reported no significant intergroup difference (Table 15.3).

These results were confirmed by six RCTs [24, 28, 32, 36, 38, 39] and three case control trials [26, 33, 37].

Acute and Chronic Pain

The impact of mesh fixation on chronic pain in TEP repair for primary inguinal hernia repair in men was analyzed using data from the Swedish Hernia Register. Permanent fixation (PF) was compared with no fixation (NF) or nonpermanent fixation (NPF) [52] in 1110 patients during a 7.5-year follow-up period. The results showed no difference regarding primary endpoint pain ($P < 0.462$) using Inguinal Pain Questionnaire and SF-36 subscales as well as no difference between PF and NF groups including subgroups of medial hernias.

One systematic review by Sajid et al. [18] analyzed three RCTs on TAPP repairs [32, 38, 39] and one RCT on TEP repair [42]. Concerning acute pain the result of the review analysis detected no significant difference between staple and fibrin sealant group. However, a significant difference was found for the incidence of chronic pain in favor of the fibrin sealant group.

Another review by Kaul et al. [19] included one RCT [42] and three case control studies [40, 43, 50] focusing on chronic pain incidence. Both reviews [18, 19] revealed significant advantages of glue fixation in lessening the incidence of chronic pain.

In contrary to the published reviews, three RCTs on TEP [23, 29, 42], which were not all included in the above mentioned reviews, detected no significant difference in chronic pain

Table 15.3 Meta-analyses, systematic reviews, randomized control trials, and clinical control studies on recurrence comparing stapling to glue fixation in endo-/laparoscopic mesh repairs

Study	Type of study	Type of repair	Follow-up	Recurrence		Level of evidence	Quality rating
				Stapling	Glue		
Sajid et al. 2013 [18]	MA	TAPP/TEP	1–27 months (5RCT)	n.s		1++	Moderate
Kaul et al. 2012 [19]	SR/MA	TEP	7–47 months (3CCS)	n.s.		1+	Moderate
Melissa et al. 2014 [23]	RCT	TEP	1 year	0/64	0/65[b]	1++	Moderate
Tolver et al. 2013 [24]	RCT	TAPP	6 months	0/50	2/50[b]	1+	Moderate
Horisberger et al. 2013 [25]	CCS	TEP	28.2 (±7.4) months* 19.5 (±7.1) months*	0/100	0/101[b]	2+	Low
Wang et al. 2013 [26]	CCS	TAPP	Tacks vs glue[a]	0/89	0/552	2+	Moderate
Bruegger et al. 2012 [28]	RCT	TAPP	38 (13–56) months*	1/35	2/32[a]	1+	Moderate
Subwongcharoen et al. 2013 [29]	RCT	TAPP	1 year	1/30	0/30[a]	1+	Moderate
Fortelny et al. 2012 [32]	RCT	TAPP	1 year	1/45	1/44[b]	1+	Moderate
Bittner et al. 2010 [33]	CCS	TAPP	6 months	0/64	0/212[b]	2+	Moderate
Boldo et al. 2008 [36]	RCT	TAPP	6 months	2/11	3/11[b]	1+	Low
Ceccarelli et al. 2008 [37]	CCS	TAPP	19 (4–40) months*	0/87	0/83[b]	2+	Low
Olmi et al. 2007 [38]	RCT	TAPP	1 month	0/450	0/150[b]	1+	Moderate
Lovisetto et al. 2007 [39]	RCT	TAPP	11.7 months	0/98	1/99[b]	1+	Low
Schwab et al. 2006 [40]	CCS	TEP	23.7 (11–47) months*	5/87	2/86[b]	2+	Moderate
Novik et al. 2006 [50]	CCS	TEP	40 months	0/96	0/9[b]	2-	Low
Lau et al. 2005 [42]	RCT	TEP	1.2 years[#]	0/94	0/92[b]	1+	Moderate
Topart et al. 2005 [43]	CCS	TEP	28.3 ± 10.9 months* 23.9 ± 11.3 months*	3/117	1/81[b]	2+	Low

[#]Mean
*Median (range)
[a]Cyanoacrylate glue
[b]Fibrin glue

when glue was compared to staple fixation. Regarding TAPP, five RCTs [24, 28, 36, 38, 39] and three case control studies [26, 33, 37] found significantly less acute pain using glue versus staple fixation.

In conclusion based on the recently published studies, the benefit of glue fixation has to be seen predominantly in the reduction of acute postoperative pain.

The updated IEHS [55] and EHS guidelines [56] recommend atraumatic mesh fixation by glue in case fixation is required in order to minimize the risk of acute postoperative pain (recommendation grade B).

15.4.3 Nonabsorbable and Absorbable Clips/Tacks

Currently, there is no RCT for TAPP or TEP repair regarding the comparison of absorbable and nonabsorbable clips or tacks. One recent published cohort study by Agresta et al. [53] comparing absorbable tacks and fibrin glue fixation in TAPP repair detected significant benefit for operating time using tacks but no differences in terms of recurrence and pain. Another aspect in this study was the significant higher costs for the tacks.

In a multicenter prospective study comparing postoperative quality of life in TEP and TAPP, Belyansky et al. [54] reported a twofold increase of early postoperative pain in cases when more than ten tacks were used for mesh fixation while having no effect on recurrence rates. Absorbable tacks seemed to be associated with a significantly higher frequency of postoperative pain compared to nonabsorbable tacks at 1 month (25.7% vs 11.5%, $P = 0.015$) due to the significantly greater number of tacks used by the surgeon when fixation was done with absorbable tacks. At 6 months and 1 year, there were no differences between permanent and absorbable tack groups in terms of the frequency of symptomatic patients.

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15.4.4 Self–Fixating Mesh

Regarding new atraumatic mesh fixation techniques, one RCT for TAPP repair by Cambal et al. [27] compared self-fixing mesh to glue fixation. In the short-term follow-up at 3 months, no hernia recurrences and no significant differences in postoperative pain between groups were found. Similar results were described in a case control study for TAPP repair by Fumagalli et al. [30] in a follow-up of 6 months.

15.5 Summary

In TEP and TAPP inguinal/femoral hernia repair, non-fixation of the mesh is recommended in almost all hernia types except large medial defects (M3 EHS classification) where mesh is recommended to be fixated.

If fixation is mandatory the use of atraumatic fixation techniques by glue (fibrin glue, cyanoacrylate) should be considered to minimize the risk of acute postoperative pain.

The use of absorbable or nonabsorbable tacks is associated with an increase of early postoperative pain compared to glue fixation, which correlates with the number of applied tacks.

The recommendation for self-fixating meshes in TAPP and TEP repair needs further evidence from RCTs and data from registries.

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Fixation (Rene Fortelny)

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Aftercare and Recovery in Laparoscopic Inguinal Hernia Surgery

Ralf M. Wilke, Andrew de Beaux, and Juliane Bingener-Casey

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16.1 Introduction

The surgical consultation for inguinal hernia is one of the most frequent encounters and is seen in all types of healthcare systems. The resulting socioeconomic influences are not to be underestimated. They result on one hand from the hospitalization itself and on the other hand they are also significantly influenced by the recovery.

It is still customary to have several weeks of inability to work after inguinal hernia surgery without any valid scientific evidence to account for this. The German Federal Institute for Worker Protection and Employee Health has been estimating the cost of the inability to work. Every year 9.1 billion Euro is lost in production and about 16 billion Euro in lost GDP (gross domestic product) which result in a potentially large preventable loss [1]. In the changing values of today's society, not only is the earlier return to work important, but also a changed lifestyle plays an increasing role. Prolonged postoperative limitations for activities of daily living and the pursuit of athletic activities are no longer well tolerated.

16.2 Postoperative Follow-up in My Practice: How I Do It

The most important element of good postoperative follow-up care consists of the avoidance of postoperative pain and the individualized recommendation for return to work or physical activity in order to avoid recurrent hernia. The appropriate treatment of unexpected postoperative results during a postoperative clinic visit is also very important.

16

16.2.1 Postoperative Pain Syndromes

The most frequent complaint in the early postoperative phase is pain. Adequate prophylaxis of postoperative pain begins before incision. In our clinics, we often find patients who may have lower pain tolerance than the average population. Often these patients are suffering significantly from pain but have limited clinical findings to explain why. Especially for this population, great attention should be paid to excellent preemptive preoperative pain medication. In addition to a nerve-sparing dissection and atraumatic fixation of mesh, we use the preemptive infiltration of local anesthetics in the umbilical trocar site, as well as the ilioinguinal block of the affected side. Postoperatively we recommend nonopioid-containing analgesics. Ibuprofen or Cox-2 inhibitors have been performing well in this role. During the hospital stay, which usually lasts about 24 h, we routinely prescribe 400 mg of ibuprofen every 8 h or a Cox-2 inhibitor in combination with a gastric ulcer prophylaxis. After the patient leaves the hospital, we only recommend pain medication as needed. Special attention is needed if unexpectedly high use of pain medication is noted. High need for pain medication should be taken seriously, and relevant complications should be excluded. Should the postoperative pain last longer than 3 months, other diagnostic exams may need to be performed, such as orthopedic, urologic, or gynecologic consultation and the investigation of intestinal organs by ultrasound or colonoscopy. Finally, the groin pain can also be somatic pain that is attributed to the groin region.

16.2.2 Postoperative Activity

The recommendation to limit physical activity after surgery is frequently in the duration of 2 weeks. Athletic activities with high intensity in the groin should especially be avoided. If the patient is allowed to be more active and overexerts himself, this can result in disappointed expectations by the patient. Generally the majority of patients can return to full work activity at 2 weeks. If a patient has a high physical workload, it is recommended to see them for a follow-up visit and assess if additional recovery time is needed.

16.2.3 Postoperative Visit in the Clinic

A general exam after surgery for all patients is not necessary. Nevertheless, it is important that a practitioner with experience is available. If a competent site is not available, operative pain or other problems can lead to chronic pain syndromes. This can then lead to several additional consultations with different physicians and frequently to unnecessary hernia surgery revisions. Early evaluation for patients with problems is very important. A groin examination by

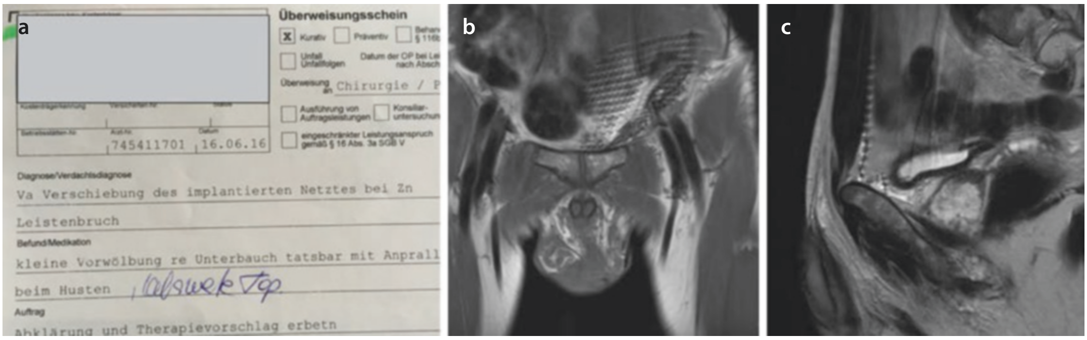

Fig. 16.1 **a** Order of a general doctor to check a mesh dislocation. **b** and **c** MRI control of an implanted visible mesh

ultrasound is an invaluable instrument to understand the postoperative results. Generally there will be seromas which do not require any further therapy. Larger symptomatic seromas can be aspirated if they are situated in the extraperitoneal space outside of the inguinal canal. Further, not unusual are small hematomas in patients with chronic anticoagulation. An aspiration should be avoided in this situation. It is difficult to demonstrate the correct mesh position in the postoperative situation. Ultrasound is often not adequate. Magnetic resonance imaging (MRI) can be used for meshes that are visible during MRI. This is possibly an optimal tool in the future for the assessment of postoperative problems (Fig. 16.1a–c).

16.3 Postoperative Follow-up: What Is Evidence Based?

The question of correct postoperative follow-up and recommendations for physical activity has not been established scientifically. It almost appears that with close of the skin incision, the evidence-based surgery is finished, and eminence-based opinions and individual experience are introduced into the daily clinical routine. The current algorithms for follow-up are based on experiences of open hernia surgery from the 1990s in respect to postoperative pain and wound infections [2, 3]. A number of technical modifications and innovations in open surgery as well as laparoscopic surgery are constantly influencing our daily activities. A unified standard in the prophylaxis of postoperative pain and recurrence of hernia has not been established. Efforts to use the registry data from Scandinavia or the German Herniamed registry to define generally valid follow-up guidelines have not been successful. The reasons for this are multiple. Laparoscopic hernia surgery is an individualized tailored approach. Many factors such as comorbidity and professional and athletic activity play a role in the postoperative follow-up, as well as the technical variations in the care. In addition, the increasing outpatient treatment of minimally invasive groin hernia surgery results in the early postoperative follow-up often being provided by primary care physicians and that can be regionally diverse.

16.3.1 Postoperative Pain Syndromes from the Open Groin Hernia Surgery

We know that preemptive local anesthesia in the operative field leads to excellent results [4–7]. The use of an ultrasound-guided transversus abdominis plane (TAP) block is recommended for prophylaxis of early postoperative pain [8, 9]. In addition, perioperative injection of local anesthetic in the laparoscopic trocar sites should be performed [9]. Standardized oral medication with low-level analgesics should be given within the first 48 h. The individual pain control can be adjusted using the VAS (visual analog scale) score system. We recommend to follow the new American guidelines for this [10]. If intraoperative nerve damage has resulted in postoperative pain, the infiltration of corticosteroid-containing injections is widely used; however, there is no valid scientific recommendation [11]. If postoperative pain is persistent for more than 3 months, the chronic pain syndrome has to be assumed. How stimulative neuromodulation contributes to pain relief is not clear [12].

16.3.2 Postoperative Activity

The etiology of the hernia recurrence is not well known. Individual patient factors or technical errors of the surgeon have been being widely discussed. However, the question remains how a recurrence can be avoided. While tobacco abstinence is still discussed for recurrence and pain avoidance with controversy [13], the several-week-long recommendation for decreased physical activity appears to be out of date. Although there are no new investigations, early postoperative activity after hernia surgery is generally used in clinical practice [2–4]; however, a general recommendation for the full ability of return to work and athletic ability cannot globally be made. The specific patient needs are very individualized. It is certain that early physical activity has no influence on a recurrence [14]. A study using registry data from Denmark cites a recuperation of about 2 days [15]. Therefore, the current clinical practice is that activities of daily living can be immediately resumed and sport activities within 14 days after surgery.

16.3.3 Postoperative Visit in the Clinic

Optimal evaluation for postoperative complication includes the early evaluation by the surgeon. Ultrasound has been established as a necessary tool in detecting hernia because of its dynamic options.

A frequent problem is the management of postoperative seromas. These often result after repair of a large hernia or after absorbing hematomas. The frequency of a postoperative seroma is estimated to be about 7% of all operative cases [14]; however, in the clinical practice, it may be much higher. Smaller seromas rarely lead to any symptoms and often absorb by themselves. Aspiration is not indicated and unnecessary [4]. A retrospective analysis revealed that of an initial 18.7% of patients with seroma after elective laparoscopic hernia repair, only 1.7% resulted in a chronic seroma [16]. It should be discussed whether this small number of chronic seromas should be aspirated despite the current general opinion, especially when permanent pain is associated with a seroma and can only be controlled with systemic or peripheral analgesics. Often the formation of a seroma can be avoided. A prophylactic maneuver, for example, is the operative gathering of the transversalis fascia for large direct hernias or the consequent dissection of a hernia sac with a large indirect defect [14].

While the use of ultrasound for the identification of a hernia has been evaluated and has been proven to be a valid imaging tool, there are only a few studies about the postoperative use of ultrasound. Postoperative ultrasound imaging appears to make sense in the first weeks after surgery. If the patient is at unusually high risk, close monitoring within the first 48 h after surgery could be entertained. The routine use of ultrasound before the patient is discharged home is possible and often used and, however, does not qualitatively improve the overall outcome and therefore should not be done [17].

A frequent problem is the late postoperative evaluation, especially in relationship to the position of the augmentation if the mesh is already integrated into the abdominal wall. Ultrasound evaluation is only vague, and in this situation, results are uncertain. Obviously, the change of position of a laparoscopically introduced mesh into the groin can happen immediately postoperatively independently of the fixation. Magnetic resonance imaging is helpful for the differential diagnosis in most cases [18]. The use of meshes that can be visualized even after years of ingrowth can be helpful in revealing the exact details of the mesh and the question of a recurrence [19, 20].

A rarely verbalized but quite relevant question is that of sexual postoperative activity. A study from the Danish registry revealed 3.1% of patients experienced a transient dysfunction of ejaculation, with 10.9% of all patients in the first week postoperatively [21]. Here it is important to remain patient as many of these problems will resolve by themselves over time. Permanent laparoscopic hernia repair induced-based infertility is unlikely based on the current evidence [22, 23].

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Check for updates

Chronic Postoperative Inguinal Pain (CPIP)

Wolfgang Reinpold and David Chen

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17.1 Introduction

It is well established that almost every surgical intervention may lead to chronic pain. According to published trials with systematic data collection, the highest chronic pain rates are reported after leg amputation, thoracotomy, and breast surgery with 60%, 50%, and 30%, respectively [1].

The last decades' main advances in hernia repair are characterized by the global introduction of mesh and laparoendoscopic techniques. Today it is generally accepted that chronic pain is the most frequent complication after inguinal hernia repair. Fortunately, chronic pain is currently attracting more attention not because it is more prevalent after mesh repair but because reduced recurrence rates have shifted surgeon's main focus to avoiding pain [2].

The first small case series on CPIP was reported in 1984 by Harms et al. [3]. In 1996 Cunningham et al. [4] published a prospective randomized trial of 315 patients comparing Bassini, McVay, and Shouldice repair with chronic pain, numbness, and recurrences being primary outcome parameters. After 1 year 63% of the patients reported inguinal pain, and 12% of patients suffered from moderate-to-severe pain. After 2 years chronic pain rates decreased only slightly to 54% and 11%, respectively. The predictors for long-term postoperative pain were absence of a visible bulge before the operation ($p < 0.001$), presence of numbness in the surgical area postoperatively ($p < 0.05$), and patient requirement of more than 4 weeks out of work postoperatively ($p < 0.004$). The message that chronic pain is a very frequent late sequela of open inguinal suture repairs changed many surgeons' attitude toward hernia repair and sparked worldwide a very strong interest among hernia surgeons to prevent and further investigate this often complex complication.

Today the search terms "inguinal hernia" and "chronic pain" yield more than 1.800 citations in the PubMed database.

17.2 Definition of Chronic Pain

In 1986 the International Association for the Study of Pain defined chronic pain as pain lasting more than 3 months [14]. This definition was used in the majority of studies on chronic postoperative inguinal pain. However, some authors argued that inflammatory tissue reactions after mesh repair may lead to a prolonged healing process which may last longer than 3 months [4] and changed the definition of chronic to pain lasting longer than 6 months.

In the absence of a more detailed definition of CPIP, the results of the many trials on chronic postoperative inguinal pain (CPIP) are difficult if not impossible to compare because there is no uniform assessment of CPIP with regard to pain intensity, duration of pain episodes, impact on daily activities, physical activities, and impact on the quality of life.

CPIP can also be classified according to its location. Most commonly postherniorrhaphy pain is located in the groin. It may also cause symptoms in the genitals, thigh, and abdomen. Testicular pain (orchialgia) should be differentiated from scrotal skin pain. Moreover, inguinal hernia repair may also lead to pain-related sexual dysfunction including dysejaculation [15, 16].

(In the future a more detailed definition and uniform assessment of CPIP is of utmost importance.)

According to current guidelines, pain specialists and Hernia Surge, a group of international experts who is working on the first worldwide guidelines on inguinal hernia repair CPIP, should be defined as bothersome and at least moderate pain with impact on daily activities lasting 3 months or longer postoperatively [5, 6].

Today CPIP intensity is mainly assessed by visual analog scales (VAS) or verbal rating scales (VRS).

17.3 Epidemiology of Chronic Pain

According to hernia registries, meta-analysis, and guidelines, 18% (range 0.7–75%) of patients suffer from chronic pain after open inguinal hernia repair, and 6% (range 1–16%) report CPIP after laparoendoscopic groin hernia repair [1, 6, 7].

This large variance of reported chronic pain prevalence is due to inconsistent definitions and assessment of chronic pain in different trials. While some trials defined any visual analog scale (VAS) score of pain >0 as chronic pain, other studies considered only VAS scores greater than 3 as chronic pain. Some trials counted only bothersome pain or pain with impact on daily activities as chronic pain [8], while other trials included any pain as chronic pain. The use of mesh seems to reduce the risk of chronic pain [21]. According to a review of Nienhuijs et al., 11% of the patients after a mesh-based inguinal hernia repair suffer from chronic pain of which one quarter report moderate-to-severe pain [56].

According to a 1 year questionnaire follow-up study of the Danish Database, 29% of the patients reported pain in the operated groin within the last month. Eleven percent suffered from work- or leisure-activity impairment, and 4.5% of the patients needed medical treatment [9]. A 6-year long-term follow-up study of these chronic pain patients revealed an overall decrease of CPIP with less chronic pain in 76%, the same pain in 17%, and increased pain in 7% of the patients [10].

A trial from the Swedish hernia register on long-term CPIP (1–6 years after surgery) reported similar results: 29% of the patients reported pain within the last week, and 6% suffered from pain interfering with daily activities [11].

The finding of the Swedish hernia register that chronic pain decreases over time [11] was not confirmed by a large prospective multiphase trial on 781 open primary inguinal hernia repairs (286 Shouldice and 495 Lichtenstein operations). The chronic pain rate at 6 months and 5 years was 16%, respectively [12].

Currently the German hernia registry “Herniamed” has documented 106.918 inguinal hernia repairs with 1-year questionnaire follow-up: 5% of the patients report pain at rest and 10% pain during activities and 4% require any kind of treatment. These data are in accordance with the results from the Scandinavian hernia registers.

The incidence of clinically significant CPIP with impact on daily activities ranges between 2% and 12% [5, 8, 13].

Debilitating CPIP with severe impact on normal daily activities or work is reported in 0.5–6% of the cases [10, 11, 13].

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Two to 3% of the patients suffer from chronic postoperative orchialgia.

17.4 Characterization and Mechanisms of CPIP

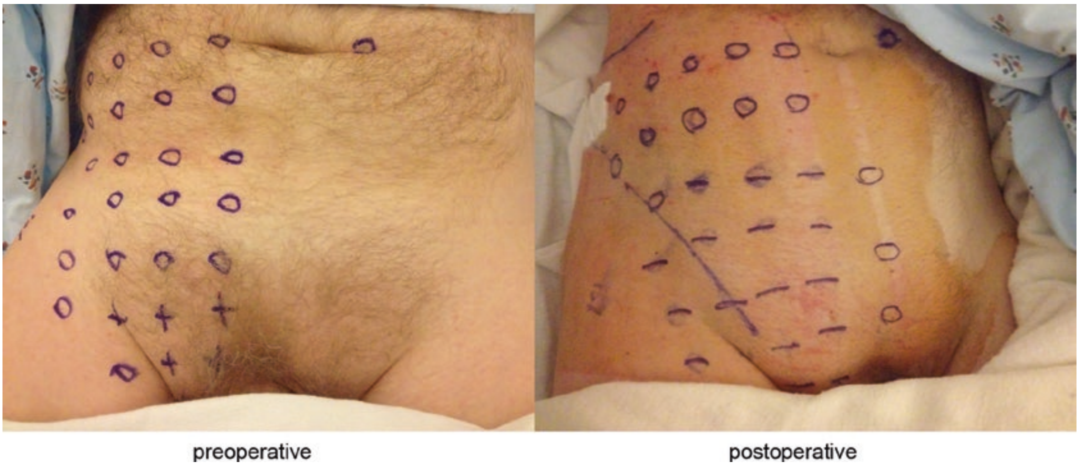
There are several overlapping causes and mechanisms of pain after prior inguinal hernia repair [1–3]. Preoperative and other non-surgery related causes of CPIP have to be considered and differentiated. Nociceptive pain is mediated by tissue damage and (chronic) inflammation without damage of nerval structures. It can be related to recurrence, muscle or ligamentous strain, perineural fibrosis, scarring with or without from mesh, meshoma pain (related to wrinkling, migration, or folding of mesh), and suture or fixation material. Nociceptive pain is characterized as a dull ache over the groin area commonly described as gnawing, tender, pulling, or throbbing.

Neuropathic pain may be caused by direct nerve injury or nerve entrapment related to mesh, staples, tacks, suture material, scar tissue, neuroma, or tumor formation. Nerve destruction can also be caused by severe inflammation or infection. Neuropathic pain is described as stabbing, burning, shooting, or pricking, aggravated by walking or sitting. It is often also characterized by paresthesia (burning, pricking, or tingling sensation), hypoesthesia (reduced sensation), allodynia (pain from a non-painful stimulus), and hyperalgesia (increased sensitivity to pain). The majority of pain experts believe that nerve damage is the most common cause of CPIP.

No studies have investigated whether nociceptive pain can be reliably distinguished from neuropathic pain and there is considerable overlap in symptoms, presentation, and findings. The classification of neuropathic and nociceptive pain has limited practical significance because there is no reproducible diagnostic method of differentiation between them. It has to be acknowledged that every skin incision in open hernia repair leads to damage of branches and sub-branches of the inguinal nerves and thus implies the risk of neuropathic pain. Visceral pain may also confound the picture and contribute to the overall presentation of pain.

17.5 Diagnostics

A careful history and structured physical examination, dermatomal somatosensory mapping, review of prior operative reports and interventions, and imaging studies are essential to help delineate the likely mechanism of pain and formulate an effective treatment plan. A recurrent hernia should always be ruled out. Dermatomal mapping (DM) may help to characterize cutaneous distributions of pain and to identify injury to one or more of the inguinal nerves ([31]; ◘ Fig. 17.1: foto



■ **Fig. 17.1** Dermatomal mapping: preoperatively painful right groin, after Triple Neurectomy no pain but numbness. ○ normal sensitivity, + painful area, – area of numbness

of DM). Focused ultrasonography of the groin is fast, economical, and without morbidity and may identify recurrence, mesh disruption, infection, foreign body, seroma/hematoma, and inflammation. If unrevealing, cross-sectional imaging with computed tomography or magnetic resonance imaging is useful to identify anatomic abnormalities, problems related to the prior repair, and alternative mechanisms for pain.

Due to the great variability and very frequent interconnections between peripheral anterior inguinal nerves, diagnostic inguinal blocks are often not very helpful to pinpoint the affected nerve. Affected nerve segments (TH11–L3) can reliably be identified with periradicular CT-guided diagnostic blocks. For the qualitative and quantitative assessment of pain and quality of life, standardized questionnaires should be used (i.e., SF 36, Carolina Comfort Scale).

17.6 Risk Factors and Pain Prevention

Surgery-related (intra- and postoperative) risk factors have to be differentiated from those not related to surgery (▶ Box 17.1; [6, 7]). Probably the most important but presently insufficiently analyzed risk factor of CPIP is the hernia surgeon. The most detailed analysis of risk factors for CPIP was published in the guidelines for laparoscopic-endoscopic treatment of inguinal hernia of the International Endohernia Society (IEHS,6,7). The use of mesh seems to reduce the risk of CPIP [4, 6, 7, 21].

Box 17.1 Risk Factors for CPIP (Strong Risk Factors in Broad Letters)

Preoperative risk factors:
- **Female gender**
- **Young age**
- **High intensity of preoperative pain**
- **History of chronic pain other than CPIP**
- **Operation for a recurrent hernia**
- Genetic predisposition (DQB1*03:02 HLA haplotype)
- Lower preoperative optimism
- High pain intensity to tonic heat stimulation (experimentally induced)
- Worker's compensation

Intraoperative risk factors:
- **Open repair technique**
- Inadequate suture/staple/clip mesh fixation
- Mesh type: heavyweight mesh in open repair
- Ilioinguinal nerve neurolysis in Lichtenstein repair
- Ignorance of the inguinal nerves
- Less experienced surgeon

Postoperative risk factors:
- **High early postoperative pain intensity**
- Sensory dysfunction in the groin
- Postoperative complications (hematoma, infection)

According to several meta-analyses and guidelines on inguinal hernia repair, there is strong evidence that the risk of acute pain, CPIP, and numbness is significantly lower and the return to normal activities faster after laparoendoscopic procedures compared to open techniques [6, 7, 18–22, 57]. The most likely explanation for this finding is the reduced access trauma and nerve

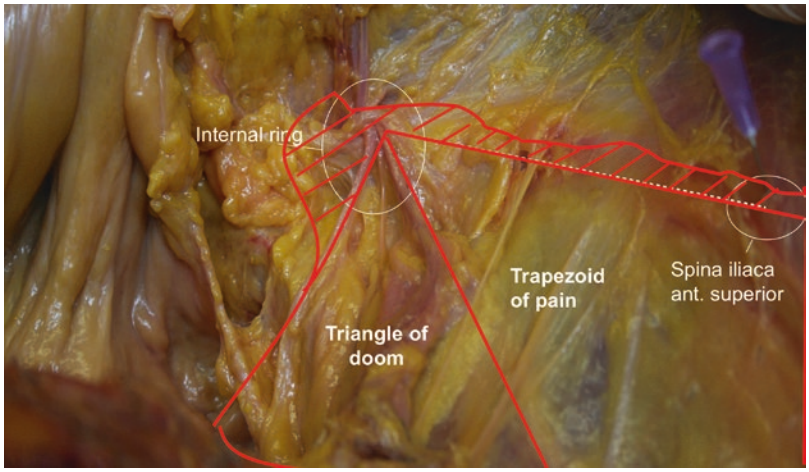


Fig. 17.2 Posterior view of the right groin: According to a recent cadaver trial, the triangle of doom and trapezoid of pain where nerves are at risk of injury during TAPP and TEP repair are larger than previously reported [30]

protecting and preserving plane of dissection in TAPP and TEP. Covered by a fascial layer, the inguinal nerves always remain in their natural embedding. However, traumatic mesh fixation in TEP and TAPP should be avoided. In open repair the skin incision always implies nerve damage. Additionally, open mesh implantation often interferes with the ilioinguinal nerves. The risk of chronic pain after TAPP and TEP is the same. Open posterior mesh repair seems to be related to less CPIP than open anterior mesh implantation: A meta-analysis of randomized trials reported more chronic pain after Lichtenstein compared to preperitoneal repair [23].

Other strong risk factors for CPIP are young age, female gender, high level of preoperative inguinal pain, history of chronic pain other than inguinal, operation for a recurrent hernia, and high early postoperative pain intensity (▶ Box 17.1, [6, 7]).

CPIP risk factors with lower evidence in the literature are genetic predisposition (DQB1*03:02 HLA haplotype), lower preoperative optimism, high pain intensity to tonic heat stimulation (experimentally induced), worker's compensation, and inadequate use of sutures, staples, clips, mesh fixation, and mesh type: heavyweight mesh in open repair, ilioinguinal nerve neurolysis in Lichtenstein repair [12], nerve-ignoring operation technique, less experienced surgeon, and sensory dysfunction in the groin postoperative complications (hematoma, infection) (▶ Box 17.1; [5–7, 18–22]). Preoperative quantitative sensory testing (QST) may help to identify patients with lowered threshold for heat stimulation who seem to have a higher risk to suffer from CPIP.

17.7 Nerve Management in Open and Laparoendoscopic Groin Hernia Repair

A detailed knowledge of the anterior and posterior inguinal nerve anatomy is of utmost importance for every hernia surgeon. In every open and laparoendoscopic groin hernia operation, the surgeon should be aware of the nerve anatomy and pay attention to the nerves. A nerve-ignoring operation is not acceptable by any means.

In a properly performed TAPP and TEP repair, the nerves remain untouched in their natural embedding. A fascial layer protects the nerves from direct mesh contact. Non-fixation or adequate atraumatic mesh fixation (Fig. 17.2) minimizes the risk of nerve injury. A recent cadaver study on the retroperitoneal course of the lumbar plexus nerves revealed that the territory where the inguinal nerves can be damaged during laparoendoscopic and open preperitoneal inguinal hernia repair is larger than previously anticipated [30].

In open groin hernia repair, the nerves are commonly encountered in the operation field and often interfere with steps of the operation.

Many trials on nerve management in open groin hernia repair have been conducted. The surgical options are preservation of the nerves with or without its mobilization, prophylactic neurectomy, or pragmatic neurectomy.

A prospective nonrandomized multicenter of Alfieri et al. [24] compared 310 open mesh repairs with identification and preservation of the iliohypogastric nerve (IHN), ilioinguinal nerve (IIN), and genital branch of the genitofemoral nerve

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(GB) with 189 cases in which the nerves were divided. After 6 months, there was significant more moderate-to-severe pain in the nerve dividing group (4.7% vs 0%; $p < 0.02$). The authors concluded that the three inguinal nerves should be identified and preserved.

Several randomized trials have studied prophylactic neurectomy vs preservation of the ilioinguinal nerve. Three meta-analyses concluded that there was no significant difference in chronic pain [25–27]. The most recent meta-analyses reported more sensory loss 6 months and 1 year after neurectomy of the IIN [27]. Two RCT on preservation vs neurectomy of the IHN revealed no difference in chronic pain but more numbness after neurectomy. There are no RCT comparing preservation and neurectomy of the GB.

According to relevant trials, meta-analyses, and guidelines, a general prophylactic neurectomy in open inguinal hernia repair cannot be recommended since it does not reduce the risk of CPIP and adds sensory loss which is in itself a risk factor for chronic pain [12, 25–27].

In recent years the term pragmatic neurectomy has been coined for the resection of nerves being damaged by the hernia, scar tissue, and surgical trauma or nerves being at risk for damage mainly due to interference with mesh [28, 29]. Despite the fact that no RCTs have been conducted on this issue and the term "nerve at risk" has not been clearly defined, the pragmatic neurectomy approach is currently favored by the majority of specialized hernia surgeons. Currently it is considered good surgical practice to preserve only intact nerves who are unlikely to cause chronic pain.

The pragmatic neurectomy approach is strongly supported by a prospective nonrandomized two-phase trial of 781 patients with primary inguinal hernias who had a Shouldice operation (LI, LII, MI inguinal hernias) or Lichtenstein repair (LIII, MII, MIII hernias; 12). After 5 years Lichtenstein repair with ilioinguinal nerve mobilization and preservation repair was an independent significant risk factor for chronic pain. Eleven out of 12 patients with relevant chronic pain (VAS > 3) at 5 years had Lichtenstein repair with mobilization of the ilioinguinal nerve. The conclusion of this study was that mesh contact with a nerve removed from its natural bed should be avoided, supporting the notion that nerve resection is superior to leaving an injured nerve intact or allowing mesh/nerve contact to occur [12].

17.8 Treatment of Chronic Post-inguinal Hernia Repair Pain

The treatment of chronic pain after inguinal hernia repair remains a significant challenge due to the complexity of overlapping etiologies, variable neuroanatomy, and psychologic and social factors that confound the presentation and complicate treatment. Because of this intrinsic heterogeneity, there is little high-level evidence regarding standard treatment algorithms, and most recommendations are based upon expert experience and opinion.

Obvious anatomic or pathologic abnormalities related to the prior repair should be corrected when identified. Infection should be treated with appropriate antibiotic therapy and may necessitate mesh removal for resolution. If hematoma or seroma are identified, these may be drained if conservative management fails. Recurrence, if identified, should be addressed. In general, a recurrence encountered after open surgery is best fixed laparoscopically, while a laparoscopic recurrence may be addressed using an open anterior approach, thereby avoiding the prior scarred field and risks associated with reoperative anatomy. However, in the patient that presents with pain and recurrence, oftentimes evaluation of the initial repair and operative field is revealing and necessary to correct the component of pain.

An expectant period of at least 3 months after the original index operation is recommended prior to consideration for any remedial operation as the definition of chronic pain implies a sufficient duration to allow for resolution of normal and typical postoperative inflammation [13, 32]. With regard to mesh repair, this period is typically extended to 6 months because of the normal healing processes, inflammation, integration, and remodeling that occur at the mesh-tissue interface. During this period, conservative measures, pharmacologic and behavioral treatments, and nonoperative interventions should be employed. Involvement of a multidisciplinary team including a pain management specialist is recommended [13, 32].

17.9 Pharmacologic and Non-pharmacologic Treatment Options

Patients with significant chronic post-inguinal repair pain are initially primarily managed with pharmacologic therapy including opioid and non-opioid analgesics. Opioids are often administered because of the severity and intensity of pain but are rarely effective in addressing the underlying cause of pain. Because of their numerous side effects, risks, and addictive potential, long-term usage is best managed by a pain specialist using long-acting formulations to mitigate these risks. Nonsteroidal anti-inflammatory analgesics may be of benefit but also have long-term implications. Neuropathic pain may be initially addressed with pharmacologic agents. Atypical antidepressants (tricyclic antidepressants, selective serotonin reuptake inhibitors) and nerve stabilizing anticonvulsants (gabapentin and pregabalin) have demonstrated benefit with neuropathic pain and are routinely used for post-inguinal herniorrhaphy pain [33]. Remarkably, all pharmacologic treatments (e.g., NSAIDs, acetaminophen, TCAs, SSRIs, gabapentin, pregabalin, and opioids) used in the specific treatment of post-hernia inguinal repair pain have rarely been studied, and efficacy is extrapolated from the generalized pain literature [34, 35]. Limited evidence exists for the use of lidocaine patches, but the minimal morbidity and side effect profile makes a trial reasonable [36]. Similarly, capsaicin patches can serve as an adjunctive therapy with little risk, low cost, and some potential for clinical benefit [37].

There is little evidence specifically supporting non-pharmacologic treatment options for post-inguinal herniorrhaphy chronic pain (e.g., psychotherapy, hypnosis, behavioral therapy, biofeedback, acupuncture, mind-body therapy). However, the interaction of psychologic, cognitive, and emotional factors on physical pain cannot be ignored. Within the generalized pain management literature, these non-pharmacologic options have been used to modulate perceptions and responses to chronic pain [34]. A stepwise approach using multimodal treatment is important and reasonable; noninterventional options should be exhausted prior to consideration for reoperation.

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17.10 Role of Interventional Nerve Blocks

There is insufficient high-quality evidence regarding the value of nerve blocks in the management of neuropathic post-inguinal repair pain. In clinical practice however, nerve blocks of the ilioinguinal, iliohypogastric, or genital nerve serve both a diagnostic and therapeutic role. This may be performed using anatomic landmarks, nerve stimulation, or ultrasound guidance to improve nerve identification and accuracy. No study has proven that adjunctive techniques (e.g., ultrasound, nerve stimulation) improve the efficacy of blocks [38, 39]. If blocks transiently alleviate the pain, this helps to delineate a neuropathic component and provides a reasonable prognostic justification for future neurectomy if needed. If blocks are effective at reducing pain, repeat blocks are recommended as they may interrupt the pain cycle and in some cases alleviate pain. If this positive effect is achieved but not durable, neuroablative techniques (e.g., radiofrequency ablation, chemo/cryoablation) or operative neurectomy is indicated. Cryoablation of the inguinal nerves has been effective in limited series [40]. Pulsed radiofrequency ablation has been demonstrated to be an effective treatment for chronic pain after inguinal hernia repair [41]. As with neurectomy, the efficacy of these techniques is predicated upon proper patient selection, identifying nerve lesions that are likely to respond to ablation, procedural technique, and being able to access the nerve proximal to the injury.

An ineffective nerve block may or may not be indicative of neuropathic involvement as efficacy, and success is operator and anatomy dependent. Computed tomography guidance has been used to access the genitofemoral nerve proximal to prior posterior repair over the psoas muscle [39]. Additionally, paravertebral and epidural blocks may be helpful as they access the nerves proximally closer to the nerve root origins where the neuroanatomy is more consistent and predictable. This is especially useful after ineffective inguinal nerve blockade and with pain after prior posterior repair (laparoscopic and preperitoneal herniorrhaphy) where the level of nerve injury is likely proximal to the inguinal canal.

17.11 Nerve Stimulation, Spinal Cord Stimulation, and Neuromodulation

Nerve stimulation, spinal cord stimulation, and neuromodulation have been used to address neuropathic chronic post-inguinal herniorrhaphy pain. These modalities approach the nerve pathology proximal to the groin at the level of the peripheral nerve, spinal cord, or dorsal root ganglia. As with most of the literature related to this topic, there is only weak evidence supporting their use limited to case series, retrospective reviews, and case reports. Implantable peripheral nerve stimulators have demonstrated pain reduction in small series [42]. Spinal cord stimulation has also been used to treat refractory neuropathic inguinodynia [43]. Early findings suggest that neuromodulation of the dorsal root ganglia (DRG) may be a more targeted and effective treatment for chronic neuropathic pain conditions in the groin region than nonselective nerve stimulation. Preliminary studies are all low level of evidence (retrospective, case series, lack control groups, short follow-up periods) but report promising outcomes with sustained pain relief, quality-of-life improvement, and/or reduction of analgesic use [44]. The drawbacks of these modalities include that these technologies are extremely expensive and are non-focused with regard to the underlying pathology. In general, these options should be reserved for refractory cases in which a solution cannot be found within the inguinal region or for inguinal and regional pain syndromes not secondary to prior hernia repair. For cases of refractory inguinodynia unresponsive to remedial surgery, proximal nerve stimulation or neuromodulation provides a promising option [34, 35].

17.12 Operative Treatment of Post-inguinal Herniorrhaphy Inguinodynia

Patients that are refractory to conservative measures and out of the expectant period of normal healing from the herniorrhaphy may be considered for operative remediation. However, failure of conservative therapy in of itself is not a justification for surgery. Successful outcomes are predicated upon careful patient selection to identify specific neuroanatomic, structural, and mesh-related problems that are amenable to correction. In general, mesh-related problems (folding, wrinkling, meshoma), foreign body reaction (suture, tacks, fixation), nerve lesions of the inguinal nerves, and recurrence may be corrected with operative intervention. In-depth knowledge of the inguinal and retroperitoneal neuroanatomy, technical details of the original repair, review of current cross-sectional imaging, and evaluation of response to prior interventions and nonoperative treatment are essential to determine the likely mechanism for pain and the options for surgery and the optimal operative approach [13, 32].

17.13 Neurectomy for Neuropathic Inguinodynia

High-level evidence is lacking regarding operative neurectomy for chronic post-inguinal herniorrhaphy pain. However, there is a significant volume of experiential data from the last 30 years regarding the role and efficacy of selective and triple inguinal neurectomy of the inguinal nerves [17, 45–52]. Retrospective and prospective series reporting outcomes of triple neurectomy operations range from 85 to 100% pain improvement. Selective single or double neurectomy studies generally report slightly lower success rates. There are no studies comparing selective and triple neurectomies, and, given the heterogeneity of patients and etiologies, a systematic study is unlikely. Triple neurectomy data is mostly derived from a single institute reporting sequentially accumulated data with over 600 open and 80 endoscopic neurectomies performed over 30 years [17, 48, 49]. However, similar results have been achieved by others [50]. In both selective and triple neurectomy studies, systematic evaluation with pain scores, follow-up, questionnaire and neurologic examination techniques is inconsistent and often absent. Consideration regarding the choice of selective versus triple neurectomy must balance the difficulty of being able to reliably identify and access the affected inguinal nerves with the resultant numbness and collateral damage of a more extensive neurectomy.

In 2011, an international consensus conference developed guidelines for the treatment of chronic post-inguinal herniorrhaphy pain recommending best available clinical practices [13]. In 2016, Hernia Surge, a collaboration from the five major international hernia societies, developed evidence-based guidelines for the treatment of chronic post-inguinal repair pain based upon the available literature, expert recommendations, and consensus voting [53]. As the source data has remained relatively constant, both guidelines advise an expectant period before remedial surgical treatment and weak level of evidence recommendations supporting both selective and triple neurectomy. Uniformly, expertise in diagnosing and treating this condition is recommended. An algorithm for management of postherniorrhaphy chronic pain was developed using the Delphi method citing similar principles [32]. This group advocated triple neurectomy and/or mesh explantation by an experienced hernia surgeon for refractory cases failing conservative measures.

17.14 Selective Neurectomy

Selective neurectomy of the ilioinguinal (IIN), iliohypogastric (IHN), genitofemoral (GFN), or lateral femoral cutaneous (LFC) nerve(s) is an effective treatment option in patients with refractory neuropathic inguinodynia. Successful selective neurectomy of the involved inguinal, preperitoneal, or retroperitoneal nerve(s) is predicated on accurate identification of the likely injured nerve(s) based upon anatomy, mechanism, prior operation, symptoms, somatosensory mapping, and adjunctive imaging and blocks. ► Box 17.2 lists common hernia repairs and the nerves that must be considered at risk with neuropathic inguinodynia. Operative neurectomy may be combined with removal of mesh and fixation material and/or revision of prior hernia repair as indicated based upon symptoms and intraoperative findings [45–47]. Removal of mesh and fixation material alone may eliminate some of the common nociceptive causes of pain but fails to address injured nerves. Additionally, nerves may be injured during reoperation in the scarred operative field. A key operative principle is that neurectomy of the injured nerve should be performed proximal to the injury. Selective neurectomy may be performed as an open anterior inguinal operation typically employed after prior open repair techniques. It may also be performed via a laparoscopic or retroperitoneal approach after prior laparoscopic preperitoneal repair, failed open reoperation, and in the absence of recurrence or meshoma requiring remediation. Selective neurectomy series demonstrate improvement in patients with CPIP [45–47]. Careful patient selection and diagnostic expertise may improve the likelihood of success while minimizing the side effects and collateral damage (numbness, deafferentation hypersensitivity, pain, recurrence, disruption of prior repair, abdominal wall laxity) caused by a more extensive neurectomy.

Box 17.2 Sites of Potential Injury: Associated Operations and Nerves at Risk for Injury

Anterior to transversalis fascia

Initial operation:

Tissue repair (Shouldice, Bassini, McVay, Desarda)

Lichtenstein repair, Trabucco (*mesh repair!*), bilayer mesh (PHS/UHS)

Plug and patch

Open transinguinal preperitoneal repairs (Kugel, ONSTEP, TIPP)

Laparoscopic repair (TEP/TAPP) using penetrating fixation

Nerves at risk:

Ilioinguinal nerve (IIN)

Visible and intramuscular segment of iliohypogastric nerve (IHN)

Inguinal segment of genital branch of genitofemoral nerve (GFN)

Posterior to transversalis fascia (preperitoneal space)

Initial operation:

Open preperitoneal (plug, plug/patch, PHS/UHS, Stoppa, Kugel, TIPP, TREPP, ONSTEP, GPRVS)

Laparoscopic preperitoneal repair (TEP/TAPP)

Nerves at risk:

Preperitoneal segment of genital branch of GFN

Preperitoneal segment of femoral branch of GFN

Main trunk of GFN

Lateral femoral cutaneous nerve (LFC)

17.15 Triple Neurectomy

In general, neuroanatomic, technical, and logistic factors make triple neurectomy more definitive and reliable for neuropathic inguinodynia. In reported series, triple neurectomy has higher efficacy rates of diminishing or resolving neuropathic

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inguinodynia as compared to selective neurectomy [48–50]. However, the overall level of evidence regarding selective versus triple neurectomy is weak consisting of primarily retrospective or prospective cohort series. The primary arguments for triple neurectomy as the standard approach are as follows: (1) there is significant variation and cross-innervation of the inguinal nerves in the retroperitoneum and inguinal canal making selective neurectomy less reliable, (2) dermatosensory mapping alone is not precise enough to definitively exclude involvement of adjacent nerves with overlapping sensory distributions, (3) predicting which nerves are injured based upon visualization is imprecise with ultrastructural damage seen in otherwise normal appearing triple neurectomy nerve specimens, and (4) multiple reoperations in the scarred field make nerve identification more difficult; increase the risk of recurrence, vascular injury, testicular compromise, and visceral injury; decrease the likelihood of success; and in general should be avoided. These diagnostic, therapeutic, and technical advantages to triple neurectomy come at a cost of increased collateral damage.

17.16 Approach: Open Triple Neurectomy

Traditional open triple neurectomy involves re-exploration through the prior inguinal operative field. It is indicated for neuropathic CPIP when a recurrence or meshoma is present or for patients that underwent anterior repair without placement of preperitoneal mesh [34, 48–50]. This operation is more complex due to the technical difficulty of reoperating in the scarred field, the challenge of identifying all three nerves, and the increased morbidity with risk to the testicle, cord structures, vascular structures, and the prior repair. The operation begins with the inguinal incision extended cephalad and lateral to enter into the canal in an unscarred area proximal to the prior repair or mesh. The ilioinguinal nerve is typically found proximal and lateral to internal ring between the ring and anterior superior iliac spine. The distal end of the iliohypogastric nerve is identified at its exit from the inguinal canal in the anatomic cleavage plane between external and internal oblique. This is then traced back proximally within fibers of internal oblique cephalad and lateral to prior operative field. The internal oblique aponeurosis is split to access the subaponeurotic intramuscular segment of the IHN that may be injured by suture or fixation [48]. The genital branch of the GFN is identified coursing lateral within the cord adjacent to the external spermatic vein and is traced laterally to the internal ring. The nerves are resected proximal to prior operative field and potential injury. It is our practice to ligate the cut nerve ending to prevent sprouting and neuroma formation. This is then buried into the internal oblique to keep nerve stump away from future scarring. In cases of pain after prior preperitoneal repair, the genitofemoral trunk must be accessed upstream of the mesh and repair. The main trunk of GFN is identified and resected in the retroperitoneum over the psoas muscle by dividing the floor of inguinal canal either cephalad from the internal ring or in the split internal oblique muscle where the intramuscular segment of the iliohypogastric nerve is identified (extended triple neurectomy) [49, 50]. All nerves are sent to pathology for histologic confirmation. If a plug or meshoma is present or recurrence is identified, this may be addressed at this time with meshectomy and subsequent inguinal hernia repair. If coexisting orchialgia is present, resection of paravasal autonomic nerve fibers enveloping the vas deferens may help to ameliorate neuropathic testicular pain [49].

17.17 Approach: Endoscopic Retroperitoneal Triple Neurectomy

Laparoscopic or endoscopic access to the retroperitoneum may be performed using a transabdominal or retroperitoneal approach to allow for proximal access to the inguinal nerve upstream of all potential sites of peripheral neuropathy. The neuroanatomy of the retroperitoneum is less variable than within the inguinal canal [51, 52]. The IIN and IHN trunks are identified overlying the quadratus lumborum just distal to the L1 nerve root [30]. The main trunk of the genitofemoral nerve is found exiting from the psoas muscle [30]. This may have a single common trunk or present as separate genital and femoral trunks. In case of lateral femoral cutaneous nerve injury, this trunk may be found exiting from L3 and coursing over the iliacus muscle lateral to the psoas in the triangle of pain. This technique is indicated for neuropathic inguinodynia after laparoscopic or open preperitoneal mesh repair and in patients that have undergone multiple failed anterior reoperations [34, 52].

Nerve identification in the retroperitoneal lumbar plexus is more reliable and overcomes many of the limitations that exist with open triple neurectomy. Accessing the nerves away from the scar tissue of any prior inguinal hernia repair is safe and decreases potential morbidity (risk of cord, testicular, or vascular injury and disruption of the prior repair). In addition, the anatomy is consistent with almost uniform ability to identify the nerves, and the operation itself is technically simple. Disadvantages of proximal neurectomy stem from sacrificing the nerve proximally and can include deafferentation hypersensitivity, a larger region of numbness in groin region and flank, as well as bulging and laxity of the lower lateral abdominal wall secondary to loss of motor function of the IIN and IHN to the transversus abdominis muscle [52]. The operation is also limited in that accompanying nociceptive causes, meshoma, or recurrence are not readily addressed through this retroperitoneal approach. However, this technique can be combined to remove preperitoneal mesh, tacks, or fixation, perform remedial inguinal hernia repair, or resect the autonomic nerve fibers to the testicle along the preperitoneal spermatic cord in cases of orchialgia.

17.18 Mesh Removal

Meshectomy, or mesh removal, may be beneficial if nociceptive pain due to mesh is present. Meshoma may occur with wrinkling, folding, contraction, and migration of the prosthetic implant. Mechanisms for mesh-related pain include compression of adjacent structures (nerves, spermatic cord), fibrosis and inflammation causing entrapment (nerves, cord, vas), extrusion or migration of three-dimensional mesh material into adjacent structures (subcutaneous tissue, bowel, bladder, femoral canal, vessels), and entrapment from mesh fixation material (suture, tacks). These changes may lead to nociceptive type mesh pain often exacerbated by position and movement. Inguinodynia commonly will have overlap between nociceptive and neuropathic causes, and the effect of mesh removal without neurectomy is difficult to interpret. There are several series of mesh removal reported, but the evidence is overall limited and cannot conclude whether mesh removal alone is feasible in patients with CPIP [34, 35, 54, 55].

In most cases, affected nerves, either preoperatively identified or nerves that are "at risk" due to iatrogenic injury during mesh removal, are simultaneously removed. Mesh removal remains one of the most challenging and morbid procedures for remediation of inguinodynia. Inadvertent vascular injury, testicular atrophy, orchiectomy, visceral injury, or disruption of the inguinal canal are possible and may lead to worsened symptoms and morbidity. Open, laparoscopic, robotic, and hybrid techniques exist to remove mesh and fixation material from adjacent vessels, viscera, cord structures, and the musculoskeletal components of the inguinal canal. The importance of appropriate technical expertise and patient selection cannot be understated with regard to optimizing outcomes with this procedure [34, 13, 32, 53].

17.19 Conclusion

The avoidance of chronic pain is a primary concern in inguinal hernia repair and may be considered the most important clinical outcome. This problem preceded modern mesh-based techniques, but, as recurrence rates have decreased, pain has become the more prevalent and important complication. Understanding the causative mechanisms of inguinodynia helps to prevent, diagnose, and treat this condition. Significant chronic postoperative inguinal pain that is refractory to conservative and interventional measures may require surgical remediation. An in-depth understanding of inguinal neuroanatomy and the mechanism of initial injury help to guide successful operative management. A tailored approach to each patient based upon individual symptoms, dermatosensory mapping, physical exam findings, imaging, and technical aspects of the prior repair is essential to properly address this complex problem. With post-inguinal herniorrhaphy inguinodynia, an ounce of prevention with meticulous operative technique, proper nerve identification and handling, optimization of prosthetic materials, and judicious fixation is worth a pound of cure.

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Costs

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18.1 Introduction

Costs associated with surgical treatments are a difficult topic. There are several types of costs which should be considered. It is important to discern institutional costs, reimbursements by health insurance companies, and societal costs. In inguinal hernia surgery, costs associated with return to work or daily activities, treatment of recurrence, and (chronic) pain are essential for discussion. In literature, however, it is rare to find complete reports for all cost-associated variables. This chapter will discuss practical methods for managing costs in laparo-endoscopic inguinal hernia repair, along with the available evidence in literature.

18.2 Part I. Considerations for Daily Practice

The surgeon's experience is most important for choice of technique in terms of costs, under the condition that patient characteristics (e.g., previous abdominal surgery, recurrence) allow for use of specific techniques.

From socioeconomic perspective, it should be recommended to perform the vast majority of endoscopic inguinal hernia repairs in day surgery. This is well feasible in most patients, even in the elderly. If patient comorbidity is minimal or absent, it may be possible to integrate one-stop visits in institutions. One-stop visits can include verification of the diagnosis by the referring physician, evaluation by an anesthesiologist, and subsequent surgery, followed by discharge on the same day. Local infrastructure and cooperation between the institution's various departments should be optimal to support this patient-centered approach. However, it should be considered that in the western countries with their high proportion of old people living alone, organization and realization of a well-functioning home care may be more expensive than one night stay in the hospital.

Antibiotic prophylaxis is not recommended in laparo-endoscopic inguinal hernia repair. Not only is the incidence of surgical site infections very low in endoscopic inguinal hernia repair, not giving antibiotic prophylaxis will prevent allergic reactions and reduce costs.

In order to prevent surgical site infections, it should be recommended to avoid shaving patient hair. If this is deemed necessary, hair should be clipped as shortly as possible before surgery. Avoiding hair removal will also save time in terms of cleaning and operation room scheduling.

The largest cost reductions can be made in laparo-endoscopic hernia surgery in limiting use of disposable instruments. Balloon trocars can be replaced by using reusable instruments with a fixating purse-string absorbable suture in the anterior fascia to prevent air leak. In total extraperitoneal repair (TEP), dissection balloons can be omitted on the condition that surgeon experience and knowledge of anatomy is sufficient to perform direct (telescopic) blunt dissection. Blunt dissection without previous balloon dissection can be challenging at first, as overview is limited and chance of inadvertent (peritoneal) injury is increased. However, especially in presence of bilateral hernia, the costs of the dissection balloon might compensate for the additional operation room time needed for (blunt) dissection of both sides. Furthermore, it should be considered to use a self-constructed low-cost indigenous dissection balloon.

As with use of disposable instruments, the choice of mesh is dependent on experience. In the beginning of the learning curve, preformed (three-dimensional) meshes can simplify mesh positioning and thereby reduce operation time and costs. As surgeon experience grows, mesh handling and positioning will improve. This can allow for switching to less costly, non-preformed meshes. With the grow of institutional experience and volume, negotiations with industrial partners can become more dynamic and lower costs of disposable instruments and materials.

Whereas in the early years of laparo-endoscopic inguinal hernia repair the mesh was fixed using a large number of clips or tacks, we have learned that in the vast majority of the cases, expensive fixation devices are unnecessary except in patients presenting with a wide hernia opening (>3–4 cm).

In terms of reusable instruments, 5 mm instrument trocars can be used. It is recommended to use a three-trocar technique. A standard 30°

laparoscopic camera (5 mm) can be utilized. These and other instruments can also be applied for other laparoscopic procedures performed in that institution. Thus, institutional costs per procedure are further reduced.

It is recommended to have experienced surgeons perform laparo-endoscopic inguinal hernia repairs, as operation time and complication rates decrease with growing surgeon experience. A strictly standardized operation technique, dedicated operation teams, and well-supervised trainees can help not only to shorten the operating time but also to schedule and perform more surgical procedures per day.

18.3 Part II. Costs in Inguinal Hernia Repair: Critical Evaluation of the Studies, Statements, and Recommendations

Search terms: "costs" and "inguinal hernia repair," "costs" and "laparoscopic inguinal hernia repair," "cost-effectiveness" and "laparoscopic inguinal hernia repair," "cost benefit" and "laparoscopic inguinal hernia repair," "quality of life" and "laparoscopic inguinal hernia repair," "value for money" and "hernia surgery," "QALY" and "hernia surgery."

Cochrane Library: list of all meta-analyses, systematic reviews, and RCTs in the field of inguinal hernia surgery.

Search machines: Pubmed, Medline. Cochrane Library.

Time period of search: 1994–2014

Out of several hundred papers found, a total of 95 publications seemed useful: Oxford Classification Level 1A, 18; Level 1B, 44; Level 2B/C, 9; Level 3, 21; and 3 papers level 5. However, according to the Sign Criteria I, only 26 papers were considered as high quality (+++), but most (51) as moderate (++) and 18 as acceptable (+). Most frequent reasons for downgrading were small study groups, long operation times showing lack of experience, lack of detailed analysis of hospital costs (e.g., costs for treatment of complications are not included) and costs for the society caused by loss of productivity during sick leave, and no inclusion of costs for treatment of recurrences.

18.3.1 Factors Influencing Costs in Inguinal Hernia Repair

Cost calculations for inguinal hernia repair are complex and difficult to perform [1]. Overall costs, including pretreatment, treatment, and posttreatment medical care, and societal and employer costs are rarely completely reported in studies. Moreover it should be considered that costs are not equal to charges [2]. Charges are not necessarily related to cost and are usually constructed using different formulas. Charges can variate greatly among hospitals and countries. Reimbursement of costs by insurance companies or patients varies widely between countries and hospitals, often depending on negotiations related to volume agreements [3].

All of the aforementioned stages in the treatment process are associated with variable costs. Highly conflicting data demonstrate clearly that cost calculations in hernia surgery are dependent on a nearly countless number of cost-relevant variables. Cost-incurring factors may be related to (1) the patient (age, gender, BMI, clotting disorders, previous operations lower abdominal quadrant like prostate resection or appendectomy, ASA); (2) the pathology of the hernia (location, size of hernia sac, diameter of defect, adhesions (recurrent) bilateral); (3) type of anesthesia; (4) case load of hernias per year; (5) type of procedure, open or laparoscopic; (6) skills of the surgeon, operating time, and materials (use of disposables, type of mesh); (7) type of fixation or no fixation; (8) frequency of complications; (9) setting in which operation is performed (ambulatory, size of hospital/institution, country, region); (10) number of postoperative visits/home care; (11) duration of sick leave; (12) recurrence rate, frequency of chronic pain, and quality of life; (13) salaries of the personnel; (14) depreciation of equipment; and (15) an appropriate share of the costs of the most relevant support departments: administration, housekeeping, cleaning, sterilization, and equipment maintenance. According to that apparently countless number of factors, the published data with regard to costs show a huge range from about 126 US $ to more than 4116 US $ [4, 5]. Moreover, even within one institution, there is a large variation in costs generated by individual providers [5].

Only a few of these factors may be influenced by the surgeon. Operating time, quality of the surgical intervention, and the choice of instruments and materials are directly under the responsibility of the surgeon [6–10]. Experience and skill of the single surgeon is a significant factor for reduction of costs when decreasing operating time as well as the rate of complications, recurrences, and long-term complaints like chronic pain [6, 7, 9, 11].

Furthermore, for comparison of quality of life and quality-adjusted life-years (QALYs), wide variations of these parameters may be observed, e.g., it has been reported that patients who receive workmen's compensation take longer time to return to work than patients without compensation [3, 12]. Patient-related factors such as age, comorbidity, type of work, employment history, local culture, and doctors' expectations influence recovery time but are difficult to evaluate [13, 14]. In addition, societal costs of patients that should be considered include costs for medication for pain, home care, and transportation costs. Rarely considered costs are loss of patient income, cost of disability insurance, and the costs of the inability for patients to care for others. For employers, the costs of insurance, loss of productivity, and replacement of the patient are relevant [3].

Another factor making comparisons of study results difficult is that conversions into a common currency over time may be problematic, and in some studies only percentages of differences in cost were estimated. In some studies, percentages of differences in effectiveness were used to calculate incremental cost per recurrence avoided and incremental cost per added day of work/usual activity [4].

Costs of (laparoscopic) repair can change over time as new equipment is purchased, costs are spread over a higher volume of procedures, or the equipment is used for other surgical procedures too [15].

18.3.2 Types of Costs and Cost Differences Between Open and Laparoscopic Inguinal Hernia Repair

Open tissue repair under local anesthesia is the least costly technique in inguinal hernia repair, however, due to longer time to return to work and higher recurrence rate may be less cost-effective compared to mesh repair [16–18].

Institutional costs and cost utility were higher for laparoscopic repair (TAPP, TEP) compared to open mesh techniques [6, 7, 19–46].

However, the reliability of some of these studies should be scrutinized. Long operating times (>60 min) [14, 16, 20, 21, 24, 25, 31, 32, 37, 38, 44, 45, 47, 48], high recurrence rates for laparoscopic repair (10%) [16, 48, 49], and high conversion rates (6–10%) [6, 39, 42] reported indicate lack of experience, and studies not mentioning the kind of instruments and materials are useless for cost calculations.

In most of the papers it is stated that the higher costs found in laparoscopic surgery is mainly a reflection of the greater use of expensive disposable equipment and longer operating time for laparoscopic hernia repair [4, 7, 14, 25, 29, 30–34, 42, 50, 52, 53]. Multiple sensitivity analyses demonstrated that when the use of disposable trocars, graspers, preperitoneal balloon, and stapling devices "tacker" was included [54], direct costs were significantly higher for laparoscopic hernia repair in comparison to open surgery. This was mainly true in the early era of laparoscopic hernia surgery [6, 13, 20, 21, 24, 32, 41, 43, 50, 55].

Nowadays, institutional costs for laparoscopic hernia repair may be comparable or even lower [3, 14, 15, 41, 56]. Some studies show that in a large-volume laparoscopic surgery center with minimal use of disposable instruments and avoidance of preperitoneal balloon and tacker for mesh fixation, the actual direct costs of laparoscopic repair are comparable to open repairs [14]. Furthermore, in one recent study analyzing routine administrative highly standardized, patient-level cost data (collected in 15 German hospitals participating in the national cost data study), lower costs for TEP/TAPP were found in comparison to open mesh repair. The authors concluded that laparoscopic approaches are not necessarily associated with higher hospital resource consumption than open mesh repair [9]. A large study from the UK also recently published came to a similar result [5]. These authors found that the mean costs of laparoscopic and open hernia surgery are equivocal but laparoscopies appear to offer higher cost utility per QALY compared to open repair and concluded that hernia surgery is cost-effective [5].

Different to the results of the calculations of hospital costs (direct), nearly all RCTs, systematic reviews, and meta-analysis prove that indirect (societal) costs for laparoscopic inguinal hernia repair are lower compared to open mesh repair associated with more rapid recovery due to less pain [14, 15, 24, 40, 46, 47, 52, 57], a shorter time of sick leave [7, 8, 20, 25, 26, 30, 32, 33, 37, 44, 50, 52, 53, 57, 59], better physiometric testing [3, 19], and decreased complication and recurrence rates as experience has grown [3, 6, 14, 18, 25, 30, 32, 38, 40, 43, 53, 57, 58, 60].

In summary, if both direct and indirect costs are taken into account, laparoscopic hernia repair appears to be more cost-effective [5, 26, 29, 43, 51, 53, 58, 61, 62, 68].

18.4 Part III.1. Evidence-Based Statements and Recommendations for Clinical Practice: Which Technique Is Most Cost-Effective?

Statements	
Tissue repair of inguinal hernias done in local anesthesia is less costly compared to open and laparoscopic mesh repair; however, effectiveness is minor	Level of evidence: XXXX – high
Institutional costs (direct) for open mesh repair are lower compared to laparoscopic mesh repair	
Societal costs (indirect) for laparoscopic mesh repair are lower compared to open	
Total cost-effectiveness in inguinal hernia repair favors laparoscopic techniques	
The higher institutional costs found in laparoscopic inguinal hernia repair are mainly a reflection of longer operation time (lack of experience) and greater use of expensive disposable equipment	Level of evidence: XXXX – high
Hernia surgery is cost-effective In high-volume centers with minimal use of disposables, costs of laparoscopic repair may be similar or even lower in comparison to open surgery	Level of evidence: XXX0 – moderate

Recommendation	
From the point of cost-effectiveness in inguinal hernia repair, mesh techniques should be preferred; however, in large-volume centers, laparoscopic should be the standard type of repair	Strong

18.5 Part III.2. How Can Cost-Effectiveness Be Increased (by the Surgeon in Particular)?

Cost-effectiveness may be improved by increasing the case load (more rapid depreciation of equipment costs, large experience) [63], shortening of the learning curve (decrease of operation time) by proper supervision of residents and junior consultants and improvement of surgical performance (lower complication and recurrence rates), by standardizing the technique, and systematic training inclusive simulation-based training [7, 11, 21, 24, 60, 64, 65], and using non-disposable trocars and instruments [7, 14, 15, 31, 66, 67, 68]. Due to improvements in mesh technology and because of better understanding of the extent of the dissection of the inguinal floor (parietalization) in hernias with a defect size less than 3 cm, expensive fixation devices may be avoided [69, 70].

Statement	
Gain of proficiency will decrease operating time, complication rates and frequency of recurrences, and thereby costs	Level of evidence: XXX – high

Recommendation	
Case load should be increased.	Strong
Learning curve should be shortened by strict standardization of operative techniques, systematic training inclusive simulation-based techniques, and proper supervision of residents and young consultants.	Strong
Disposables and expensive fixation devices should be avoided as far as possible.	Strong

18.6 Part IV. How Can Cost-Effectiveness be Increased in Low-Resource Countries?

Inguinal hernia repair represents one of the most common general surgical operations performed in the world, yet many hernias in low-resource settings are not repaired secondary to the lack of adequate resources and affordable surgical care. Many strategies may be employed in low-resource countries in attempts to improve cost-effectiveness of inguinal hernia repair.

18.6.1 Burden of Disease

The rigorous and objective estimates of the burden of inguinal hernia disease in low- and middle-income countries are lacking [71]. Estimates of the prevalence of inguinal hernia in Ghana have ranged from 2.7% to 3.15% [72, 73] (with some estimates ranging from 7.7% to 30%) [74]. Using these estimates of hernia prevalence and based on the population in sub-Saharan Africa, it can be projected that 6.3 million adult African Males have hernias [71].

18.6.2 Cost-Effectiveness in Low-Resource Setting

Several studies have reported on the efficacy and cost-effectiveness of hernia repair in low-resource environments. Single-series studies in pediatric [75, 76] and adult inguinal hernia repair in Nigeria [75, 77], Ghana [78], and Ecuador [79] have reported on the cost-effectiveness of open inguinal hernia with a study from Tanzania highlighting the need for early presentation and elective repair to improve the morbidity and mortality associated with emergency repairs [80]. In the previously mentioned study from Ghana, surgery proved effective by analyzing disability-adjusted life-years (DALYs). With DALYs, reductions in premature death and disability can be measured; this approach is well suited for low- and middle-resource environments [79]. One systemic review has evaluated the cost-effectiveness of surgery in low- and middle-income countries and reported that inguinal hernia repair was found to be a cost-effective intervention [81].

18.6.3 Use of Anesthesia

Local anesthesia is most cost-effective compared to all other techniques [82]; however, laparoscopic surgery, by definition, is performed under general anesthesia. There has been little literature specifically related to the use of anesthesia in inguinal hernia repair in low-resource settings. One study evaluated the patients with giant inguinoscrotal hernia repair in a resource poor area of Nigeria using local anesthesia [83]. They reported that this technique was well tolerated with acceptable results [83]. Another study has evaluated the anesthetic techniques in seven hospitals in Ghana reporting that only 22.4% of the 1038 hernia repairs were done under local anesthesia and commented that valuable resources could be saved if there was an increased use of local anesthesia [74].

18.6.4 Non-commercial Mesh

The use and availability of mesh may be one of the determining factors for cost in low-resources countries. Several studies have addressed the feasibility and efficacy of the use of low-cost, non-commercial mesh. In one basic science study, a mosquito net mesh made of a polyethylene homopolymer was shown to have material and mechanical properties similar to commercial lightweight meshes [84–89] and shown to have a similar in vitro infection risk similar to monofilament polypropylene commercial prosthetics (and lower than commonly used commercial multifilament mesh) [86].

Two systematic reviews have evaluated the cost-effectiveness and efficacy of non-commercial mesh in resource-limited settings [71, 90]. The most recent systematic review performed in 2012 evaluated the efficacy of the use of non-commercial meshes, with the majority being sterilized mosquito nets, for hernioplasty [90]. They evaluated five studies with a total of 577 non-commercial meshes used in human and reported a 6.1% short-term complication rate and 0.17% recurrence rate [90]. In comparison, 122 commercially available meshes were used in these studies with an 8.2% rate of short-term complications and no recurrences [90]. They concluded that operating using non-commercial mesh is highly cost-effective [90]

Another study has evaluated the use of resterilized polypropylene mesh for inguinal hernia repair [91]. In this randomized prospective study, mechanical properties, cost-effectiveness, and overall complications rates were evaluated in 91 patients treated with original polypropylene mesh and 93 with resterilized polypropylene mesh [91]. They reported a slight decrease in tensile strength in the resterilized mesh from a mean of 66.6 to 58.2 N/cm with overall complication rates being similar in the two groups with a decrease in overall cost of the operation by decrease mesh cost from 15.9% to 8.3% of the total amount [91]. Decreasing mesh size has been associated with increased recurrence rates and should be advised against [42, 49, 92].

18.6.5 Use of Dilatation Balloons in TEP

Controversially discussed is the use of dilatation balloons in TEP for further cost reduction.

Several studies have evaluated the need for commercially available balloon dissection in laparoscopic totally extraperitoneal (TEP) hernia repair with randomized studies reporting that the balloon may not be necessary but may decrease conversion rate and be beneficial in the learning curve of TEP [93, 94]. Alternatively indigenous balloons may be used [95]. Other studies have evaluated and reviewed cost minimization strategies and reported significantly decreased cost using non-disposable cannulas and without the balloon dissector [66, 67].

Statement	
Non-commercial mesh can be used safely to decrease direct cost in inguinal hernia repair	Level of evidence: XXXX – high

In TEP indigenous dilatation, balloons may be similarly effective compared to expensive commercially available devices	Level of evidence: XXX – high

Recommendation	
To provide open or laparoscopic mesh repair in low-resource countries, non-commercial meshes, indigenous dilatation balloons, and non-disposable equipment can be used	Strong
To provide laparoscopic mesh repair in low-resource countries, mesh fixation, if necessary, should be done by simple sutures	Weak

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Sportsmen Hernia

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19.1 Introduction

Sportsmen hernia (SH) is one of the least understood, poorly defined, and under-researched maladies to affect the human body and is a leading cause of athletes' retirement from competitive sports. It is more common in high-level athletes, although it could be also present in active young people. It is an obscure condition of uncertain etiology commonly seen in soccer, football, rugby, and ice hockey players. It reflects a compilation of diagnoses grouped together with a wide range of other pathologies that need to be excluded before this should be considered as a diagnosis. The top five causes for groin pain in athletes have been determined in a recent systematic review [1] and include femoroacetabular impingement (FAI) (32%), athletic pubalgia (24%), adductor-related pathology (12%), inguinal pathology (10%), and labral pathology (5%), with 35% of this labral pathology specifically attributed to FAI.

The etiology of this entity, onset, anatomy involved, and terminology used to define it vary widely in the literature. The precise sequence of events that leads to its development is not well known, but the combination of abdominal and hip adductor muscle strength, endurance, and coordination imbalances, lumbopelvic and hip rotation range of motion deficits, poor tissue extensibility, and intense or high-repetition hip adductor muscle shearing forces through their pelvic attachments may be the primary factors [2]. Some authors emphasize inguinal nerve compression (entrapment) as a cause of chronic pain in athletes produced by direct trauma or overzealous training and hypertrophy of abdominal musculature [3]. The phrase "groin disruption" was popularized by Gilmore for sport injuries followed by chronic pain in the groin and abdominal muscles area with no findings of hernia but inguinal wall and superficial inguinal ring disorders caused by injuries to the internal oblique aponeurosis, conjoined tendon-pubic tubercle attachment, and dehiscence between the tendon-inguinal ligaments. He successfully advised a surgical technique as a treatment based on modifications of the historic Bassini operation. Gilmore, as well as others, found that the pain is caused by posterior wall deficiency (PWD) as a result of trauma to the transversalis fascia or conjoint tendon, which is formed by the medial portion of internal oblique and transversus abdominis muscle [3]. Nevertheless, many uncertainties remain, not at least due to the existence of other pathologies around the symphysis pubis which were in some way easier to diagnose. Diagnostic imaging is useful to exclude other conditions [2] but does not generally reveal a sports hernia. With time, especially after the introduction of laparoscopy, the understanding of the different pathologies and pathogenetic mechanisms has improved. Today, posterior inguinal wall insufficiency that creates an occult hernia that is not apparent on physical examination is recognized as the most common surgical findings [2]. For this reason, the pathological definition of PWD was accepted as equivalent to the pathology of SH and confirmed by multiple studies.

19.2 Which Are the Pathophysiological Aspects of This Entity?

From an anatomical point of view, the definition and the name of this entity should be reviewed. Confusion related to "sportsmen hernia" often arises from the complex anatomy and biomechanics of the symphysis region, from the large number of potential sources of groin pain, and from the similarity of symptoms in athletes with different sites of injuries. There are different anatomic areas to be considered when we talk about this entity, including ligaments, tendons, nerves, muscles, and bones.

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 muscles inserting at or near the pubis are 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 [4].

As it has been said, 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, and just this last possibility could be defined as SH.

On the other hand, this disruption of the muscle/tendon at their insertion site could be defined as a PBSI (pubic bone stress injury) which affects not only the pubic bone itself but also the muscles and their tendons on both sides of the symphysis pubis [5] (in the past, it was mistakenly referred to as osteitis pubis). For that reasons, this term could include different entities such as tendon enthesitis, pubic osteitis, or avulsion fractures.

In conclusion, 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, once a true origin is not detected, since, for example, a hernia is a hernia or a nerve entrapment is a nerve entrapment, etc., which may lead to a degenerative arthropathy of the pubic symphyses in the advances stages.

19.3 How Is This Entity Diagnosed?

Diagnosis of chronic groin pain is difficult, but early diagnosis is very important since morbidity will be reduced. These groin injuries are some of the most challenging injuries in the field of sports medicine, and the literature provides no consensus on definitions of or diagnostic criteria for groin pain in athletes. The combination of complex anatomy, the variability of presentation, and the nonspecific nature of the signs and symptoms make the diagnostic process problematical [6].

Therefore, management of groin injuries can be challenging, and diagnosis can be difficult because of the degree of overlap of symptoms between the different problems. This clinical setting demands the recruitment of a team with experience of different aspects of groin pain, being necessary to establish a multidisciplinary investigation in order to reveal the underlying cause [7]. These examinations included general surgeons for detection of inguinal hernia and neuralgia, orthopedic surgeons for detection of adductor tenoperiostitis and symphysitis, urologist for detection of prostatitis, radiologist for performing different imaging tests, and nuclear medicine for isotope studies. For all these reasons, the so-called SH is largely a clinical diagnosis of exclusion.

SH must be distinguished from the more common osteitis pubis and musculotendinous injuries [8]. But the first step is to determine the differential diagnosis of hip and groin pain with respect to the high frequency of referred pain from the lumbar spine, lower abdomen, and pelvis [9], which is very difficult in some cases. A systematic approach to the hip and groin area is important to identify the origin of pain. Both the history and quality of symptoms and the physical exam are the basics of the diagnostic algorithm, completed in some cases the diagnostic work-up with roentgenograms and possibly an injection with a local anesthetic to the suspected origin of pain often complete [9]. On the other hand, there are clinical signs in the diagnosis of nerve pathologies, such as obturator neuropathies; these patients usually show clinical symptoms and signs of postexercise groin, lower abdominal or medial tight pain, and adductor muscle weakness and paresthesia in cutaneous distribution of medial thigh. Except clinical signs in the diagnosis of obturator neuropathy, diagnostic local anesthetic block and electromyography could be used.

History of chronic groin pain that is nonresponsive to treatment should raise suspicion of SH, but physical examination findings are subtle, and most diagnostic tests do not definitively confirm the diagnosis. Traditional physiotherapy of isometric active weight-bearing exercise will result in complete healing of almost all athletes [10]. It is important to highlight that adductor strain is a possible part of this pathological syndrome and so tenotomy, as procedure only performed, should not be performed under any circumstances.

Finally it must be said that, in selected cases, correct diagnosis is only possible with diagnostic laparoscopy [11].

19.3.1 Physical Examination

Physical examination is the first step in the diagnosis of groin pain, although symptoms are often vague and diffuse. When active, sportsmen start to feel a dull pain in the groin region.

A deep palpation above the inguinal canal will find the area to be sensitive, the external inguinal ring dilated [2]. In a digital examination of the canal, a soft bulge can be felt against the tip of the finger and extreme sensitivity to pressure applied with the tip of the finger against the floor of the canal where the genitofemoral nerve passes. With this syndrome, the nerve is entrapped under the IPT (ileo-pubic tract) in the internal inguinal ring area. In addition, all the symptoms increase during coughing.

The clinical assessment of groin pain in athletes is difficult, with the lack of specific clinical tests being in part responsible. The examinations could include evaluation of adductor muscle-related pain and strength; iliopsoas muscle-related pain, strength, and flexibility; abdominal muscle-related pain; and strength and pain at the symphysis joint, but the only test without acceptable interobserver reliability was the strength test for iliopsoas muscle [12].

Gradual physical therapy combined with pharmacotherapy should be effective in most cases and should be part of the diagnosis process. This process includes nonsteroid anti-inflammatory drugs and muscle relaxants. A physical therapy program usually involves stretching and strengthening of the adductor muscles, abdominal wall muscles, iliopsoas muscle, quadriceps, and hamstrings. In case that physical therapy and pharmacotherapy fail, different tests should be performed.

19.3.2 Ultrasound

Ultrasound is a useful adjunct in evaluating the groin for hernia. The overall accuracy in finding a hernia of any kind by ultrasound is 92%, and, on the other hand, this imaging test identifies the pathology in a groin without a palpable bulge at an accuracy of 75% [13].

On the other hand, ultrasound enables a dynamic assessment that is particularly useful in these patients [2, 11]. Dynamic ultrasound examination should be the diagnostic tool of first choice, since it is able to detect inguinal canal posterior wall deficiency in young males with no clinical signs of hernia with chronic groin pain. As the patient actively strains during the investigation, a real-time convex anterior bulge and ballooning of the inguinal canal can be observed at the superficial inguinal ring. This examination has been proposed [14] to be performed with the patient in the supine and erect positions, in a relaxed state, as well as during coughing and during Valsalva maneuver.

A correlation between bilateral deficiency of the posterior wall and groin pain has been shown [15], although the temporal relationship between the clinical and ultrasound findings is not established. Ultrasound is also a useful tool for identifying hernias and, therefore, aids surgical management, since 39% of the patients examined presenting groin pain were positive for hernias in some studies [16], finding a very low rate of false positive, giving a positive predictive value of 94% in operated patients.

Ultrasound could be also useful in detecting other findings that could be related to groin pain, such as a preperitoneal lipoma herniating into the inner inguinal ring and canal, an evidence of genitofemoral nerve entrapment by identifying an edema behind the IPT on the level of internal inguinal ring, or even a tear and strain of the conjoint tendon in its insertion to the pubis.

19.3.3 MRI and CT Scan

Bone scan, plain radiography, and ultrasound have been used for diagnosing these entities, but MRI appears to be a useful tool. A clinical and imaging diagnosis is crucial, since in PBSI, there is no need for surgical intervention.

MRI provided an accurate depiction of pubic bone alterations and of adjacent myotendinous structures [17], being also very useful to determine the presence of inguinal hernias [17], since allows the direct visualization of the hernial sac within the inguinal canal. Athletes with groin pain and tenderness of the pubic symphysis and/or superior pubic ramus have clinical features consistent with the diagnosis of osteitis pubis. The increased signal intensity seen on MRI is due to pubic bone marrow edema. A stress injury to the pubic bone is the most likely explanation for these MRI findings.

MRI can permit an accurate and early diagnosis of the different sport-related pubic conditions, being also a valuable tool in monitoring the alterations with reference to their response to treatment, which may also help bring the athletes back to their activities. But it should also be considered that abnormal magnetic resonance imaging findings are also common in asymptomatic athletes, which decrease the value of magnetic resonance imaging in surgical decision-making

[18], and, on the other hand, those patients with the presence of pubic bone marrow edema in MRI who undergo endoscopic repair for athletic pubalgia are not affected by this entity in the recovery period, so this finding could lead to confusion [19].

On the other hand, CT scan has been also described as a diagnostic technique with high accuracy in detecting posterior wall deficiencies [20].

19.4 How Is This Entity Treated?

Chronic groin pain in athletes is a difficult problem requiring a multidisciplinary approach not only to diagnosis but also to treatment planning [21]. Based on previous definitions, in case this imbalance of the groin causes a disruption of the muscle/tendon at their insertion site on the pubis, treatment should be based on rest, anti-inflammatory medication, and a proper training program followed by a reevaluation. For that reason, conservative treatment is tried first [22], but there is no evidence-based consensus available to guide decision-making [21]. But in case that a weak area has been found at the groin due to the forces produced by the muscles, patients should undergo a surgical repair of the groin reinforcing the posterior wall with or without a mesh, since if a conjoined tendon is adequately supported by a mesh or with a stabilization by a suture repair like a minimal repair [3], adductor discomfort almost uniformly resolves with postoperative rehabilitation, being rarely that the abductor requires an operative release, a tenotomy, or a perforation on the pubis.

19.4.1 Conservative Treatment

Traditional conservative treatment has low success rates [2], being demonstrated in one RCT that an active physical training program aiming at strengthening the muscles to stabilize the hip and pelvis is of advantage for the patient when compared with rather passive measures [23].

Many groin pain due to problems related to the musculoskeletal system are a self-limiting disease that can take several months to resolve, and corticosteroid injection can sometimes hasten this rehabilitation process. This treatment can be expected to afford at least 1 year of relief of adductor-related groin pain in a competitive athlete with normal findings on a magnetic resonance imaging scan; however, it should be employed only as a diagnostic test or short-term treatment for a competitive athlete with evidence of enthesopathy on magnetic resonance imaging. But, on the other hand, recent studies have demonstrated that for conservative treatment, the use of radio-frequency denervation of both ilioinguinal nerve and inguinal ligament in the treatment of refractory SH is safe and efficacious at least in the short term and is superior to anesthetic/steroid injection [24].

Finally we can state that most studies agree that surgical therapy seems to be superior to nonsurgical treatment [2, 11], even that a recent systematic review states that after conservative treatment, athletes return faster to play [25], although the studies included are of poor quality. In this sense, a recent prospective randomized trial, conducted by Paajanen et al. [26], supports our way of treating these patients, offering a surgical treatment to solve the groin pain. This study compared conservative treatment to endoscopic mesh repair on 60 patients with a diagnosis of chronic groin pain and suspected SH. Operative repair was more effective than nonoperative treatment to decrease chronic groin pain after 1 month and up to 12 months of follow-up. Of the 30 athletes who underwent operation, 90% returned to sports activities after 3 months of convalescence compared to 27% of the 30 athletes in the nonoperative group. For this reason, surgical treatment should be considered a valid option to solve this entity. On the other hand, a preventive training program could be successful to avoid such injuries. An 8-year experience in Australian rules football professionals with a preventive core stability program shows a significant decrease of groin problems [27].

19.4.2 Surgery

Conservative treatment of this entity does not often result in resolution of symptoms [28]. In some series the athletes have received different conservative treatments without success, and the surgical procedures performed in these cases have offered a definitive resolution to this problem.

Although, several surgical approaches are available for the repair of inguinal hernias, but without knowing the true natural history of this disorder, and the problem is that it is difficult to know when it is appropriate to have a surgical intervention [14]. The conclusion could be that it is recommended operating only if conservative therapy, with prolonged rest, fails [29].

It is important to establish that precise diagnosis is always preferable, before to perform a surgical approach in a patient with chronic groin pain. Steele et al. [30] show no significant difference in outcome between subjects who had an abnormal ultrasound scan on the symptomatic side and those who had a normal scan. There was a significant difference in outcome between patients who had a bone scan with increased uptake at the symptomatic pubic tubercle and those who did not ($p < 0.04$). This study supports other researches that show that good results can be obtained with surgery when posterior inguinal wall deficiency is the sole diagnosis.

Surgical intervention of chronic groin pain by performing a posterior repair results in pain-free return of full activities in a majority of cases [28], although there is no consensus view supporting any particular surgical procedure for SH [8]. Various types of operations, based on the variable theories regarding the pathophysiological process, have been developed for the treatment of this syndrome. Some surgeons focus on the external elements of the inguinal canal and repair the external oblique fascia or enforce the groin with the rectus abdominis. Some researchers believe that the problem is in the lower abdominal muscles, or is caused by nerve entrapment, and treat it accordingly, showing good results performing an open technique, Bassini or Shouldice [31], and neurotomy of the inguinal nerve, describing benefits for the patients, but the overall quality of most of the studies is low [22].

But the most popular surgical procedure associated to the posterior repair of the groin, with mesh or sutures, is tenotomy [32–35], being also performed as an isolated technique by some groups [36, 37]. There are some groups who believe on the need of performing this systematic tenotomy of the abductor longus muscles during the laparoscopic or open repair of the posterior deficiency of the abdominal wall. But, basically the main recommendation of most of the authors is that, in cases where PWD or tear of the posterior inguinal wall are clearly diagnosed, routine inguinal hernia repair should be done as the main procedure [11, 28], being the need of a tenotomy a current discussion in the literature nowadays that we usually do not perform.

In this last sense, a number of reports have been published describing different repairs of the posterior inguinal wall deficiency as the main approach for the SH with excellent results. This procedure can be performed either with sutures or synthetic mesh, being performed by an open approach or laparoscopically, both with good results [2, 38], being the endoscopic preperitoneal approach the technique more used in the last year [18, 39–41] and the one recommended by our groups and recent guidelines [42–46]. The laparoscopic approach may provide better posterior inguinal wall exposure, enabling easier bilateral reinforcement [47], and possibly allow a quicker recovery time than open surgery [2, 21, 32, 37, 48]. In this sense, CJ Ingoldby [38] has published a comparative nonrandomized study comparing the open and the laparoscopic approach, showing that the endoscopic repair permits an early return to activity. In fact, overall postsurgical recovery time (based on return to sports activity) was found to be in some studies of 17.7 weeks after open and 6.1 weeks after laparoscopic repair [2].

Regarding the two types of laparoscopic approaches, TEP and TAPP, both have been successfully applied to treat this entity. There are no studies showing the true efficacy of these different techniques, and a recent systematic review comparing the different laparoscopic approaches shows no difference between the two techniques in terms of return to sporting activity, although more reported cases to date in the literature used the TAPP technique compared with TEP repair [49]; thus a recommendation for one or the other method cannot be given and depends on the skill and personal preference of the surgeon involved, being the TEP approach the preferable technique by our groups.

Finally, beside the placement of the mesh in the preperitoneal space, during the operation, the inguinal canal should be thoroughly explored in order to find the different entities that could be detected during the surgery such as a true inguinal hernia, a wide internal ring and peritoneal

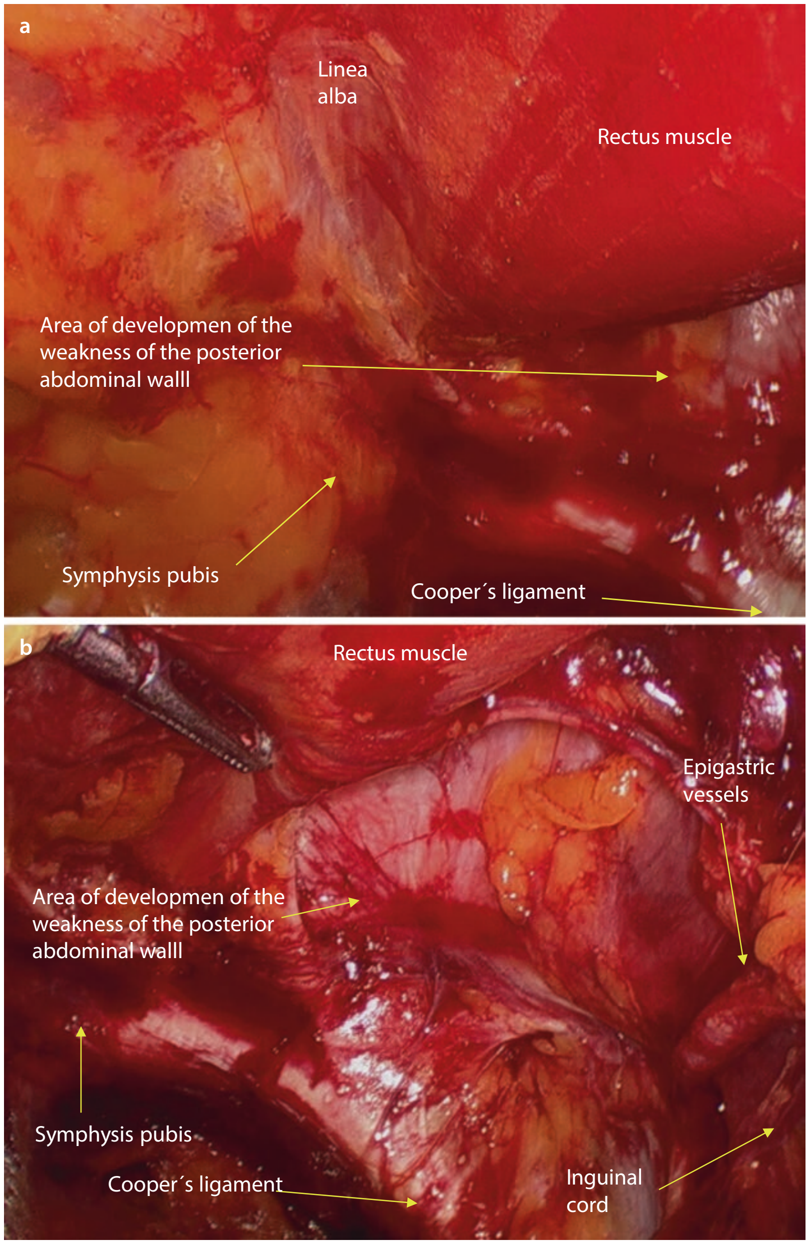

Fig. 19.1 **a** and **b** Endoscopic view (TEP) of the inguinal area that could be involved in the development of a "sportsmen hernia"

dimple, a hernia femoralis, a preperitoneal lipoma, hernia obturatoria, a pre-vascular hernia, an obvious musculotendinous tear, a muscle asymmetry, and a significant bulge in the posterior wall, but even if no clear pathology is identified, reinforcement of the wall using a mesh offers good clinical results for athletes with idiopathic groin pain. Basically, the most common finding in athletes with chronic groin pain was a deficiency of the posterior wall of the inguinal canal (Figs. 19.1a, b and 19.2).

The endoscopic repair of this entity requires the placement of a mesh in the inguinal region. Recent meta-analysis has shown that the only advantage of the so-called lightweight meshes is that they improve the discomfort at short term and could offer an additional advantage to this group of patients who are willing to return to sports activities as soon as possible [50]. Atraumatic fixation with glue in in these cases should also be considered in order to decrease acute and chronic pain, being the alternative used by our group in these patients.

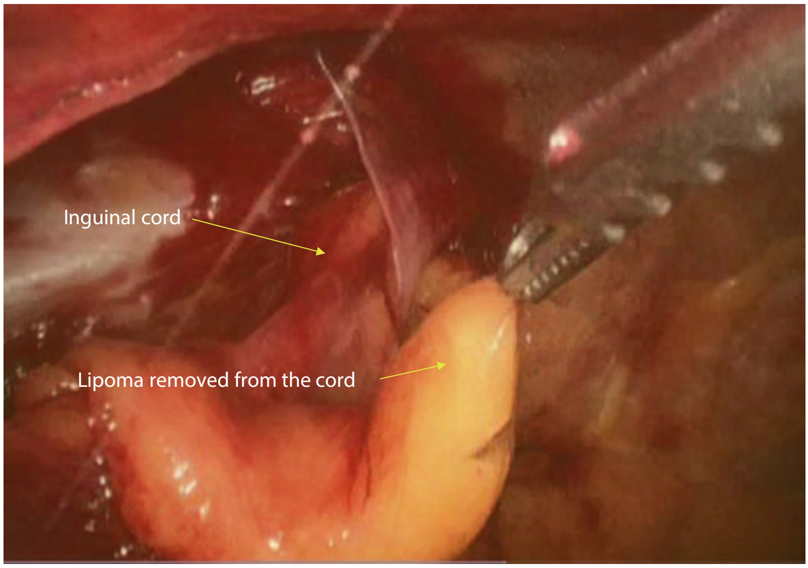

Fig. 19.2 Lipoma at the cord as a cause of pain in the inguinal region

19.5 Rehabilitation After Surgical Treatment

With respect to postsurgical rehabilitation programs, up to now, there is no general agreement about the best postoperative physical training program to enable the athletes to return to full sports activity in shortest time [28]. Valuable studies having a high level of evidence are urgently needed.

The effect of the presence of pubic bone marrow edema in magnetic resonance imaging on recovery from endoscopic surgery for athletic pubalgia has been published recently [19], and it has been found that the presence of this entity does not affect the recovery period after the endoscopic surgical treatment of these patients, so the presence of this edema should not change the rehabilitation program.

The following program works well in our experience:

- First postoperative day: ergometer training up to 50 W.
- Second to sixth postoperative day: ergometer training up to 200 W.
- Seventh postoperative day: starting with slight running.
- Week 2: increasing load of training up to full training in the third or fourth postoperative week.
- Associated manual lymphatic drainage and physiotherapy should start already at day 1.

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Comparison to Open Techniques

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20.1 Part 1 How I do It

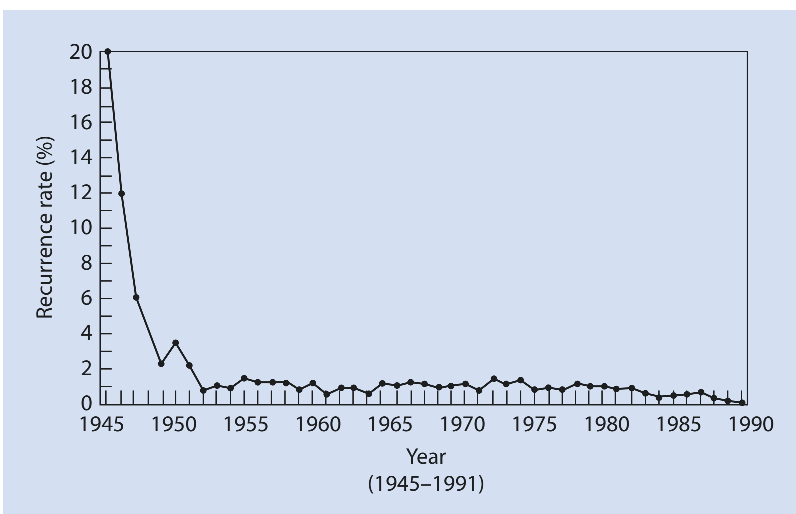
20.1.1 Introduction

The basic principles of modern inguinal hernia surgery were born in 1884 when the Italian surgeon Edoardo Bassini (1844–1924) introduced a new surgical technique [3, 37, 44]. Bassini discovered that the inguinal floor played an important role in the etiology of inguinal hernias. He approached the hernia from the anterior side. He realized the importance of differentiating direct from indirect hernias, isolating the spermatic cord, resecting indirect hernia sacs at the deep inguinal ring flush with the peritoneum, complete division of the external oblique aponeurosis and the transversalis fascia and oblique reconstruction of the posterior wall of the inguinal canal by a triple layer method with an anterior and posterior wall with an internal and external opening (rings). The three layers consisted of the transversalis fascia, the aponeurosis of the internal oblique muscle, and the aponeurosis of the transversus abdominis muscle, which he sutured to the inguinal ligament [39]. Bassini published his results showing a recurrence rate of 2.8% after 5 years of follow-up. Modifications were common and in fact at least 70 named tissue repairs have been described in the literature [2]. The technique (or one of its modifications) became accepted and was the gold standard for inguinal hernia repair for most of the twentieth century.

Perhaps the most widely accepted Bassini modification was born in 1945 when the Canadian surgeon Earle Shouldice (1890–1965) opened a small hospital treating only inguinal hernias [4]. His surgical technique resembled Bassini, except that instead of interrupted sutures to reconstruct the inguinal floor he used four rows of continuous stainless steel wire and excluded the periosteum from the first suture. Shouldice recognized the importance of perioperative care of inguinal hernia patients as well, including preoperative preparation, local anesthesia, early mobilization, short hospital stay and resuming normal activities as soon as the patient felt comfortable [39]. After an initial learning curve, a consistent recurrence rate of approximately 1% was reported by Shouldice as is depicted in Fig. 20.1. In general practice long-term results are less satisfying and show a recurrence rate of 1.7–15% [40]. Nevertheless, the Shouldice technique is considered by most authorities to be the best pure tissue repair for a primary inguinal hernia.

Results from single centers usually with a specific interest in hernia repair using the Bassini operation or one of its modifications were similar with recurrence rates less than 5%. However, population based studies in the latter half of the twentieth century revealed a recurrence rate as high as 30% in general practice causing investigators to consider alternatives [3]. A popular theory was that the tension produced by suturing structures together that were not normally in apposition resulted in undo tension and the poor results. In 1958 the American surgeon Francis Usher (1908–1980) introduced the revolutionary tension-free mesh repair [36]. He had developed a

Fig. 20.1 Recurrence rates of the Shouldice technique after its introduction in 1945



polyethylene mesh, which he placed on the anterior side of the posterior wall of the inguinal canal for reinforcement. Anatomical reconstruction of the posterior wall was not performed in favor of reinforcing the inguinal floor with his mesh. In 1962 he introduced the polypropylene mesh, which is still the mesh of choice today [48].

The surgical technique proposed by Usher never became widely used until another American surgeon Irving Lichtenstein (1920–2000) in 1964 introduced the idea of performing the repair under local anesthesia and promoted its tension-free nature. Lichtenstein and colleagues at the Lichtenstein clinic were such strong advocates of the approach that the anterior tension-free mesh repair is now known as the "Lichtenstein tension free repair" or TFR [29, 30, 36, 37]. By the 1990s, it had become the most common surgical repair for an inguinal hernia in the Unites States and many other parts of the world. The recurrence rate dropped significantly even in general practice and it is still today considered the gold standard for an anterior inguinal hernia repair.

Hernia surgeons discovered new possibilities with the use of synthetic mesh and in 1975 the French surgeon René Stoppa (1921–2006) added another technique to the armamentarium of the inguinal hernia surgeon [42, 43]. Stoppa approached the posterior side of the inguinal floor through an abdominal midline incision and placed a large mesh in the preperitoneal space posterior to the abdominal wall for bilateral augmentation. This became known as the giant prosthetic reinforcement of the visceral sac, resulting in equally low recurrence rates.

In 1982 the South African surgeon Ralph Ger (1921–2012) was the first to describe the laparoscopic approach for the treatment of an inguinal hernia. He reported a series of 12 cases in which he primarily sutured the hernia defect in the abdominal wall laparoscopically [16]. Hernia surgeons explored the possibilities that the laparoscopic approach offered, and within a short period of time, the first synthetic mesh was placed on the posterior side of the abdominal wall in the preperitoneal space covering the hernia defect. Endeavors to find the ideal position led to the introduction of intra-abdominal placement of the mesh in 1991 [46]. Their intraperitoneal onlay mesh (IPOM) procedure placed a prosthesis (usually ePTFE to avoid erosion into intra-abdominal viscera by mesh) intra-abdominally covering the hernia defect by fixing it to the peritoneum of the abdominal wall. They emphasized the simplicity and short operative time. The technique never gained popularity, which is somewhat surprising because of the frequent use of the procedure for ventral hernias. Long-term results revealed high recurrence rates and increased rates of neuralgia [5, 15, 24] possibly due to technical factors such as inadequate fixation to stable structures such as Cooper's ligament or too vigorous bimanual stapling. Nevertheless, it is generally perceived to be inferior compared to other minimal invasive techniques [5] but can be useful as a salvage procedure in a multiply recurrent situation.

Two laparoscopic techniques for inguinal hernia repair remain in practice today. In both the hernia defect is approached from the posterior side of the abdominal wall, and a mesh is placed in the preperitoneal space. The difference is that in the Total Extraperitoneal Preperitoneal repair (TEP) the preperitoneal space is entered through a small incision in the anterior rectus sheath, allowing the rectus muscle to be retracted laterally. Dissection then proceeds caudally along the posterior rectus sheath and the preperitoneal space is entered. The peritoneal cavity itself is not entered. A radical dissection of the preperitoneal space is then performed. The key structures that must be identified are the ipsilateral and contralateral pubic tubercles, inferior epigastric vessels, Cooper's ligament, and iliopubic tract. The hernia sac is reduced and a large mesh is placed to cover the entire myopectineal orifice. For the Trans-Abdominal Preperitoneal repair (TAPP) the peritoneal cavity is entered as with conventional laparoscopy and the hernia orifice is visualized from within the abdominal cavity. The peritoneum at the groin is opened laparoscopically and the mesh is placed in the same location as with TEP repair. There is no clear cut advantage of one of the techniques over the other as both have the same advantages over the open techniques, equal rates of complications, and equal operative times [31]. The TEP technique might require more procedures to achieve surgical competence compared to the TAPP technique, and therefore most authorities believe that a laparoscopic surgeon should be comfortable with the TAPP herniorrhaphy before progressing to the TEP.

20.1.2 Choice of Technique

Given this plethora of techniques for repairing an inguinal hernia, the surgeon is left with a clinical dilemma: which operative technique should be chosen in which case. Literature on this subject is extensive, and in most studies two techniques are compared to one another, including a heterogeneous group of types of hernias, using different definitions of outcomes, especially chronic pain, and different schemes and lengths of follow-up. This indicates the difficulty in comparing the literature with regard to different techniques and caution in drawing any conclusions. As discussed above, the two most common mesh techniques used are the open anterior mesh "Lichtenstein" technique and the laparoscopic posterior mesh technique (TAPP or TEP). In the Guidelines of the European Hernia Society, either of these techniques are recommended as the best evidence-based option for repair of a primary unilateral hernia provided that the surgeon is sufficiently experienced in the specific procedure [32, 40]. Therefore, we will focus on these two main groups in this chapter as type of repair for a unilateral inguinal hernia repair.

20.1.3 Open Versus Laparoscopic Mesh Repair

Several randomized controlled studies and meta-analysis have been published comparing the open Lichtenstein technique with the laparoscopic posterior mesh technique. It is important to appraise the methods of these studies critically. Some studies include, in addition to unilateral primary inguinal hernias in male patients, bilateral and recurrent hernias or female patients. Striving for the most objective comparison as possible, only studies including unilateral inguinal mesh repair in male patients are used for outcomes in this section. For recommendations on female, bilateral, complicated or recurrent hernias, we refer to the designated writings elsewhere in this book (▶ Chap. 11).

Intraoperative and Postoperative Complications

Intra-operative and postoperative complications are comparable in both open and laparoscopic mesh techniques [8, 11, 21, 22, 28]. The overall risk of complications after inguinal hernia mesh repair reported vary from 15% to 28% in systematic reviews [40]. The most frequent early complications are hematomas and seromas, wound infection, urinary retention and acute pain [35]. Seromas are more likely to occur after laparoscopic repair compared to open technique, 6% versus 4% [40]. Wound infection is less common after laparoscopic repair, 1–2% versus 3% [35, 40]. Early postoperative pain is less common in patients after laparoscopic inguinal hernia repair requiring less analgesic consumption [9, 11].

Operative Time

The duration of an open Lichtenstein mesh repair for a primary unilateral inguinal hernia is comparable to the duration of a laparoscopic mesh repair. In randomized controlled studies including more than 100 patients per arm operation time is equal, or a small significant advantage towards the laparoscopic technique is shown. The operation time for an open Lichtenstein mesh repair varies between 55 and 70 min and for laparoscopic mesh repair between 50 and 60 min [8, 11, 28].

Duration of Admission

Generally, both procedures can be performed in day surgery [14]. There are no significant differences in hospital stay after the two techniques.

Return to Work and Return to Normal Activities

Time to return to work and to normal activities is significantly shorter after laparoscopic inguinal hernia mesh repair compared to open Lichtenstein mesh repair. Generally, it takes 7–13 days to return to work after laparoscopic repair compared to 12–17 days after open Lichtenstein repair. Similarly, it takes 14–20 days to return to normal activities after laparoscopic repair versus 20–31 days after open Lichtenstein repair [11, 20–22, 28]. In an extensive effectiveness review published on the Internet only by the US Agency for Healthcare Research and Quality (AHRQ), patients undergoing laparoscopic herniorrhaphy were noted to return to daily activities 3.9 days earlier (CI, 2.2–5.6) and to work 4.6 days earlier (CI, 3.1–6.1) [47].

Chronic Pain

Chronic pain after surgery is particularly difficult to appraise. Different definitions and different diagnostics are used. There is an urgent need to reach international consensus on the definition of chronic postoperative pain, its diagnostics and therapy. Nonetheless, there are some randomized trials on chronic pain that reveal less chronic pain after laparoscopic inguinal hernia repair [10, 13, 18, 33]. The incidence of chronic pain after open Lichtenstein repair is 19% after 5 years versus 9% after laparoscopic repair. Lau et al. compared 100 Lichtenstein repairs to 100 TEP repairs. They report similar results and an incidence of chronic pain after Lichtenstein repair of 22% at 1 year versus 10% after laparoscopic repair [28]. In the AHRQ effectiveness study, long-term pain was better for the laparoscopic approach, with odds ratio of 0.61 (CI, 0.48–0.78) [47].

Recurrences

The recurrence rate after open Lichtenstein or laparoscopic mesh repair is generally not considered different [26, 32]. The average incidence of recurrence is 0–5% [12, 17, 21, 22, 28, 35]. However in the AHRQ analysis, the open repair was favored with a relative risk, 1.43 (CI, 1.2–1.8), but the evidence was graded as low [47].

Type of Anesthesia

One of the strongest arguments for the proponents of the open anterior repair is that it can be performed under local anesthesia [4]. Despite this, epidemiologic studies from Scotland, Sweden, and Denmark have shown that general anesthesia is the preferred method for hernia repair in 60–70% of cases, regional in 10–20% and local in about 10% [23]. Regional anesthesia is associated with an increased risk for urinary retention especially with the use of high-dose and long-acting agents.

Laparoscopic repair is usually performed under general anesthesia. There are some reports that show the possibility of performing a TEP repair under regional anesthesia [27, 41]. TAPP repair however is nearly impossible to perform under anything but general anesthesia because of the pneumoperitoneum. Patient comorbidities have a decisive influence on which technique should be used for a specific patient. If a patient is not fit enough for general anesthesia, an open Lichtenstein should be performed under local anesthetics, and a laparoscopic repair requiring general anesthesia should be discouraged.

Inspection of the Contralateral Side

Finding an occult inguinal hernia on the contralateral side is a common phenomenon. Some observational studies have found incidences of 11–51% [6, 7, 19, 25, 34, 38, 45]. Proponents of laparoscopic inguinal herniorrhaphy consider inspection of the contralateral side to be a distinct advantage because if a defect is found, an immediate repair can be undertaken. This is controversial however because by definition the contralateral side is asymptomatic; a repair opens the possibility of producing a postherniorrhaphy pain syndrome in this otherwise asymptomatic patient. The advantage of the laparoscopic approach for bilateral hernias is universally agreed upon by authorities as the contralateral hernia repair can be executed with same trocar positioning and no additional incisions are needed. On the other hand, the open technique requires identical symmetric incisions, essentially doubling the morbidity.

20.1.4 Clinical Practice

The most important consideration for choosing a particular procedure for a patient is surgeon experience [10, 12]. Assuming proper training, no differences have been observed in the intra- or postoperative complications following primary unilateral inguinal hernia repair in male patients between the laparoscopic and Lichtenstein open tension-free techniques. Advantages have been observed for the laparoscopic technique in terms of less early postoperative pain and analgesic consumption: earlier return to normal daily and work activities and less chronic pain. Moreover, due to earlier return to work, the cost for the society is lower. An additional benefit, although controversial as noted above, is that the contralateral side can be inspected, and the possibility of an immediate repair of an occult defect. These potential advantages must be interpreted in light of the disadvantages of a laparoscopic approach. These include some rare but serious complications related to laparoscopy such as bowel perforation or major vascular injury, potential adhesive complications at sites where the peritoneum has been breached, the need for a general anesthetic, the increased hospital cost when expensive materials are used (▶ Chap. 15), and a steep learning curve. On the other hand, the conventional operation can be performed under local anesthesia with minimal risk of intra-abdominal injury but is burdened with a higher frequency of wound complications. The result is that widespread adoption of laparoscopic inguinal herniorrhaphy in contrast to other minimally invasive operations has not been observed. The adoption rate varies dramatically from country to country. It is estimated that between 15% and 20% of inguinal hernias in the United States are repaired laparoscopically, but this number seems to be gradually increasing as newly trained surgeons enter the workforce. In Germany, more than 55% of inguinal hernias are repaired laparo-endoscopically. Recurrence after an anterior repair, bilateral hernias and instances when another laparoscopic procedure needs to be performed (e.g., a cholecystectomy) are the best indications for a laparoscopic herniorrhaphy. For the uncomplicated unilateral inguinal hernia, there is no universal agreement. Therefore, the most important recommendation is to perform the procedure most comfortable with. However, if the surgeon is competent and has the financial resources for both the open and the laparoscopic technique, and the patient is fit for general anesthesia, the laparoscopic technique is preferred by many for primary unilateral inguinal hernia especially in those young male patients who need to return to the workforce as soon as possible, are active in sports, or are anticipated to have a low pain threshold [1].

20.2 Part 2 Statements and Recommendations

Statements

Laparoscopic mesh repair of a primary unilateral inguinal hernia in a male patient shows significant advantages in terms of early postoperative pain and chronic pain compared with open Lichtenstein technique.

Level of evidence: high

Given that the operating surgeon is skilled in the laparoscopic mesh repair for a primary unilateral inguinal hernia, recurrence rates are equivalent after laparoscopic repair compared to open inguinal mesh repair.

Level of evidence: high

Given that the operating surgeon is skilled in the laparoscopic mesh repair for a primary unilateral inguinal hernia, operating time is equivalent for laparoscopic repair and open inguinal mesh repair.

Level of evidence: high

Postoperative complications are similar after open and laparoscopic mesh repair. Seromas are more frequently encountered after laparoscopic repair, while wound infections are more common after open repair.

Level of evidence: high

Postoperative time to return to work and time to regain normal activities is significantly shorter after laparoscopic mesh repair than open mesh repair.

Level of evidence: high

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Reduced Port in Laparoendoscopic Inguinal Hernia Repair

Davide Lomanto, Rajesh Khullar, Thomas Carus, and Sujith Wijerathne

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21.1 Principles and Concept

Endo-laparoscopic surgery has evolved over the past few decades proving the concept of "minimally invasive surgery" a reality in hernia repair and achieving comparable, if not superior, clinical outcomes compared to open surgery in bilateral and recurrent hernias. The transition of open to laparoscopic approach for inguinal hernia repair has taken a smooth and a steady journey despite early debates on recurrence and complication rates [1–3]. The evolution to further minimize the surgical trauma continued with an early introduction of needlescopic technique [4] and then with reduced port surgery and single-incision surgery. Both totally extraperitoneal (TEP) [5–7] and transabdominal pre-peritoneal (TAPP) [8, 9] approaches have been widely utilized using reduced port technique by maintaining simple principles and surgical techniques similar to their conventional procedures [10].

Several studies have shown comparable outcomes in both reduced port TAPP and TEP when compared to conventional technique [5–9] with no significant difference in the postoperative outcomes, recurrences, and pain between the two groups except a few studies showing a longer operative time.

The principle behind the concept of "reduced port surgery" (RPS) is to minimize the surgical trauma in patients undergoing surgery in an attempt to improve both intraoperative and postoperative outcomes without compromising safety. Over the past few years, this has been accomplished successfully in the field of laparoscopic inguinal hernia repair as evidenced by the numerous studies and their results mentioned earlier. Minimizing surgical trauma improves pain intraoperatively as well as postoperatively. It is well known that improving pain improves postoperative recovery. The other advantage of reduced port surgery compared to the traditional open surgery and conventional laparoscopic surgery is the obvious effect on cosmesis.

The technique gives rise to several challenges, mainly from the lack of triangulation with consequent conflict between telescope and instruments, increased cost and learning curve. Different ways to overcome these challenges have been reported and will be explained in detail in this chapter. Despite the challenges, the concept of RPS is becoming increasingly popular especially among patients concerned about cosmesis and pain regardless of the cost, if expertise is available.

21.2 Instrumentation and Devices

The main challenge in single-port surgery (SPS) or RPS is the lack of triangulation with consequent clashing between instruments and the telescope; instruments in RPS surgery should allow the operator to have similar degrees of freedom as in conventional multi-port surgery in order to complete a surgery safely and successfully. Over the years, many types of articulating instruments and devices have appeared in the operating theaters. The devices range from sophisticated ones that give access to more instruments inside a limited space to simple self-made devices that use conventional instruments.

The key influential factor when using any device or instrument is its safety in patients. The other factors are; simplicity of the device, user-friendliness, and cost. The cost depends on whether the instruments or the devices are reusable after sterilization, their reproducibility, and the number of competitive devices available in the market. At the initial stages of RPS, the cost of these minimally invasive devices was quite high owing to the fact that they are new and very few types are available, but later on with multiple devices appearing in the market, the price has become more affordable, and the quality of the devices and the user-friendliness have improved. In single-port surgery, we can classify the devices into access devices, telescope, and working instruments.

21.2.1 Access Devices

Various types of single-port devices are available in the current surgical practice. From a basic three to five ports attached to a glove (glove port) to the more sophisticated single-port devices can be utilized in RPS.

Tsai et al. [6] used a simple self-made single-port device during their study comparing single-port and multi-port inguinal hernia repair. The

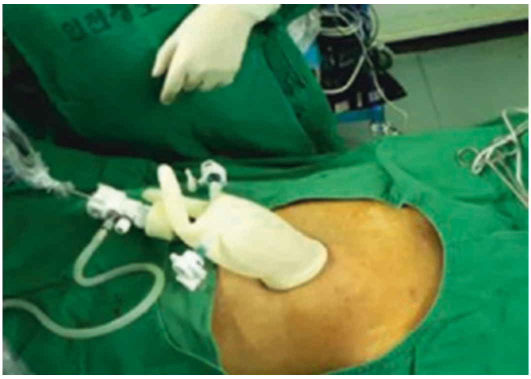

Fig. 21.1 Self-made "glove port"

device is similar to the commonly known "glove port" (Fig. 21.1), where a wound protector is used to retract the fascia and also as a base and a surgical glove is prepared by inserting two to four metal or plastic trocars as working ports and a 10–12 mm trocar used to insert the camera device. All ports are inserted through the fingers of the glove and tied around to make it airtight. Then the glove is carefully placed around the wound protector to prevent air leak. Gas insufflation is through the 10 mm trocar. This device can be made easily by commonly available trocars, and it is a good alternative to other commercially available devices.

The single-port device that Wakasugi et al. [11] used for their study on single-incision inguinal hernia repair (EZ Access; Hakko Co., Ltd., Nagano, Japan) had a 10 mm port which allowed a 10 mm flexible scope and two 5 mm working ports, and it was used to maintain the insufflation of the pre-peritoneal space after placing a base (Lap-Protector Mini; Hakko Co., Ltd.) in the incision. We used TriPort™ (Olympus, Japan, Germany) in our study where we compared single-port and conventional inguinal hernia repair [7], and it can be inserted through a 1.5 cm infraumbilical incision. TriPort+ (Olympus, Japan, Germany) (Fig. 21.2) is the currently available version of the device. Other commonly available devices for reduced port hernia repair include SILS™ (Covidien, USA) port (Fig. 21.3) and GelPort (Applied Medical, USA) (Fig. 21.4). The preference of the device would depend on the surgeon, cost of the device, availability, and patient's body habitus.

Fig. 21.2 TriPort+ (Olympus, USA)

Fig. 21.3 SILS™ port (Covidien, USA)

21.2.2 Telescope

It depends on surgeon's preference, which laparoscope is used, and through which access it is introduced. In general, a 5 mm or a 10 mm 30° laparoscope is utilized. In our experience and considering the high-definition quality image that a 5 mm telescope produce, it is preferable to choose it as it may improve the conflict between instruments by reducing the overall space taken inside an access device (15 mm versus 20 mm if a 10 mm telescope is used with two 5 mm trocars). The 5 mm will increase maneuverability and will reduce conflict between instruments [10]. The scope should be held in a different axis to the working ports (either on top or below), but the working instruments can be used on the same axis. To avoid conflict between the telescope and the instruments, there are few other options; one is the use of

Fig. 21.4 GelPort (Applied Medical, USA)

Fig. 21.5 EndoEYE (Olympus, Japan)

a 90 degree light cord adaptor to put the light cable in an angled position; the other is to utilize a long telescope similar to the ones utilized in bariatric surgery. Lastly the use of an in-line telescope, like EndoEYE (Olympus, Japan) (Fig. 21.5) in which the light cable is embedded in the camera cable, avoids the lateral conflict with the instruments.

21.2.3 Instruments

Instruments commonly used in laparoscopic TAPP inguinal hernia repair for dissection are

Fig. 21.6 Articulating instruments

Fig. 21.7 Pre-bent instruments

usually graspers, scissor, and hook with diathermy. In RPS, these instruments can be conventional (straight), articulating (Fig. 21.6), or pre-bent (Fig. 21.7), while the last two allows more freedom in a limited space. Due to the less triangulation and limited space in laparoscopic TEP repair, the use of articulating or pre-bent instruments are not very useful, while in TAPP with a wider space, they may be useful especially for the peritoneal flap retraction. A combination of both straight and pre-bent instruments can be helpful at different steps of the procedure in both simple and large hernia in which the sac manipulation may require more traction and space. Other items used such as premade loops and fixation devices are the same as in conventional technique. Devices like Endo Stitch (Covidien, USA) can be helpful for suturing when considering the challenges and difficulties during RPS. “Instruments and devices in reduced port inguinal hernia repair” is a constantly evolving topic with the addition of new devices as the technique continues to be utilized worldwide. Assessment of these devices and instruments for safety and feasibility will keep the clinician scientists busy for the years to come.

21.3 Indications and Setup

Similar to any surgical technique, the success of a procedure depends on the correct indication and operating room setting. This is even more important in RPS due to the intrinsic challenges of this novel surgical approach.

21.3.1 Indications

Primary uncomplicated hernia, female patients, and non-obese patients are probably the best candidates for RPS hernia repair. Surgeons experience in TEP and TAPP is another important factor. It is important for beginners to adhere to strict exclusion criteria until they become familiar with the technique and overcome the challenges of RPS. All patients with contraindications and relative contraindications to conventional endo-laparoscopic repair should also be avoided in RPS. With increasing expertise in the field, recurrent, reducible inguinoscrotal hernia and patients with increased risk for bleeding can be attempted considering pros and cons of the procedure.

21.3.2 Preoperative Preparation

It is imperative that the patient knows and understands the basic mechanism of herniation, exact disease process, and its treatment. The various available modalities of treatment with their potential benefits and risks need to be explained to the patient.

A proper consent for RPS TEP or TAPP should be taken. Surgeons should explain to the patient and relatives about their own experience on the technique and the possibility of conversion to conventional surgery if necessary for the interest of the patient's safety and well-being. A thorough history must be taken of the presenting illness and comorbid conditions. The surgeon should check with the patient about the usage of antiplatelets and anticoagulants especially in patients with hypertension and coronary artery disease.

For the remaining, the same principles of surgery for inguinal hernia repair should be taken into account.

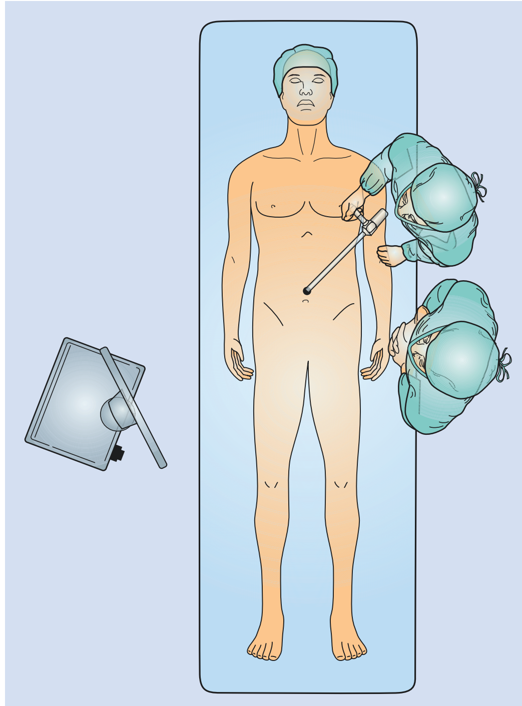

Fig. 21.8 Theater layout in unilateral (*right side*) hernia repair

21.4 Operation Theater Layout

The surgery is carried out under general anesthesia, and the patient is placed in a slight Trendelenburg position. Both the arms are tucked in at the sides. In unilateral hernia, the surgeon and the assistant stand on the opposite side of the hernia with the monitor placed on the same side of the hernia toward the foot end (Fig. 21.8). In bilateral hernia repair, the monitor is positioned at the foot end of the patient, and the surgeon stands on the side opposite the hernia with the first assistant (camera holder) on the same side as the hernia (Fig. 21.9). In the case of a bilateral repair, the surgeon and the camera assistant switch positions to repair the contralateral side.

21.5 Surgical Techniques

In the operation theater, the patient is placed at supine (Trendelenburg) position. The preoperative setup is the same for reduced port TEP and TAPP procedure including single dose of antibiotics, surgical disinfection, and sterile draping. A hernia

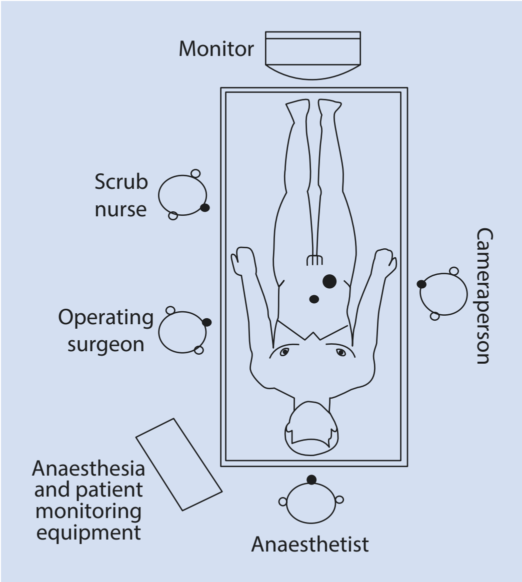

Fig. 21.9 Theater layout in bilateral hernia repair

side marking should be done preoperatively and should be checked by the surgeon in the operation theater.

Before making the first incision, a team time-out between surgeon, operation nurse, and anesthesiologist is mandatory to reassure patient's name, diagnosis, hernia side(s), and planned procedure.

21.5.1 Reduced Port TEP

A single 2.5 cm infraumbilical, transverse skin incision is used [12–14]. After dissection of the subcutaneous fat, the anterior fascial sheath of the rectus muscle is opened by a transverse incision of 3 cm length. To access the pre-peritoneal space, the surgeon can start with a digital dissection below the muscle, followed by using a gauze to widen the retro-muscular space and to allow an easy placement of the single-port device. Placement of two additional stitches on the anterior rectus sheath cut edges can be done to facilitate the introduction of the port.

After placing the single-port device, the CO_2 insufflation can be started with a maximum pressure of 12–15 mm Hg.

It depends on surgeon's preference, which laparoscope is used, and through which access it is introduced. In general, a 5 mm 30° laparoscope is preferred to increase maneuverability and reduce conflict with the instruments [10]. This should be used at the most distal access (up or down) to create a "V" shape between the laparoscope and two instruments (left and right). To avoid conflict between the telescope and the instruments, there are few options; one is the use of a 90 degree light cord adaptor to put the light cable in angled position; the other is to utilize a long telescope similarly to the ones utilized in bariatric surgery. Lastly the use of an in-line telescope like EndoEYE (Olympus, Japan) in which the light cable is embedded in the camera cable avoids the lateral conflict with the instruments. The telescope is then utilized for preparing the pre-peritoneal space by pushing toward the pubic arch. As in the standard TEP, a blunt dissection can be adequately done using a grasper or even a scissor; by steps, first is the pre-peritoneal space towards the pubis bone with the dissection of the Retzius space medially and then laterally to the lateral space of Bogros. The use of premade dissection balloon can be challenging, and difficulties may arise depending on the single-port device utilized.

The preparation of the hernia can be done with one instrument or with two instruments using blunt dissectors or scissors. Preparation using only one instrument will reduce the conflict between laparoscope and instruments, and it is quite easy in direct hernia. For indirect hernia, a second instrument should be used to give enough tension to the hernia sac during preparation. Pre-bent or articulated instruments can be helpful in selected cases or can be used in addition to a straight instrument to reduce conflict.

Further steps after the creation of the pre-peritoneal space are the isolation, separation, and reduction of the hernia sac from the spermatic cord. Once the myopectineal orifices are cleared, a standard 10 × 15 cm mesh is placed. Fixation can be done with absorbable tackers or glue, which depends on the surgeons' preference and the type of mesh used. After releasing of gas, the operation is completed by removing the single-port device and closing the fascia and skin incision.

21.5.2 Reduced Port TAPP

There is almost no difference between RPS TAPP and conventional TAPP except for the access and instrument placement. Some of the technical steps described in the TEP technique are similar in TAPP.

A single 1.5–2.5 cm infra- or transumbilical, transverse skin incision is used [8, 9]. The length of the incision depends on the single-port device utilized. After entering the abdominal cavity, the device is inserted. A 5 or 10 mm 30° laparoscope is inserted with two 5 mm instruments (usually grasper and hook or scissors) *(see TEP chapter)*. The same technique can be modified by using the two 5 mm trocars without the gas valve to reduce the conflict between the telescope and the instruments [14]. The next step after the creation of pneumoperitoneum is gaining access to the preperitoneal space which is done by incising the peritoneum above the hernia defect. Following the standard TAPP approach, dissection is carried out lateral to medial using straight, pre-bent, or articulated instruments according to the surgeons' preference. Similarly, the isolation, separation, and reduction of the hernia sac from the spermatic cord are performed. Once the myopectineal orifices are cleared, a standard 10 × 15 cm mesh is placed. Fixation can be done with either absorbable tackers, or glue, depending on the surgeons' preference and the type of mesh used. The closure of the peritoneal flap can be done by suturing or tacking. Suturing through a single-port device is much more difficult because of the poor triangulation. Absorbable tackers are recommended in view of the easy handling which can improve the operation time. The fascial incisions should be closed to prevent incisional hernias.

21.6 Evidence from Literature and Guidelines

There are few reports and randomized controlled studies [7, 15, 16] comparing RPS with conventional endo-laparoscopic inguinal hernia repair.

The reduced port technique aims to reduce morbidity and postoperative pain as well as improve aesthetic outcome. Up to now, there is limited data concerning the safety and efficacy of this technique. Worse triangulation and the reduced freedom of instrument movement make the single-port procedure more difficult compared with a conventional laparoscopic operation. Laparo-endoscopic single site (LESS) TEP surgery is known to be associated with lower procedural efficiency due to instrument clashing [17, 18]. Regarding postoperative advantages concerning pain, need for analgesia, hospital stay, and return to normal activity, published studies show controversial results. Araujo et al. [12] have described a longer operation time and a superior cosmetic result for unilateral and bilateral LESS TEP inguinal hernia repair, and no difference could be shown concerning postoperative parameters compared with the standard TEP technique, however LESS TEP is safe and effective with better cosmetic results. Cugura et al. [19] compared 25 LESS TEP hernia repairs with 29 standard TEP operations. All analyzed parameters were comparable, and one early recurrence (due to mesh displacement) was reported in the LESS TEP group during a median follow-up period of 11.5 ± 2.5 months. Tai et al. [17] reported 98 successfully completed LESS TEP hernia repairs in 54 patients and compared them with 152 standard TEP operations. The mean operative time was significantly longer in the LESS TEP group (70.9 ± 23.8 min. versus 61.8 ± 26.0 min, $p = 0.04$). All perioperative parameters (length of hospital stay, time until return to full activity, complication rate, pain score, cosmetic result) were comparable between the two groups and did not show any significant differences. They concluded that LESS TEP inguinal hernia repair is a safe procedure in experienced hands but not an effective surgical alternative to the standard TEP operation.

Siddiqui et al. [20] published a literature review and a meta-analysis of 13 studies with 325 patients comparing LESS TEP and standard TEP operation; they found no significant differences in hospital stay ($p > 0.99$), intraoperative complications ($p = 0.82$), or early recurrence rates ($p = 0.82$). The only advantage of LESS TEP hernia repair was a trend towards earlier return to activity ($p = 0.07$).

In keeping with all other authors, they concluded that further studies with clear definitions of outcome measures are necessary to strengthen the evidence.

As to be expected, studies about LESS TAPP showed results similar to LESS TEP. LESS TAPP is feasible and safe with no evidence for a higher early recurrence rates.

Over the last 7 years, several international guidelines for treatment of inguinal hernia have been published [21, 22], and LESS TAPP and LESS TEP procedures were not mentioned due to the lack of supporting evidence. In summary, there is no clear evidence for significant advantage of LESS TEP and LESS TAPP surgery. Two randomized controlled clinical trials showed the feasibility of this new technique and its safety with possible better cosmetic results and similar postoperative pain compared to the conventional technique. Similar to any novel surgical approach, the success of this new technique depends on further studies that will contribute more data to the outcome measures, longterm results, and patient satisfaction.

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Ventral and Incisional Hernias

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Anatomy of the Abdominal Wall: What Is Important for Laparoscopic Surgery?

Romed Hörmann, Helga Fritsch, and Karl A. LeBlanc

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22.1 The View of the Anatomist

Romed Hörmann and Helga Fritsch

22.1.1 Introduction

This chapter is meant to give an overview of the topographic regions of the abdominal wall, thus presenting an anatomic map for a laparoscopic expertise for the following chapters.

22.1.2 The Body Wall

The abdominal wall is an extremely dynamic construction and, concerning its dimension, subject to huge variations. The portion from the breast downward to the inguinal sulcus is called the abdominal wall; thus, the abdominal wall stretches from the elastically malleable area of the inferior thoracic aperture to the pubic symphysis, on both sides via the inguinal ligament to the anterior superior iliac spine and via the iliac crest to the spinous process of the fifth lumbar vertebra. So caudally we have a fixation to the stiff pelvic ring. In its middle parts the abdominal wall reaches the lumbar spine via the deep lamina of the thoracolumbar fascia. The term abdomen refers to the peritoneal cavity with its organs and the pre- and retroperitoneal area. The shape of the abdominal wall changes due to a person's age and gender, respectively. The varying increase in size of the pelvic-osseous structures and the descent of the ribs cause a change of the abdominal shape in the development from child to adult, and in men and women it differs widely due to the different dimensions of their ilia [1].

Resulting from the grid-like nature of its elements, the abdominal wall provides shelter and stability for the organs of the peritoneal cavity. With the help of their aponeurotic extensions, the lateral abdominal muscles form a muscle-tendon taping, which grows stronger in caudal direction. With its tone the frontal abdominal wall counteracts the pressure of the viscera [2]. Progressive corpulence and age result in a steady tone decrease of the abdominal muscles [3]. The mean intra-abdominal pressure in a recumbent position and with normal respiration amounts to 0.3 kPa (2.5 mmHg). From 0.6 kPa (5.0 mmHg) at forced breathing, the pressure may rise to 5.3–10.6 kPa (40 mmHg and 80 mmHg, respectively) [4].

The clinically relevant epidermis thickness of the abdominal wall in a newborn child amounts to 23 µm, in 11–15-year-old children, to 51 µm and eventually reaches a level of 34–47 µm in adults. The skin thickness shows gender-specific (in men it is about the factor 1.4 thicker than in women), body mass index, and ethnic dependencies [5–7].

22.1.3 Fasciae and Muscles

The adipose abdominal panniculus and the abdominal membranous stratum are usually summarized under the term subcutaneous tissue of the abdomen [8]. The abdominal membranous stratum is surgically important since between it and the abdominal fascia the larger subcutaneous vascular vessels are located (◘ Fig. 22.1a and 22.2a), and it extends laterally to the thigh, radiating into the fascia lata. Medially it is annexed to the genitals as fundiform ligament of either the penis or the clitoris. From the pectoral fascia, the superficial abdominal fascia, which in the area of the linea alba is strengthened with enclosed elastic fibers, continues to the suspensory ligament of the penis or the clitoris. In the areas of the linea alba and the inguinal sulcus, the superficial abdominal fascia is solidly linked with the aponeurosis of the external abdominal oblique muscle (◘ Fig. 22.1a). The fascia, which encloses the transverse abdominal muscle, is stronger on the side facing the peritoneum and is therefore called transversal fascia. The firm area around the navel is called umbilical fascia. From the arcuate line (or zone) downward, the dorsal lamina of the rectus sheath is missing, and the transversal fascia is in direct contact with the rectal abdominal muscle. Via a pre- and retro-peritoneal adipose tissue layer, respectively, the transversal fascia is loosely linked to the parietal peritoneum. The five peritoneal elevations lips – the median umbilical fold (obliterated urachus), the medial umbilical folds (chordae aa. umbilicales), and the lateral umbilical folds (inferior epigastric arteries and veins) – move in the direction of the navel. The plica umbilicalis lateralis or plica epigastrica, starting in the area of the interfoveolar ligament,

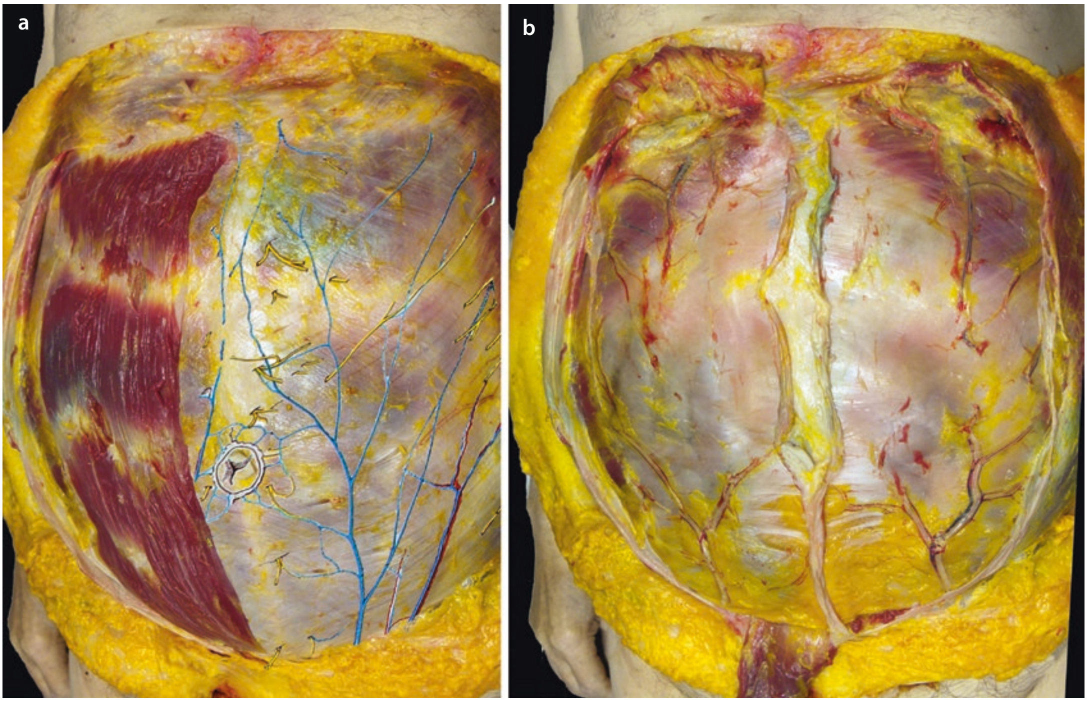

Fig. 22.1 Abdominal fresh (cadaver) dissection of the subcutaneous and retromuscular layers. **a** Rectus sheath with the linea alba. **b** Retromuscular situation with the inferior epigastric artery and vein

edges away in cranial direction, since in the arcuate zone its vascular content pierces the rear wall of the rectus sheath and then ascends inside the sheath behind the rectal abdominal muscle. The median umbilical fold starts at the bladder's apex, the medial one in the lesser pelvis at the offspring of the umbilical artery from the internal iliac artery.

22.1.4 Topographic Situation

Ventrally the abdominal wall is usually supplied by longitudinally running branches of the internal thoracic artery branching off from the subclavian artery, and the external iliac artery via the inferior epigastric artery. Moreover, smaller arteries like the thoracodorsal artery and the lateral thoracic artery branching off from the axillary artery and the superficial epigastric artery branching off from the femoral artery, running subfascially and epifascially, are also involved in supplying the abdominal wall.

Segmentally the abdominal wall is supplied by the posterior intercostal, the subcostal, and the lumbal arteries (Fig. 22.2a).

Below and behind, respectively, the rectal abdominal muscle run the inferior epigastric artery and vein which anastomose above the navel in various ways with the superior epigastric artery and vein branching off from the internal thoracic vessels [9, 10, 11]. These two vessels produce a profound longitudinal anastomosis between the subclavian and the external iliac vessels (Fig. 22.2b).

Below the inguinal ligament the superficial circumflex artery, which in 43% branches off from the femoral artery together with the superficial epigastric artery, moves subcutaneously in cranial direction, laterally of the inguinal ring releasing several branches into the skin. Before passing through the vascular lacuna, the external iliac artery releases the inferior epigastric and the profound circumflex artery in the direction of the internal surface of the abdominal wall. In most cases, both arteries originate at close quarters; a common origin, however, is rare. The profound circumflex artery runs directly below the peritoneum between the iliac and the transversal fascia, lateral of the inner inguinal ring and along the rear side of the inguinal ligament in the direction of the anterior superior iliac spine, in its course sending branches to the lateral abdominal

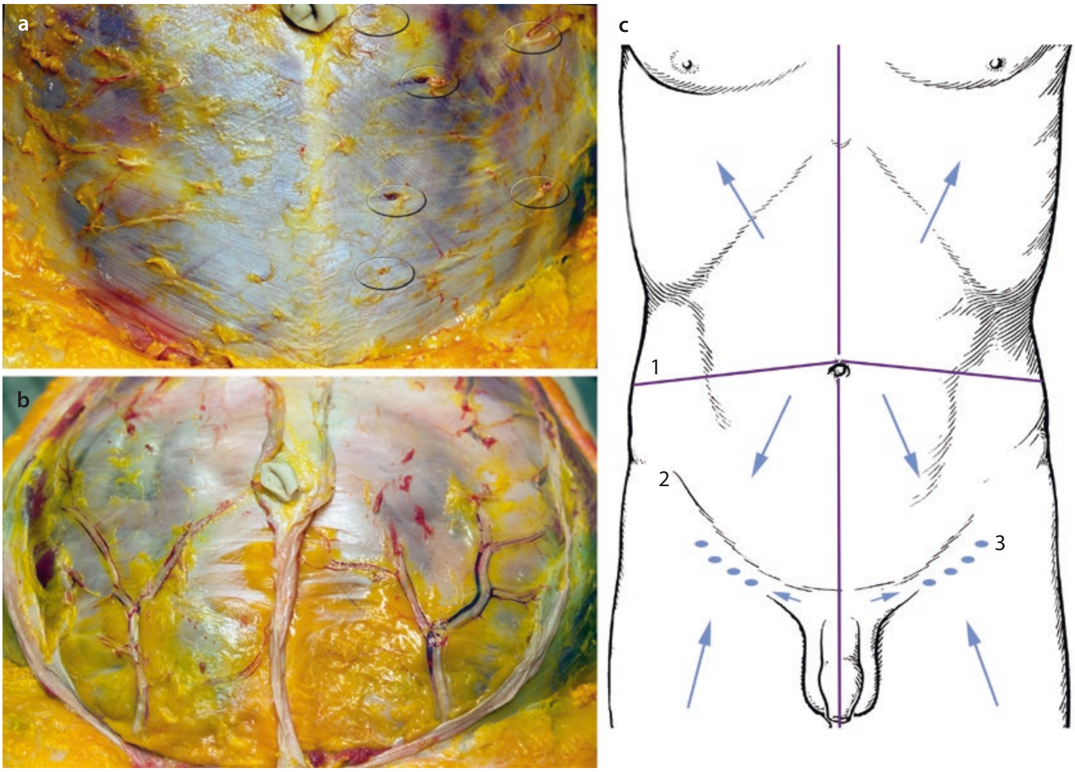

Fig. 22.2 **a** Opening of the rectus sheath on the right side, on the left side projection of the subcutaneous vessel and nerve exits (*circles*). **b** Dissection of the retromuscular area with a view to the inferior and superior epigastric artery and vein. **c** Drawing of the lymph drainage: *1*. Horizontal main "watershed", *2*. Inguinal ligament, *3*. Inguinal lymph nodes, *arrows*: direction of lymph drainage

muscles. On the level of the anterior superior iliac spine, the profound circumflex artery divides into an ascending abdominal branch, which supplies the lateral abdominal muscles, and an iliac branch, which follows the inner lip (labium internum) of the iliac crest. The thick artery ascending between the internal oblique and the transverse abdominal muscles is also called external epigastric artery [12].

Between the tela subcutanea and the tender abdominal fascia run the subcutaneous vessels and also the nerves. The subcutaneous paraumbilical veins that anastomose with the superficial epigastric and the thoraco-epigastric veins are clinically important (Fig. 22.2a). The epigastric vessels cross the inguinal ligament, while the superficial epigastric veins reach the femoral vein via the saphenous opening. All the veins of the abdominal wall with the exception of the paraumbilical veins accompany the matching arteries.

The anterior cutaneous branches of the intercostal nerves VIII–XII (usually running between the transverse abdominal and the internal oblique muscles) pass through the sheath of the rectus abdominis muscle and the abdominal fascia paramedianly from lateral and usually penetrate the rectus abdominis muscle (Fig. 22.2a). The skin area between the linea alba and the mamillary line is supplied by the anterior cutaneous branches of the respective segmental nerves. Laterally from the rectus sheath run the lateral cutaneous branches of the intercostal nerves IX–XII which supply the skin between the medioscapular line and the mamillary line (Fig. 22.2a). Often there are transversal anastomoses among the segmental nerves.

Originating from the segments Th 12 and L1, the iliohypogastric nerve in 34.2% [13] shares a common trunk with the ilioinguinal nerve. Moving ventrally the iliohypogastric nerve is situated medial to the anterior superior iliac spine between the transversal and the internal oblique muscles. Medially from the anterior superior iliac spine, the iliohypogastric nerve divides into lateral and anterior cutaneous branches.

The anterior cutaneous branch of the iliohypogastric nerve penetrates the fascia cranially of the superficial inguinal ring, while the lateral cutaneous branch in the lateral area of the anterior superior iliac spine [14, 15]. The iliohypogastric nerve has muscular branches to the lateral abdominal muscles, the caudal part of the rectus abdominis muscle, and the pyramidalis muscle.

The ilioinguinal nerve from the segment L1 usually penetrates the original aponeurosis of the transverse abdominal muscle at the transition of the middle to the anterior third of the iliac crest. Subsequently it clings to the structure of the inguinal canal on its surface and its outer side, which results in a long course below the aponeurosis of the external oblique muscle. In most cases its sensitive final branch reaches the subcutis in the medial area of the external inguinal ring.

22.1.5 Superficial Lymphatic Drainage

The superficial lymphatic drainage of the abdominal wall is arranged in four quadrants. The division of the draining areas takes place via the longitudinal middle line and transversally above the navel in a somehow convex line in cranial direction below the costal arch (◘ Fig. 22.2c). The lymph of the abdominal skin caudally of the principal horizontal "watershed" is conveyed more or less directly to the superficial inguinal lymph nodes [16]. Cranially of the principal "watershed," the lymph is mostly drained via the axillary lymph vessels. In the area of the costal arch, it is drained via the intercostal lymph nodes and paraumbilically on the surface via all four quadrants. The lymph of the deep paraumbilical layers flow via the lower epigastric to the deep lumbal and then to the accompanying iliac lymphatic vessels or via the falciform ligament (parallel to the contained round ligament of the liver) to the portal vein. Due to these different draining possibilities, circular incisions above or below the principal "watershed" result very rarely in lymphedema of the trunk.

22.2 The Surgical View

Karl A. LeBlanc

22.2.1 Introduction

The anatomy of the abdominal wall is important for all repairs of incisional and ventral hernias. There are several critical factors regarding entry into the abdominal cavity, dissection, measurement of the defect(s) and fixation, etc. that are covered in other sections of this book. This portion will simply outline general areas of importance. There is little evidence published on the various aspects on this subject. This chapter will focus on technique and its relation to anatomy.

The one specific hernia that is affected significantly by anatomy is the Spigelian hernia. This entity can be especially difficult to diagnose because, in many cases, the herniation occurs in the interstitial plane between the transversus abdominis and internal oblique muscles. It should not be forgotten that this fascial defect could occur at any location along the semilunar line of the abdominal wall. The laparoscopic approach is particularly helpful for diagnosis and treatment of this uncommon hernia.

22.2.2 Abdominal Entry

All laparoscopic surgical procedures require penetration of the muscles of the abdominal wall. Generally speaking, for incisional and ventral hernias, the trocars will be placed laterally as 90% of these are midline hernias. Care must be taken when piercing through these structures because injury to the epigastric vessels occurs. Lateral placement for midline hernias makes this a very low risk, but for other hernias, such as lumbar hernias, these vessels could be at higher risk.

During entry of the trocars, the surgeon should avoid dissection of the flat muscles of the wall so that dissection between the layers will not occur by the insufflation of the carbon dioxide. Excessive manipulation of these trocars could also result in this phenomenon as well. Likewise, avoidance of stripping the peritoneum from the transversus abdominis fascia will prevent such an occurrence with that structure.

22.2.3 Hernia Location

There are certain areas of the abdominal wall that represent specific challenges that must be addressed to accomplish as sound and enduring repair. These hernias are very likely to recur if adherence of certain principles is ignored. The two most common locations are in the upper (subxiphoid) and lower abdomen (suprapubic). In both of these locations, a wider dissection of the tissues will be required. As discussed in a later chapter, the adipose deposits must be dissected free from the anterior abdominal wall. Specifically, the falciform ligament and the extraperitoneal space above the bladder must be released. In only this manner will the mesh used be presented with the most surface area of the abdominal wall to allow for the most rapid ingrowth of collagen.

Due to the fact that the diaphragm and pericardium lie just above the xiphoid, care must be taken to avoid placement of any fixation device or suture into or through these structures. It is preferred to use an extended amount (8 cm) of fascial overlap of the mesh to minimize the risk of recurrence. Additionally, I prefer to suture the cephalad portion of the mesh to the diaphragm. The suprapubic hernias require the same consideration of larger mesh overlap. In this location, this means that the prosthetic should be large enough to extend over to Cooper's ligament bilaterally. Fixation to this periosteum is required as well. These points are critically important.

Hernias in the lumbar regions are similar in the sense that larger mesh overlap is required, and careful suture fixation to either the diaphragm, psoas, or iliacus muscle may be necessary. Some surgeons have advocated the use of bone anchors to the iliac bone for the inferior lumbar hernias.

It is known that as many as 25% of patients will have a hernia that has more than one defect. Usually these are close together and may be repaired as a single hernia repair. On occasion, however, there will be two or more fascial defects that are so separated that more than one mesh will be necessary to repair them. In these cases, if it is not feasible to approach them from the same trocars, additional trocars should be place appropriately. Sometimes, this requires penetration through the initial prosthetic. If this occurs, it is important to close this violation of the mesh unless the trocar used is small. However, to my knowledge, herniation through such a mesh defect has not been reported.

22.2.4 Fixation

Currently, nearly all forms of prosthetic materials are used to repair incisional and ventral hernias. In all cases, this requires penetration into at least one layer of the abdominal wall musculature. When the selection of these devices is made, the surgeon should be familiar with the depth of penetration of the fastener itself. The thickness of the mesh must be taken into account to know the amount of the transversus fascia and muscle that is grasped. There is a possibility that they could penetrate deeper in thinner patients.

Many surgeons continue to use transfascial sutures. These, of course, will penetrate through all layers of the abdominal wall (transversus abdominis, internal oblique, and external oblique). Because of this, there is a risk of trapping a subcutaneous nerve when the knot is tied. This is unavoidable and can be the source of pain. More commonly, however, is the fact that the suture will cut through the layers of the fascia and muscle. This will most commonly result in chronic pain. This is best avoided by making the knot snug, but not strangulating to the tissues.

22.3 Conclusion

It is important to understand the anatomy of the abdominal wall to effectively repair the abnormalities that result in the development of herniation. There are some special considerations related to the laparoscopic approach. This review of the important points should lead the reader to the investigation of the entire contents of this textbook to ensure a proper repair.

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Ventral and Incisional Hernias: Differences and Indications for Laparoscopic Surgery

Ferdinand Köckerling and Anil Sharma

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23.1 Different Diseases?

Ferdinand Köckerling

In a consensus meeting of the European Hernia Society (EHS), a consensus was reached on the decision to separate primary ventral hernias (PVH) and incisional hernias (IH) into two entities, since in the participants' opinion primary ventral hernias have a different etiopathology compared with incisional abdominal wall hernias resulting from failure of a previous incision [1]. A classification for primary abdominal wall hernias and a division into subgroups for incisional abdominal wall hernias, concerning the localization of the hernia, were formulated [1]. Interestingly the outcome and results of laparoscopic repair of PVH and IH have consistently been pooled together in case series and randomized clinical trials [2–10]. Even recent systematic reviews and meta-analysis comparing laparoscopic and open hernia repair have included RCTs that analyzed a mix of PVH and IH in the laparoscopic repair group [2, 11–16]. This meant that when analyzing the results, no distinction was made between primary ventral hernias and incisional hernias nor was any information given on the proportion of umbilical hernias, epigastric hernias, and incisional hernias identified in the entire patient group analyzed [17]. It was only at the beginning of 2015 that Awaiz et al. [17] and Al Chalabi et al. [18] published the first meta-analyses and systematic reviews on laparoscopic vs open incisional hernia repair [19].

Kurian et al. [20], Subramanian et al. [21], Stirler et al. [2], Lambrecht et al. [22], and Köckerling et al. [19] showed significant differences in the results obtained for primary ventral hernias compared with incisional hernias.

Subramanian et al. [21] reported that laparoscopic repair of IH is associated with increased recurrence, greater postoperative pain scores, chronic pain issues, and lower patient satisfaction scores.

Stirler et al. [2] found for the laparoscopic repair of IH in comparison to PVH more requirements for adhesiolysis, a longer procedure time, a longer hospital stay, a higher recurrence rate, and a higher complication rate.

Köckerling et al. [19] analyzed the Herniamed Registry showing the use of laparoscopic IPOM significantly more often for incisional hernias than for epigastric and umbilical hernias. Likewise, the open technique with suturing of defect was significantly more often for umbilical hernias than for epigastric and incisional hernias. The postoperative complication rates for umbilical and epigastric hernias were significantly lower than for incisional hernias. That was also true for the reoperation rates due to postoperative complications. The 1-year follow-up revealed significantly higher recurrence rates as well as rates of chronic pain needing treatment for incisional hernias, compared with epigastric and umbilical hernias [19].

Subramanian et al. (2013) concluded that PVH and IH are different. Future studies should evaluate laparoscopic repair for PVH separate from those for IH.

Stirler et al. [2] pointed out that his study showed significant differences in baseline characteristics and operative findings between patients undergoing PVH repair and those undergoing IH repair. Continued pooling of data on laparoscopic repair of PVH and IH combined, commonly found in the current literature, seems incorrect.

Köckerling et al. [19] concluded that significant differences were identified in the therapy and results between umbilical hernia, epigastric hernia, and incisional hernia, and therefore scientific studies should be conducted comparing the various surgical techniques only for a single hernia type (Fig. 23.1).

23.2 Indications for Laparoscopic Surgery: Limitations

Anil Sharma

23.2.1 How Do I Do It?

Laparoscopic repair of incisional and ventral abdominal wall hernia is required in patients with pain, discomfort, and disfigurement from the hernia. It is also indicated to prevent complications like incarceration, bowel obstruction, and strangulation. A laparoscopic approach may be considered in all patients for repair of incisional and ventral abdominal wall hernias unless it is contraindicated.

In our clinical practice, we adhere to the following rules.

Absolute Contraindications

- Medically unfit for GA
- Uncontrollable coagulopathy
- Giant hernia with major loss of abdominal domain
- Acute abdomen with abdominal distension and gross bowel dilatation
- Major abdominal sepsis
- Strangulated bowel within the hernia sack
- Abdominal wall hernia in children (<12 years)

Relative Contraindications

- Excessive redundant abdominal wall and tissue. Such a patient would need abdominoplasty to excise redundant abdominal wall skin folds and provide optimal contouring of the abdominal wall.
- Wide divarication of rectus abdominis muscles from the xiphisternum to the pubis. A large intraperitoneal sublay mesh repair with or without approximation of recti muscles may not be the optimal treatment.
- Multiple previous abdominal surgery (with or without previous mesh repairs) may preclude safe intraperitoneal access. Such a patient may present widespread, severe intraperitoneal bowel and omental adhesions. The incidence of inadvertent bowel injury during adhesiolysis is high in these circumstances. Such patients are best treated by experienced surgeons at hernia centers of expertise.
- A large abdominal wall hernial defect. No unanimity exists to define the size of a "large hernia." A large hernial defect may be unsuitable for laparoscopic repair. A large hernia may be practically defined as a hernia of such large size that precludes the safe performance of peritoneal access, reduction of hernial sac contents, and deployment of a large mesh with at least 7–8cm of mesh cover on all sides of the hernia defect.

Indications for Hybrid/Combined Laparoscopic and Open Approach

A combined laparoscopic and open approach for incisional and ventral abdominal wall hernias is sometimes required to facilitate completion of the surgical procedure and achieve optimal outcomes. The combined approach involves a limited targeted skin incision at the site of hernia and adjacent abdominal wall along with laparoscopic adhesiolysis and laparoscopic intraperitoneal mesh placement. The open approach may be performed for safe reduction of incarcerated bowel, safe adhesiolysis, bowel inspection ± resection, primary closure of hernial defect, or excision of redundant abdominal skin and tissue.

23.2.2 What Is Evidence Based in Clinical Practice?

According to Simon [23] no precise data on the incidence and prevalence of ventral and incisional hernias are available. An epidemiologic study showed an increasing proportion of midline abdominal wall hernias, with a relative frequency of 19% for umbilical/par umbilical hernias, 8.6% for epigastric hernias, and 4.8% for incisional hernias. The incidence for incisional hernia is 10–20%, making it one of the most common surgical complications after laparotomy. Ventral and incisional hernias are treated with surgery to relieve symptoms (pain and discomfort), to prevent complications (strangulation, respiratory dysfunction, or skin problems), or to resolve acute complications (incarceration and strangulation). When developing the IEHS guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias [23] regarding indication and limitations for laparoscopic surgery, Simon summarized and analyzed the literature in accordance to the Oxford Classification of evidence and came to the following "statements" and "recommendations"; however, due to the minor quality of most of the studies, the level of evidence is rather low:

Statements

- **Level 4**: Symptoms develop for 33–78% of patients with a ventral or incisional hernia.
- **Level 4**: Surgery is performed for 5–15% of patients with a ventral or incisional hernia because of an acute complication (obstruction/strangulation).
  - Emergency repairs are associated with high morbidity.
  - Umbilical hernias obstruct five times more often than other ventral and incisional hernias.

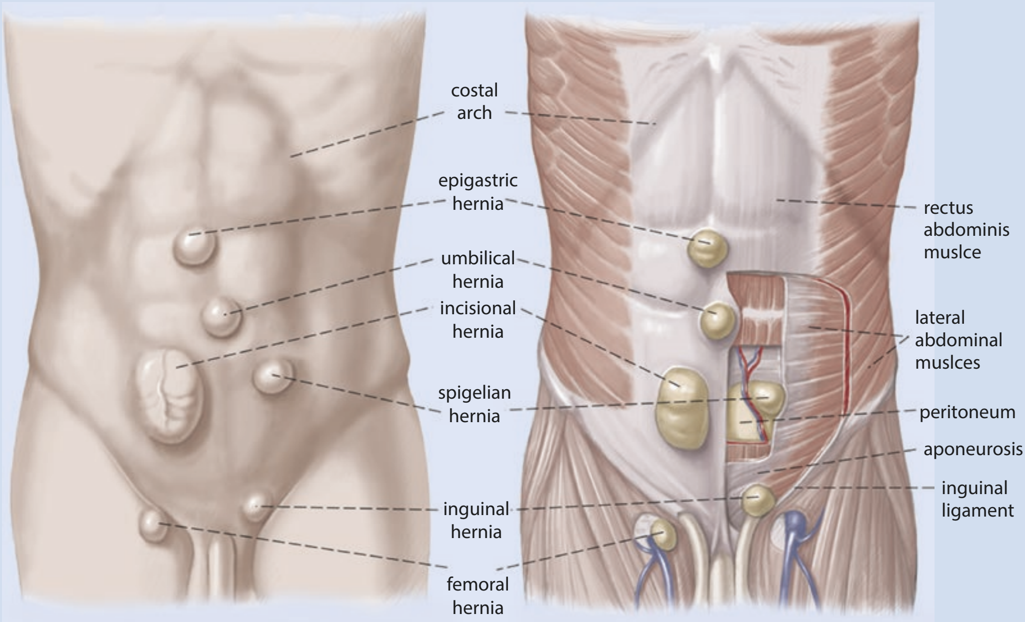

Fig. 23.1 Different hernia entities

- **Level 4**: The defect size of incisional hernias predicts recurrence rates.
- **Level 4**: Findings seem to indicate no difference in terms of morbidity or mortality regarding laparoscopic surgery for ventral hernias in advanced age.
  - The reduced risk of SSI in laparoscopic techniques has an impact especially for elderly patient.

The statements demonstrate a very low level of evidence; therefore, no clear recommendations (Grade D) for treatment can be given:

Recommendations

- **Grade D**: Symptomatic ventral and incisional hernias should be treated surgically.
- **Grade D**: The laparoscopic technique for ventral and incisional hernias should preferably be reserved for defect sizes smaller than 10 cm in diameter.
- **Grade D**: The laparoscopic technique for ventral and incisional hernia repair can be used even for patients advanced in age.

Regarding the size of the defect, some studies show that laparoscopic surgery is possible in hernias presenting with a defect size of larger than 15 cm, but studies with a reasonable level of evidence (2B) show that the rate of recurrence will increase in patients with a defect size of more than 10 cm (Bingener/Rohr in [23]). Furthermore the operating time in patients presenting with a large defect is significantly longer which indicates that the operative performance is more difficult. In conclusion patients with a hernia defect of more than 10 cm are better be operated by an open technique:

Statements

- **Level 3**: Laparoscopic IPOM is feasible for defects larger than 15 cm.
- **Level 2B**: Hernia recurrence is more likely with defects wider than 10 cm.
- **Level 3**: The operating time is longer with defects larger than 15 cm.
- **Level 4**: LVHR is feasible for defects of up to 880 cm^2.

Literature shows that laparoscopic hernia repair is feasible even in morbid obese patients (Bingener/Rohr and Koeckerling in (23)); however, the complication and recurrence rates are higher:

Statements regarding feasibility in obese patients:

- **Level 3**: Laparoscopic IPOM is feasible for obese patients (BMI > 30 kg/m^2).
- **Level 3**: Laparoscopic IPOM is feasible for morbidly obese patients (BMI > 40 kg/m^2).
- **Level 3**: Laparoscopic IPOM is feasible for super morbidly obese patients (BMI > 50 kg/m^2).
- **Level 4**: Laparoscopic IPOM is feasible for patients with a BMI up to 82 kg/m^2.

Statements regarding safety and recurrence in obese patients:

- **Level 3**: Complication rates in patients with a BMI ≥ 40 kg/m^2 undergoing LVHR are higher than for patients with a BMI < 40 kg/m^2.
- **Level 2B**: The recurrence rate is increased with BMI > 30 kg/m^2.

From these statements the following recommendations may be drawn:

- **Grade B**: Obese patients should be informed that LVHR is feasible.
- **Grade B**: Patients should be informed that the risk of complications and hernia recurrence increases with BMI.
- **Grade B**: Patients should be informed that complications and wound infections are less likely with LVHR for obese patients than with the open approach.

In summary, laparoscopic repair techniques for ventral and incisional abdominal wall hernias are feasible in aged patients, in patients with a large hernia defect, and in obese patients. The main advantage in comparison to open surgery is that after laparoscopic repair a lower frequency of complications and wound infections may be observed. However, it should be kept in mind that with an increasing defect size or body weight, both the complication and recurrence rates will increase as well. Informed consent of the patients is necessary.

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Pathophysiology and Diagnostics of Ventral and Incisional Hernias

Rudolf Schrittwieser

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24.1 Part I

24.1.1 How I Do It

There is very little literature concerning the pathophysiology of ventral hernias. We must differentiate primary ventral hernias (umbilical hernias, epigastric hernias, lumbar hernia, spigelian hernias, and other rare primary hernias) as well as incisional hernias and relapses following the treatment of ventral hernias. Some authors report genetic predispositions being a risk factor for the occurrence of incisional hernias. This is explained by a change in the type I collagen to type III collagen ratio. Nicotine abuse is a significant risk factor for the formation of incisional hernias. This is explained to patients in the course of laparotomy procedures. Patients are recommended to urgently quit smoking. In cases where a postoperative wound healing disorder is discovered, there is a greater chance of an incisional hernia occurring. Likewise there is an increased likelihood of incisional hernias occurring following relaparotomies.

The first diagnostic step comprises of a thorough anamnesis. In addition to inquiring about the patient's medical history, risk factors are taken into account, and furthermore they are asked about existing complaints, restrictions in daily life, and, in the case of working-age patients, their ability to work. With incisional hernias we look at the reports from previous operations, as far as they are available, and carry out a review. In cases of relapses, comprehensive information about the techniques used in previous operations is important when making decisions about the type of surgical procedure to implement. In particular, the use of meshes in previous operations is critical in influencing the choice of surgical procedure. In the case of an intraperitoneal mesh, adhesions are likely to be required; therefore, particular caution is necessary when proceeding with adhesiolysis. Should a mesh be inserted using the sublay technique, then we opt, where possible, for a laparoscopic approach.

The clinical investigation encompasses the precise palpation of the abdomen and a rough investigation of the abdominal wall function. Preoperative photographic documentation can be helpful.

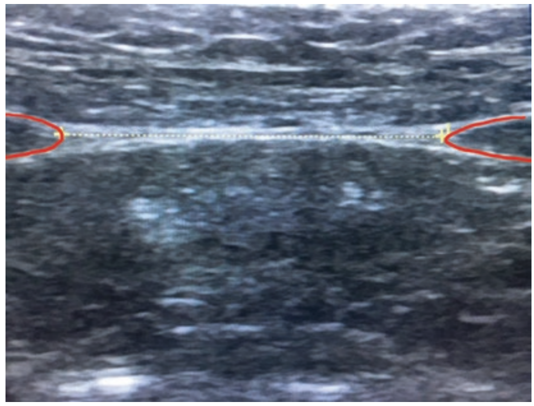

Fig. 24.1 Ultrasound of rectus diastasis

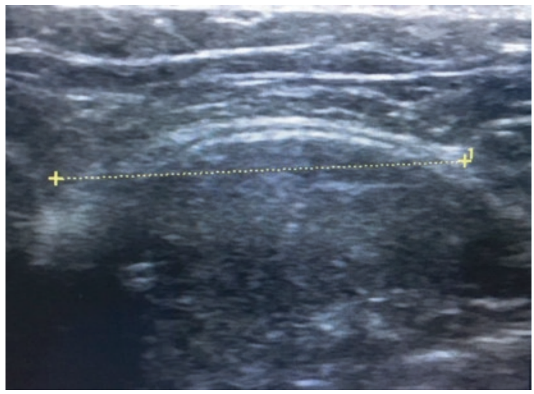

Fig. 24.2 Ultrasound of rectus diastasis (Valsalva maneuver)

With a sonographic examination, the hernia contents are presented as well as a measurement of the hernia gap size and the number of defects. A possible additional rectus diastasis can be detected (Figs. 24.1 and 24.2). A differentiation between the intestine and the greater omentum is possible in most cases. Particularly with relapses following laparoscopic repair, sonographic examination can eliminate a pseudo relapse in many cases. Usually an isolated seroma formation or the remains of an incarcerated greater omentum can be identified as the cause of a relapse interpreted swelling. By means of sonographic examination, remaining clinically undiscovered hernias can also be identified. Sonographic examination can be difficult with obesity. Therefore, for very obese patients, and also in cases of large ventral hernias, we undertake a CT examination of the abdomen and the pelvis. The size of the hernia gap can be

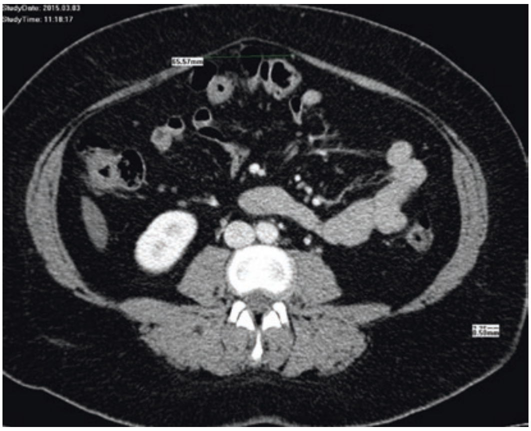

Fig. 24.3 CT scan shows rectus diastasis

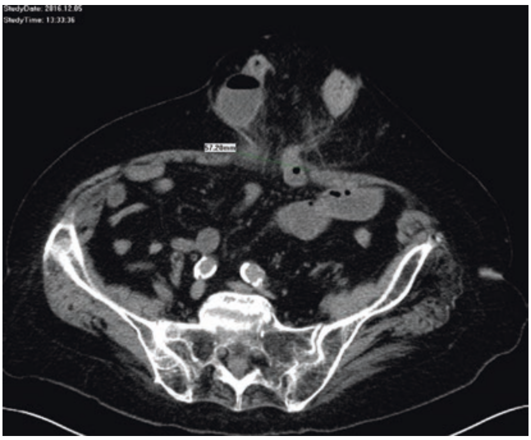

Fig. 24.4 CT scan shows incarcerated large umbilical hernia

measured easily (Figs. 24.3, 24.4, and 24.5). By using computed tomography, clinically and sonographically undiscovered hernias can be diagnosed. Likewise possible further pathological findings can be eliminated. In most cases, pseudo-relapses can be detected by means of CT investigation. With large hernias, an approximate measurement of the ratio between the volume of the hernia's contents and the abdominal cavity is possible (Fig. 24.6). This is particularly indispensable in terms of hernias with loss of domain, in order to make a decision about the necessary preoperative preparation of the patient. Also with traumatic hernias, we undertake a CT investigation so that accompanying injuries can be excluded.

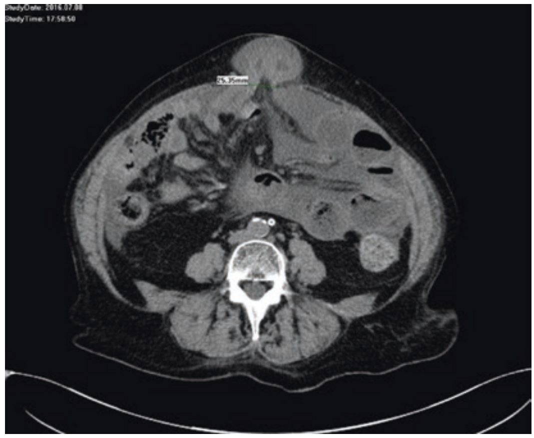

Fig. 24.5 CT scan shows incarcerated small umbilical hernia

Fig. 24.6 Incarcerated incisional hernia with large defect and big hernia content

MRI scans are performed very rarely in connection with ventral hernia.

24.2 Part II

24.2.1 Scientific Evidence

Preoperative diagnostics are essential to decide for which technique of hernia repair to opt. We must know as exact as possible how big the defect is, how many defects there are, how big the hernia sac is, and what are the hernia sac contents.

Dynamic abdominal sonography is a useful tool for the accurate characterization of incisional hernia. Especially for obese patients and

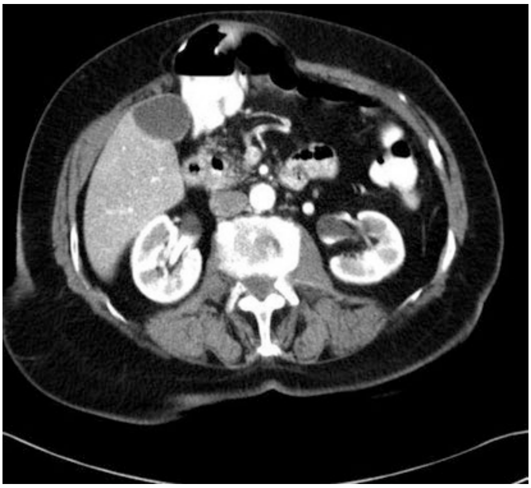

Fig. 24.7 Incisional hernia: CT shows precisely the thickness of the abdominal wall and the size of the defect and gives information about the hernia content

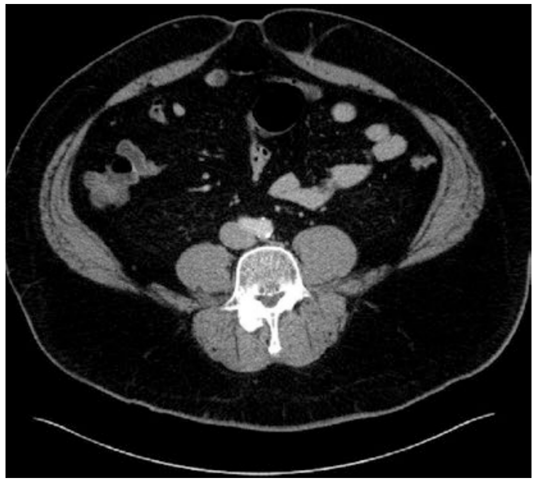

Fig. 24.8 CT shows a hernia umbilicalis with a concomitant rectus diastasis

in patients with large hernias, it demonstrated its accuracy [1]. It offers the advantages of real-time imaging and no ionizing radiation.

With regard to preoperative CT investigation, there are isolated studies, which in some cases provide important additional new information. Killeen et al. [2] carried out CT examinations of patients with blunt abdominal trauma and traumatic hernias. 9 of the 14 patients were found to have accompanying injuries, although only 1 patient displayed clinical indications of a hernia. Computed tomography can therefore supply valuable information about accompanying injuries, about potential hematomas, and also about the general condition of the hernia. But CT scans also provide important information about the clinically relevant parameters of the hernia (Figs. 24.6, 24.7, 24.8, and 24.9). Protocols were developed to predict the need for a bridging mesh or if fascial closure can be reached [3].

Likewise a CT investigation can be helpful with rare hernias. Skrekas et al. [4] reported the case of a patient with swelling in the left lumbar region, which computed tomography showed as being a Grynfeltt hernia. Gough et al. [5] described an incarcerated spigelian hernia as the cause of abdominal pain.

In connection with obese patients, there are references in literature indicating that new information can be obtained through computed tomography. Thus, Rose et al. [6] reported that with three patients it was not possible to clinically diagnose a ventral hernia. However, by undertaking CT investigations, ventral hernias were discovered to be the cause of the complaint.

Fig. 24.9 Trocar hernia: CT shows severe small bowel ileus because of a strangulated hernia

In relation to undertaking an MRI investigation within the context of preoperative diagnosis, there is at present insufficient data in order to be able to give any recommendations, although there is literature that indicates that a cine MRI can be helpful to detect intraperitoneal adhesions [7].

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Classification of Ventral and Incisional Hernias

Ulrich A. Dietz and Juliane Bingener-Casey

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25

25.1 Introduction

Classifications are an expression of the need for structure and organization within complex realities. The manner in which complex phenomena are classified is fundamental to how they are understood and dealt with [1]. It is therefore necessary that classification systems are subjected to validation. The first step in this process can be the retrospective evaluation of the data that were collected and the second step prospective confirmation of the validation. A classification system is accepted as useful if it can generate verifiable hypotheses. In the validation process, a classification is tested for its utility in answering specific questions, a test that can have one of three results: the system is verified (its methodology confirmed), it is falsified (its methodology refuted), or the test is inconclusive (neither confirmed nor refuted). Validation of a classification confirms that it has met the requirements for its intended use. Any classification, however, is valid only so long as it can withstand or adapt to continued critical testing based on continuous refinement of the knowledge on which it is based. Unlike truth, provisional validation is based on a large body of basic data [2]. Every type of classification thus relies on empirical validation. The goal is to create an evidentiary foundation upon which to build as knowledge increases [3].

Surgical data sets can be very heterogeneous: values, entities, terminologies, conventions, ontologies, and algorithms are only a few of the facets. Such data sets can only be organized by taking into account factors that extend far beyond the field of surgery. Philosophy contributes in providing epistemological methodologies and the consequences arising from them. Computer science and statistics facilitate the systematic collection and evaluation of information – especially large bodies of data. But what instruments are available for validating systems of classification? The following discussion of the methodology of validation of incisional hernia classifications will explore the significance of taxonomy and the choice of validation criteria.

Classification of any entity requires from the outset general acceptance and clarity regarding the terms applied. A nomenclature attempts to anchor the meaning of words within a system and incorporates for this purpose in terms of natural language in an analyzable data set [1]. This requires an unambiguous and unique taxonomy of both terms and abbreviations. In the context of international communications, in particular, the use of natural language is of vital importance; at the start a widely recognized language and/or nomenclature must be worked out [1]. In medicine this consists in large part of Latin roots and the English language (Anglicization of communication). It is precisely in the English-speaking world that the use of natural language is widespread in surgery. A precise, simple, practical, everyday relevant terminology is essential. Confusion and misunderstanding are especially likely in the use of eponyms and abbreviations. It can be assumed that in international publications, definitions and terminologies will be used fortuitously, imprecisely, and injudiciously; this should be prevented by all means.

In order to avoid sources of error in classifications, the terminology must ensure the most objective possible statements regarding the entities they are classifying. Terminology must always remain distinct from concepts because concepts change over time with the natural increase in knowledge. Terminologies and definitions must be comprised of recognized terms free of bias. Terminology can be defined as follows: "Standardized terms and their synonyms which record patient findings, circumstances, events, and interventions with sufficient details to support clinical care, decision support, outcomes research, and quality improvement; and can be efficiently mapped to broader classifications for administrative, regulatory, oversight, and fiscal requirements" [4]. A clear terminology makes the comparison of data from multiple patients possible, a key to improving patient care [4]. Consider the virtual scenario: data from a patient is entered into a data bank, and a request is made to see whether the system already contains data from a similar case. If a similar case is found, information of the prior patient's outcome should be made available and what can be predicted regarding the present patient based on this "model patient" [1, 4, 5]. The significance of unambiguous terminologies for the sharing of medical knowledge finds its strongest expression in the Unified Medical Language System (UMLS).

How complex can a data set be and still be of use in clinical routine? The complexity of medical knowledge is best conveyed by breaking it down into smaller units. How this can be done is explained in the theory of granular partitions [6]. Granularity is the way in which something can be fitted into a larger context and determines the perspective from which knowledge or data are viewed. The higher the level of granularity (as in an organigram), the more general is its subject matter (simpler, more intelligible, more superficial); the lower the granulation level, the finer are its details distinguished from entities at an immediately higher level (clearer, more focused, finer grained). Thus, different granulation levels are created. The findings on patients with, e.g., incisional hernias are apportioned to different levels of granulation, which allows the data to be viewed and used from different perspectives. A classification of incisional hernias must therefore apply terminologically unambiguous criteria and a level of granulation that balances a minimum of information (for meaningful clinical utility) and a maximum of predictive value.

Four classifications described in the literature attempt to summarize these essential points [7–10].

25.2 Chevrel and Rath (2000)

The 2000 classification of Chevrel and Rath represents the first attempt to classify incisional hernias [7]. It applies three criteria: the site of the incisional hernia, its width, and the type of occurrence (◘ Fig. 25.1). The site of the hernia is divided into two groups: medial ("M") and lateral ("L"); each group is further divided into subgroups. Because the authors chose the site of the hernia in relation to the midline rather than morphology, clinically relevant aspects are disregarded. Medial hernias are classified in their relation to the umbilicus, which is not always of clinical relevance. Supraumbilical hernias (M1), for example, can vary greatly depending on the nature of the sternocostal angle, whereas subumbilical hernias (M4) are of particular concern if they are suprapubic (lack of posterior rectus sheath). Chevrel and Rath define the size of the hernial opening by width ("W") subdivided in 5 cm increments (W1 to W4), thus registering but a single aspect of the size and rendering impossible by this subgrouping subsequent defragmentation of the data. Because morphology and width are coded applying an arbitrary principle, the data set reflects an interpretive bias. In their original paper, the authors offer a validation, but they limit it to a definition of the patient population without epidemiological or prognostic relevance [7].

Chevral and Rath (2000)

Site:

Medial incisional hernias are coded as M, with 4 subgroups:
M1 - supraumbilical incisional hernias
M2 - juxtaumbilical incisional hernias
M3 - subumbilical incisional hernias
M4 - xipho-public incisional hernias
Lateral incisional hernias are coded as L, with 4 subgroups:
L1 - subcostal incisional hernias
L2 - transverse incisional hernias
L3 - iliac incisional hernias
L4 - lumber incisional hernias.

Width (preoperative measurement) is classified by 5 cm increments:
W1 - < 5cm
W2 - 5 to 10 cm
W3 - 10 to 15 cm
W4 - > 15 cm

Recurrence is defined by its number:

No recurrence:	Rfirst
First recurrence:	R1
Second recurrence:	R2, etc.

◘ **Fig. 25.1** Chevrel and Rath (2000) classification [of incisional hernias]. The morphology (site) is divided into medial and lateral and the hernial opening measured only as width. This sets limiting values for future subgroup analyses with a variance of 5 cm. Already in 2000, Chevrel and Rath pointed out the importance of recurrence status

25.3 Consensus Classification of Korenkov et al. (2001)

A second incisional hernia classification system is that of Korenkov et al., whose criteria were worked out by an international panel of experts [8]. As with Chevrel and Rath, the recommended criteria are "site," "size," and "recurrence" (Fig. 25.2) [7, 8]. The category "site" is subdivided into vertical, transversal, oblique, and combined. This morphological approach takes into account anatomical features that are highly important for hernia repair. The "size" of the hernial opening is categorized according to length or width into three subcategories, large, medium, and small. Here too, Korenkov's definition "length or width" is inadequate from the clinical point of view because in the planning of a Ramirez operation, for example, it is important to note whether it is the length or the width that is "large." A new criterion is used regarding the hernial opening ("reducible" or "not reducible") and clinical presentation ("symptomatic" or "asymptomatic"). The Korenkov classification does not include risk factors [8].

The classifications of Chevrel and Korenkov were rarely used. This may be due to their imprecise taxonomy of morphological findings and the categorization into interpretative subgroups, both deviations from natural language and early obstacles to granularity. Both classification systems offer little room for the addition of lower granulation levels to accommodate advances in medical knowledge. An entirely different approach is taken by the Ventral Hernia Working Group, which recommends a hernia grading system based on risk factors for a tailored approach and for mesh selection (biological or synthetic). This instrument, however, does not represent a true incisional hernia classification [11].

Fig. 25.2 Classification criteria of Korenkov et al. (2001). Categorization of the morphology notes the orientation of the incision, and thus groups under vertical hernias morphologically are very diverse types of hernia, such as *midline* and paramedian hernias. The categorization of hernial opening size is done similar to Chevrel and Rath but with only three subcategories. The criterion "symptomatic" can be useful for "watchful waiting," and it need not however be part of a classification

Korenkov et al. (2001)

According to localisation:

1	Vertical
1.1	Midline above or below umbilicus
1.2	Midline including umbilicus right or left
1.3	Paramedian right or left
2	Transversal
2.1	Above or below umbilicus right or left
2.2	Crossed midline or not
3	Oblique
3.1	Above or below umbilicus right or left
4	Combined (midline + oblique; midline + parastomal; etc)

According to size:

1	Small (<5 cm in width or length)
2	Medium (5–10 cm in width or length)
3	Large (> 10 cm in width or length)

According to recurrence:

1	Primary incisional hernia
2	Recurrence of an incisional hernia (1,2,3, etc. with type of hernioplasty: adaptation, Mayo-duplication, prosthetic implantation, autodermal etc.)

According to the situation at the hernia gate:

1	Reducible with or without obstruction
2	Irreducible with or without obstruction

According to symptoms:

1	Asymptomatic
2	Symptomatic

25.4 Würzburg Classification (2007)

The Würzburg Incisional Hernia Classification does not only allow an easily comprehensible classification of hernia findings but the preoperative assessment of risks for use in surgical planning [9]. It encompasses three granularity levels: (1) pathophysiologically different "ventral" and "incisional" hernias; (2) the criteria "occurrence," "morphology," "size," and "risk factors"; and (3) a more precise breakdown of the criteria of levels (1) and (2). The pathophysiological category (pv = primary ventral or pi = primary incisional) is present as "occurrence" in the incisional hernias, with the addition if applicable of the number of recurrences (e.g., r1, r2, etc.). The morphology involves the clinical-anatomic description of what the examiner sees in the patient (natural language) applying accepted anatomical terms (median, median-subcostal, umbilical, suprapubic, transversal, subcostal, and/or lumbal), with the optional designation as "not classifiable" (n.c.). These terms can be inserted into the classification scheme using their respective unambiguous abbreviations with no interpretive loss. Taxonomically, the terms are defined and meet the abovementioned requirements for nomenclature; no conflicts of semantic comprehension arise. The size of the hernial opening is measured in length and width, which allows calculation of the elliptic area of the hernia orifice. The last criterion is the number of relevant risk factors (◘ Fig. 25.3) [9].

A good example of a successful taxonomy with abbreviations is the TNM classification [14]. In analogy to the TNM classification, the graphic representation of the Würzburg Classification is not given as a table but as a hernia formula. This can be easily included in any medical report. The data in our own classification are not divided into categories, which enables adaptation of individual criteria with variation in cutoffs – in the sense of regroupings – to be made in light of future developments with no loss of data [14].

Heuristic criteria are of central importance in the validation process. Useful solutions must be found applying limited knowledge and an acceptable expenditure of time. Ideal for this purpose are simple data sets which provide a good overview of the case at hand [15]. Validation of the Würzburg Incisional Hernia Classification confirmed that (a) the contents of the data collection are available in clinical routine, (b) individual errors did not endanger the entire data set, and (c) the collected data delivered epidemiological and prognostic clues that can be applied in a treatment algorithm. In-house validation of the Würzburg Classification was done in 2012 using a cohort of 330 patients. In multivariate analysis, "occurrence" (on the first granularity level) was an independent predictor for the occurrence of postoperative complications: "ventral hernias" had fewer complications than "primary incisional hernias," while these in turn had fewer complications than "recurrent incisional hernias" (OR 2.04; 95% CI 1.09–3.84). In our cohort, morphology was a not a significant factor; this however was confounded by the fact that morphology as a criterion was already preoperatively part of the decision-making process regarding the surgical procedure. The "width" of the hernia opening can also serve as a predictor of the occurrence of postoperative complications in multivariate analysis (OR 1.98; 95% CI 1.19–3.29; <5 cm vs. >5 cm). The "length" of the hernial opening is an independent predictor of recurrence during follow-up (HR 2.05; 95% CI 1.25–3.37; <5 cm vs. >5 cm). Comorbidities also have an influence on the incidence of recurrences (HR 2.25; 95% CI 1.28–9.92) [12, 16].

These classification criteria can be of great practical value in routine clinical practice. The morphology is regarded by some authors as important for planning surgical strategy. Conze (2005) and Losanoff (2007) point out the peculiarities of subxiphoidal incisional hernias, in the Würzburg system denoted as "Mm + sc" (median + subcostal) [17, 18]. Varnell (2008) describes the special characteristics of the suprapubic incisional hernias and underscores the importance of this morphological subgroup [19]. These examples show that the grouping of these hernias exclusively as "median hernias" does not do justice to the surgical exigencies. The phenotype of the patient must sometimes also be considered, being especially relevant to surgery on subxiphoidal hernias with a narrow subcostal angle [9]. Also of clinical relevance is the complex of comorbidities, termed risk factors. In an overview paper, Höer (2002) retrospectively investigated the cause of incisional hernias in 2,983 patients who had undergone laparotomy and emphasized the significance of

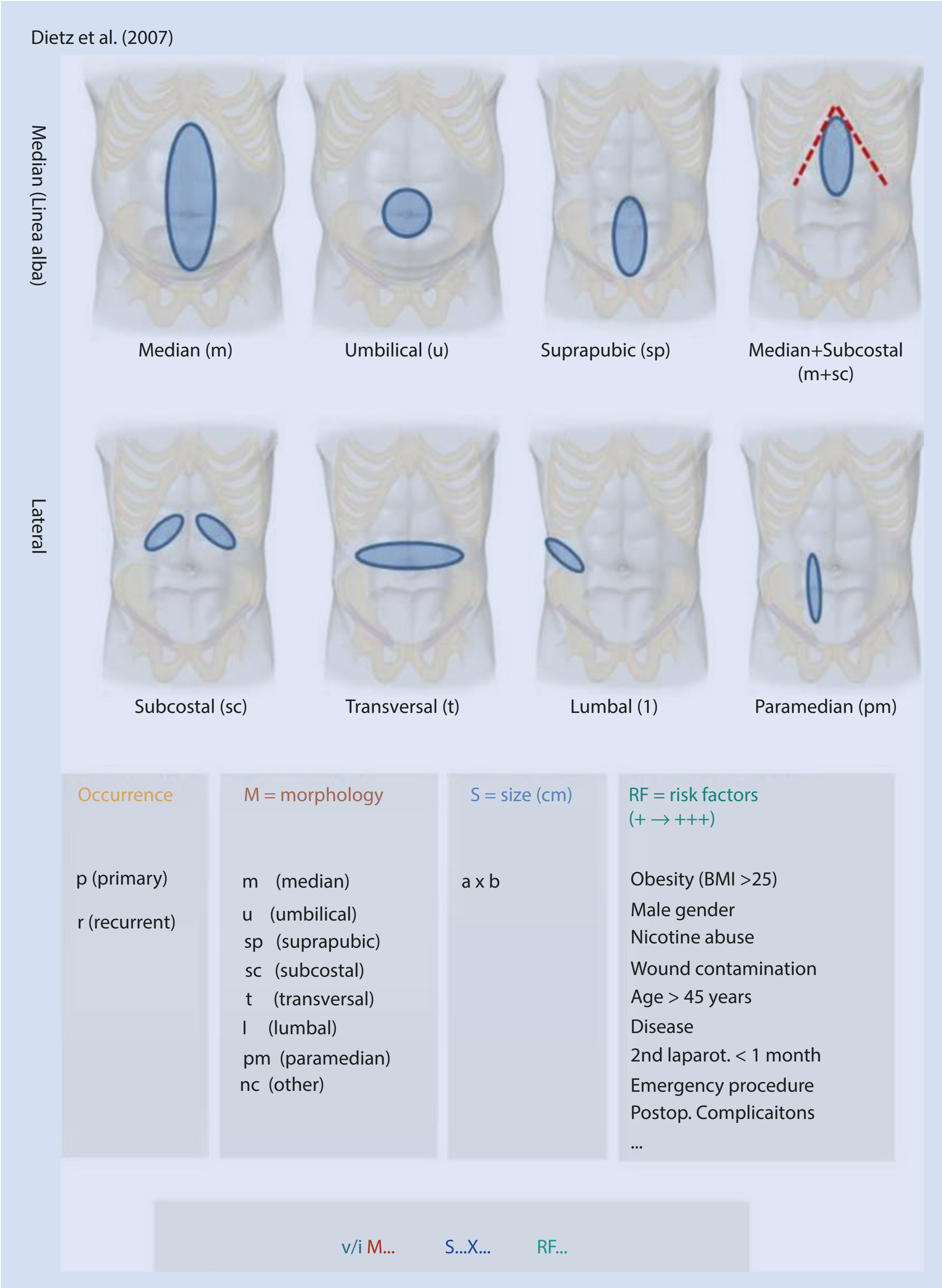


Fig. 25.3 Würzburg Classification according to Dietz et al. (2007) [9]. This classification notes the difference between ventral and incisional (v/i); in morphology (M), it takes into account phenotypical criteria that can influence the choice of OP technique (e.g., "*m + sc*"), calculates hernial opening size as length × width (S), and registers risk factors of possible prognostic relevance (RF). Every risk factor is qualified by a " + ," up to a maximum of "+++." The Würzburg Classification underwent in-house validation on a series of 330 patients [12, 13]

the endogenous risk factors [20]. Klinge (2001) pointed out the importance of collagen [21] and Sorensen (2005) of smoking [22]. Jenkins (2010) thought COPD was an independent factor that exacerbated the complexity of laparoscopic hernia surgery, while the higher the BMI and ASA status, the longer the time needed to create the pneumoperitoneum [23]. Similarly, Klinge (2008) postulated that incisional hernia patients required an individual assessment for surgical planning, a requirement that cannot be met in the context of randomized controlled studies [24]. Our in-house validation process showed that risk factors play a hitherto underestimated and highly significant role that should be included in patient counseling, surgical decision-making, and the formulation of new avenues of research; for these reasons they must be incorporated into a classification. In the future, surgical planning may also take the risk profile into account of, with patients in one risk group receiving treatment by surgical technique A and patients in another risk group by surgical technique B. This could mean, for example, that young patients with fewer comorbidities and a larger median hernia would be treated with sublay or retromuscular mesh implantation (morphological reconstruction of the linea alba, although major surgical trauma with good wound healing prerogatives), whereas patients with a high-risk profile for wound healing disturbance (obesity, advanced age, nicotine, diabetes, steroid medication, hernia orifice <8 cm) would receive a laparoscopic intraperitoneal mesh (IPOM) as a means of symptomatic treatment [13, 25, 26]. Detailed specification of the risk factors in the incisional hernia classification will soon require one or more finer granularity levels. Among other things, chronic diseases must be assessed with regard to their clinical activity. Studies are already planned to investigate this matter, including the European Incisional Hernia Registry of the European Hernia Society (visit the EuraHS website at ► www.eurahs.eu). It is also conceivable that different combinations of these risk factors could have not only an aggravating but also a protective effect on the postoperative results.

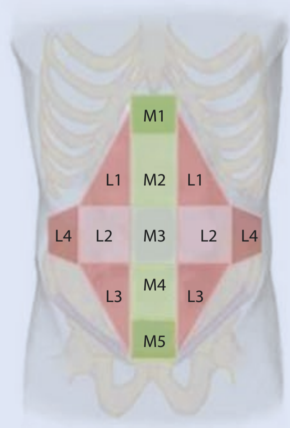
25.5 EHS Classification (2009)

The European Hernia Society (EHS) has put forth a further classification approach [10]. It is based on previous systems and is summarized in the form of a table. The EHS Classification is oriented intraoperatively with regard to definitions and – unlike the Würzburg Classification – is designed to be a tool for description of the hernia site alone, with no claim to predicting surgical planning or assessing surgical risk. The morphology is divided into medial and lateral regions, each having four subregions. The medial area (or linea alba) is divided into the regions M1 to M5 and the lateral area in the regions L1 to L4 (each designated with R = right or L = left). Hernia orifice size is denoted as length and width (in cm); in the classification summary table, it is placed into one of three width categories (W1 to W3) (◘ Fig. 25.4) [10]. The EHS Classification is recommended by a panel of experts as the standard for the classification of ventral and incisional hernias. Due to its high acceptance, it should make possible for the first time the standardized collection and evaluation of data across national borders [10]. The EHS Classification still has no validation data; they are expected soon however as part of the European Registry of Ventral and Incisional Hernias (EuraHS) from the EHS, the so-called EuraHS Project "Class of 2013."

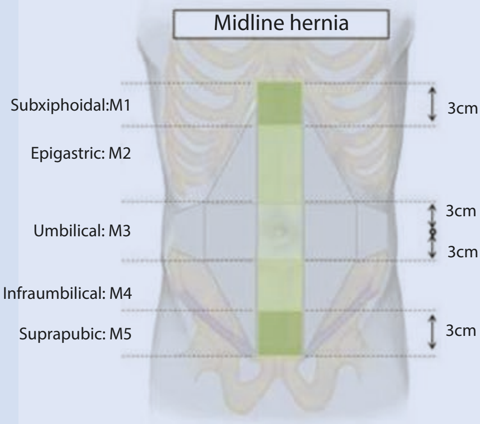
25.6 Conclusions and Prospects

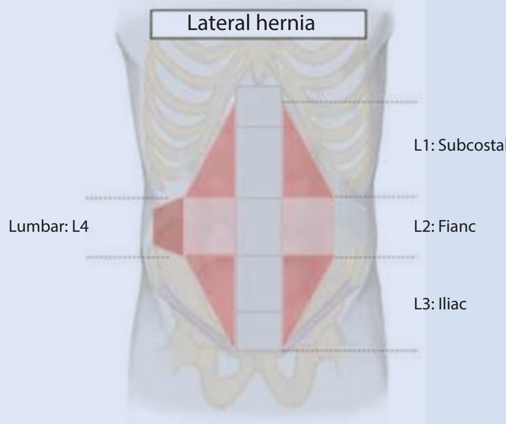
The classification criteria discussed above are highly significant for estimation of surgical risk, for patient counseling (prognosis for recurrence and complications), and for planning of surgical strategy (◘ Fig. 25.5). Preoperative assessment of the classification criteria is especially useful for patient counseling and surgical planning; if risk factors are included, they assist in estimating the risk. Data collected intraoperatively regarding the exact size of the hernial opening facilitate subsequent comparison of data. The corresponding author for the present chapter therefore uses the Würzburg Classification for patient counseling, risk assessment, and selection of surgical procedure [9] and the EHS Classification for documentation of intraoperative findings in EuraHS [10]. The two classifications are not mutually exclusive but rather compliment each other (the Würzburg Classification for OP planning, the EHS for standardized data collection for future data comparison). The use of both classifications is a natural constituent of patient care and does not require any significant time and effort for documentation.

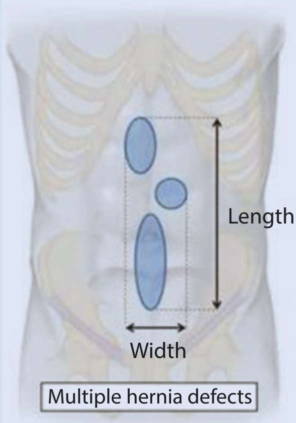
Muysoms et al. (2009)



E H S Incisional Hernia Classification			
Midline	subxiphoidal	M1	
	epigastric	M2	
	umbilical	M3	
	Infraumbilical	M4	
	suprapubic	M5	
Lateral	subcostal	L1	
	flank	L2	
	iliac	L3	
	lumbar	L4	
Recurrent incisional hernia?	Yes O	No O	
Length: cm		Width cm	
Width cm	W1 <4cm O	W2 ≥4-10cm O	W3 ≥10cm O







E H S Primary Abdominal Wall Hernia Classification		Diameter cm	Small <2cm	Medium ≥2-4cm	Large ≥4cm
Midline	Epigastric				
	Umbilical				
Lateral	Spigelian				
	Lumbar				

Fig. 25.4 EHS Classification. Figure according to Muysoms et al. (2009). This is the classification recommended in EuraHS [3] and by the current EHS guidelines (European Hernia Society) [16]

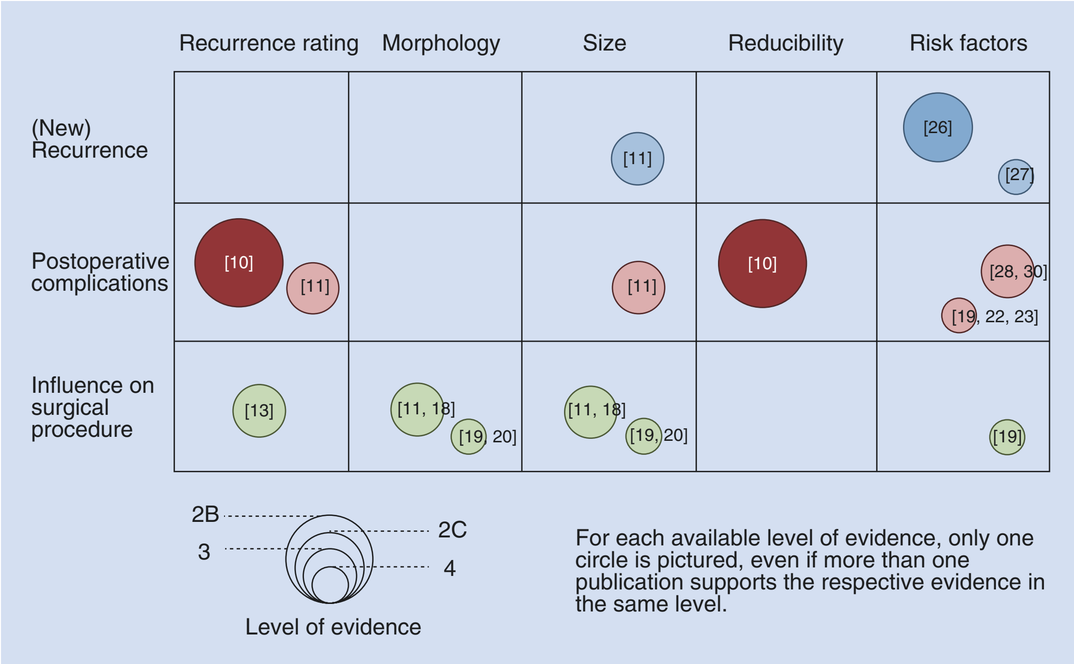


Fig. 25.5 Classification criteria for patient counseling (prognosis and postoperative complications) and planning of OP strategy (From Ref. [16])

The International Endohernia Society (IEHS) guidelines of 2013 devote a chapter to the topic of classification [16]. The consensus among experts is that ventral and incisional hernias must be classified in order to standardize the collection of data and to facilitate individualized patient therapy and comparison of data (statement level 5). The IEHS recommends classification prior to surgical therapy, intraoperatively immediately prior to the surgical treatment (recommendation grade D) according to the recommendation of the EHS classification (recommendation grade D) [10]. Data from all ventral and incisional hernia patients should be prospectively collected into a registry to facilitate standardized evaluations. Examples [of such registries] are the EuraHS (▶ www.eurahs.eu), the registry of the EHS, and the Herniamed Registry (▶ www.herniamed.de) in Germany.

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Rudolf Schrittwieser

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26.1 Part I

26.1.1 How I Do It

For patients with small primary ventral hernias, such as a small umbilical hernia or an epigastric hernia, no specific preoperative preparation is carried out. Any accompanying conditions, which could have a possible influence on the patient's suitability for surgery, are crucial. After relevant examinations are performed, the patient is introduced to the anaesthetist, who assesses the patient's degree of fitness to potentially undergo a pneumoperitoneum.

In the case of small, primary ventral hernias, without the presence of any accompanying illnesses, it is possible to perform surgery on a day patient basis.

Larger ventral hernias and all incisional hernias are treated without exception on an inpatient basis. With large hernias, it is advisable to undertake a lung function test, due to the fact that following the displacement of very often quite extensive hernia contents, postoperative pulmonary problems can result in patients who have no previous pulmonary impairments. Thorough breathing exercises, as part of the preoperative preparations, can in many cases significantly improve the patient's condition prior to surgery.

With very obese patients and the absence of an incarceration trend as well as with complaints only slightly linked to hernias, a preoperative weight reduction is recommended. The patient must however be informed about the higher perioperative risks concerning systemic as well as local complications. Likewise smokers also need to be informed about the higher risks of relapse, and a preoperative period of abstinence from smoking should be demanded.

Within the context of the initial examination, particularly with very obese patients, a close skin condition inspection should be performed in order to be able to strive for an improvement where necessary.

Patients who have hernias with loss of domain represent special cases.

With the help of a preoperative progressive pneumoperitoneum, it is sometimes possible to achieve an enlargement of the abdominal cavity in order to make displacement of the hernia contents feasible.

This method, however, involves a considerable degree of complexity and is therefore only employed in very special cases.

For all patients with ventral hernias and with the implanting of meshes, we undertake a single-shot antibiotic prophylaxis, regardless of whether an open or laparoscopic approach is used. Ideally this should be given on the ward about 1 h before surgery.

Thromboembolic occurrences present particularly difficult perioperative complications. A thrombosis prophylaxis with low-molecular heparin is given to all patients with risk factors at least until their discharge from hospital or their full rehabilitation. As rapid a postoperative rehabilitation as possible should be aimed for. Compression stockings can be prescribed; however, many patients are unable to tolerate wearing them, particularly during the summer months.

We provide an abdominal compression belt at the operating table, above all with the aim of preventing the build-up of serum, which can occur quite frequently. In the case of laparoscopic repair and large hernias with open repair, we recommend to wear an elastic mieder for 6 weeks.

The length of physical recuperation required depends upon the size of the hernia. With large hernias, it is advisable that patients avoid lifting heavy loads and general heavy physical activity for approximately 6 weeks. Regular, light physical activity is of course permitted and required.

26.2 Part II: Scientific Evidence

In relation to the question of antibiotic prophylaxis in connection with ventral hernias, there is very little literature available. Concerning inguinal hernia repair, there are several studies available. A recently published meta-analysis does not support the routine use of antibiotic prophylaxis in open mesh repair for inguinal hernia [1]. The infection rate for laparoscopic ventral hernia repair can be as much as 16% according to some studies; however, it normally lies in the range 0.5–4%.

Rios et al. [2] showed, in a study published in 2001 about open ventral hernia operations, that there are significant advantages in using antibiotic prophylaxis; however, the rate of infections was recorded as 18.1%, which is rather high.

Likewise Abramov et al. [3] undertook a study of 35 patients chosen at random, who had undergone open umbilical hernia and incisional hernia surgery. This study considered the effectiveness of preoperative an antibiotic prophylaxis using 1 g of cefonicid 30 min before surgery.

The wound infection rate amongst the antibiotic group was 1 in 17 patients, whilst the rate in the nonantibiotic rate was 8 from 18. Also here the infection rate amongst the nonantibiotic group appears to be high.

In connection with wound infection, White et al. [4] carried out a follow-up study of 250 hernia operations performed on a total of 206 patients over a period of 14 years. They could not identify any significant impact caused by either administering an antibiotic prophylaxis or inserting a wound drain.

Furthermore, there are a number of publications that acknowledge the routine use of an antibiotic prophylaxis. They range from administering amoxicillin (1 g) and clavulanic acid (200 mg) before surgery and 8 h following an operation [5] up to administering a first-generation cephalosporin at the time of the skin incision and a repeat dose during operations that take longer than 2 h [6]. From these investigations, clear recommendations for or against the use of an antibiotic prophylaxis cannot be derived.

The increased intraperitoneal pressure and the reverse Trendelenburg bed position could, according to some studies, lead to a higher rate of thromboembolic incidences in connection with laparoscopic surgical interventions [7].

In an extensive study of laparoscopic surgery and the incidences of thromboembolic complications, a total of 2384 patients were examined [8]. From this study, the authors drew the conclusion that thrombosis prophylaxis should continue to be given up until the time of hospital discharge.

In relation to the use of abdominal compression to prevent the build-up of seroma formation and reduce postoperative pain, there is only non-significant data. After open and laparoscopic ventral hernia repair, no effects on postoperative well-being, quality of life and movement limitation could be found [9]. But physical function was improved, and the binder had also a beneficial effect on psychological distress after open abdominal surgery [10].

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Standard Technique Laparoscopic Repair of Ventral and Incisional Hernia

Karl A. LeBlanc, Anil Sharma and Jan F. Kukleta

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27.1 Introduction

This repair of these hernias laparoscopically has been well established. There are many variations in technique to obtain the best outcomes. We have attempted to outline the methods that are known to provide for the best results within the literature reviewed. The reader is encouraged to explore the most recent data in an effort of continuous quality improvement.

27.2 Positioning of the Patient

The position of the patient for the standard midline hernia is generally supine. It is preferable to put the arms at the side of the patient to allow the surgeon and staff access to the entire abdominal wall without the hindrance of the arms that are not tucked. However, in the modern era of obesity, this may not be feasible in many patients. It is important to drape the patient as far as possible laterally to permit trocar placement to be as far away from the midline as this can be. This will facilitate all aspects of the operation, dissection, mesh manipulation, and the fixation of it.

For midline hernias that are either high in the abdomen or suprapubic, the patient will require steep reverse or traditional Trendelenburg position, respectively. In these instances, the patient must be padded and secured to the table appropriately.

For hernias that are off midline, one must allow for some degree of rotation of the patient on the operating table. Special padding or “beanbags” will aid in the maintenance of the position of the patient. This is especially true for lumbar or parastomal hernias.

27.3 Pneumoperitoneum

The entry into the abdominal cavity can be accomplished in many different methods. The older methods of Hasson technique or Veress needle insertion reliably allow for the establishment of the required pneumoperitoneum [1, 2]. The newer method of the use of an optical trocar also permits this to be achieved easily [3]. The latter method does necessitate more experience to appreciate the different tissue planes that are penetrated as one gains entry into the abdominal cavity. An alternative method is direct trocar entry, which appears to be safe and effective also [4].

Once this has been achieved, the surgeon must decide upon the level of pressures that are needed during the operation. Generally speaking, the operating level is between 12 and 15 mm Hg. This will allow for greatest visualization of the contents of the abdomen while aiding in the separation of the adhesions and/or intestine from the anterior abdominal wall. However, this also serves to distract the fascial defect(s) apart thereby increasing the hernia size. This becomes an important consideration when the hernia is fully dissected, and the measurement of the fascial separation must be done to choose the appropriate size of mesh. This is the surgeon’s preference as to making this measurement at this pressure (which increases overlap) or lowering the pressure (which decreases the defect size and mesh size somewhat).

If the choice is made to lower the pressure, this is usually decreased to 8 or 9 mm Hg. This lessens the distractive forces on the abdominal wall. If so chosen, the defect will be more easily closed at the lower level. The mesh will provide more coverage and be more easily fixed at the lower level of Hg. Additionally, this will be slightly more physiologic than the higher levels of pressure. However, the level of evidence for these statements is only level 5.

27.4 Positioning of Trocars

The trocar positions in laparoscopic incisional and ventral hernia repair (LIVHR) vary depending on the site of the hernia (Figs. 27.1, 27.2, 27.3, and 27.4).

In a patient with incisional hernia, the position of the initial trocar for peritoneal access should be at least 10 cms away from the previous abdominal incision. The initial access with the first trocar may be Palmer point in the left hypochondrium (a fingerbreadth below left subcostal margin in midclavicular line) [5]. The trocars on the abdominal wall should be located at least 5 cm away from each other.

One 10/12 mm trocar is required for introduction of the mesh. All other trocars are 5 mm. The trocars are sited on the abdominal wall in the form of an arc of a circle whose center is the hernial defect. One or two 5 mm ports on the contralateral flank may be required to fix the margin of mesh on the ipsilateral flank.

27

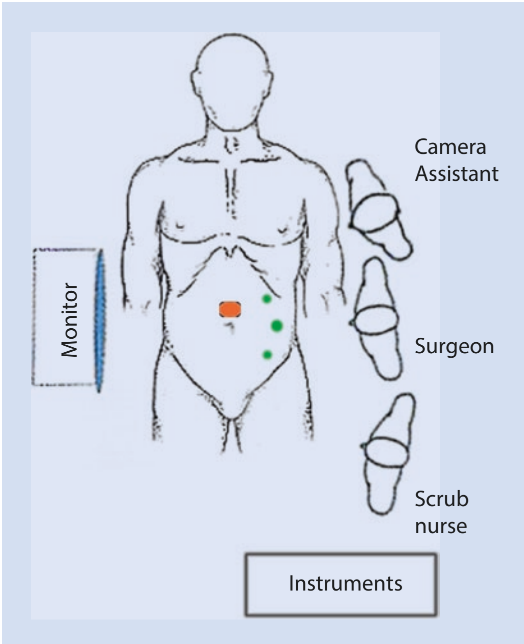


Fig. 27.1 Typical trocar positions for a midline hernia

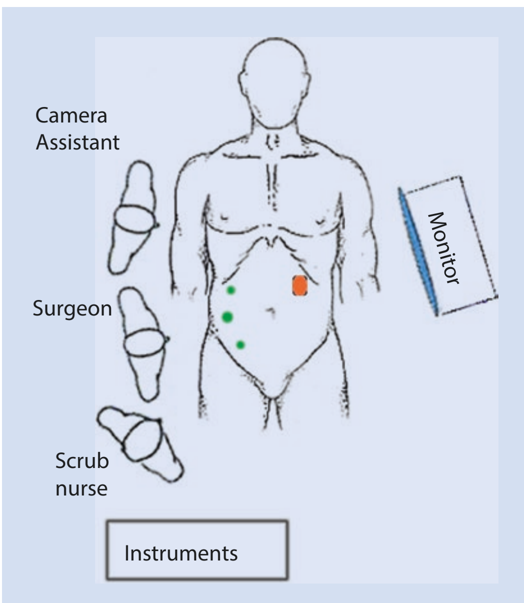


Fig. 27.2 Typical trocar positions for a left upper quadrant hernia

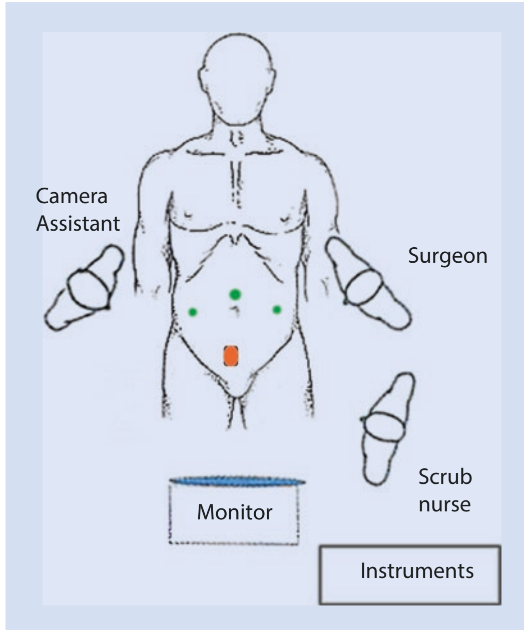


Fig. 27.3 Typical trocar positions for a suprapubic hernia

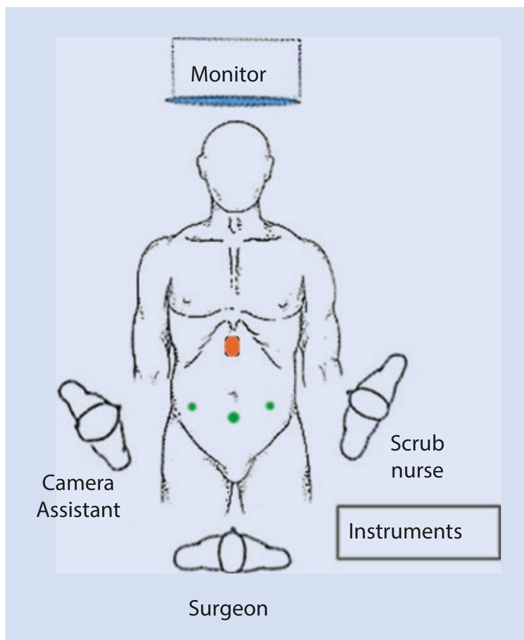


Fig. 27.4 Typical trocar positions for a subxiphoid hernia

The left subcostal trocar may be used for the telescope (angled, 30°/45° to optimally view the hernia and the anterior abdominal wall) and the other trocars for the operating instruments [1]. However, the telescope may need to be used from other trocars also for optimal fixation of different segments of the mesh.

Additional 5 mm trocars may be used whenever required to facilitate the operative procedure, particularly when the trocar site is likely to be covered with mesh used for the hernia repair.

Ergonomically, the most comfortable working position is when the surgeon, his primary operative trocar, operative site and primary monitor are all located in one straight line (Chowbey et al. 2012) [5].

Recommendations

- **Grade B**: Visually guided entry of trocars is recommended because these decrease the size of the wound.
- **Grade D**: When additional trocars are needed, the principles of triangulation and maintenance of optimal distance should be taken into consideration.
- The left or right upper quadrant subcostally is recommended for the first access port to the peritoneal cavity. The use of a 30° laparoscope is recommended.
- The trocar entry points should be as far as possible from the site of expected adhesions and the size, site, and number of wall defects, and they should be placed to achieve triangulation of the hernia site.

27.5 Defining Defect Size

The exact sizing of the defect is critical to the repair of any hernia. It is especially critical for mesh size selection. There are a number of methods that have been used to measure the defect(s). Approximately 25% of incisional hernias will be composed of more than one defect. In these circumstances, one simply measures the furthest extent of the combined defects as if they were one. The lateral extent should be the defect that is the largest of all of the defects. Despite the many years that this repair has been done, there is no standard method of measurement. It is well known that improper measurement will result in an inadequately sized mesh, which will result in increased rates of recurrence [6, 7].

Measurement of the defect by physical examination alone is inaccurate [8]. Another method that I personally prefer is to mark the anterior abdominal wall externally (Figs. 27.5, 27.6, and 27.7) with the abdomen fully insufflated then measuring the marks following deflation [9]. One effective method is to insert a ruler into the abdominal cavity and measure the defect directly with a reduction of the pressure. Some surgeons do not lower the pressure to measure so as to provide for a larger mesh size. Other surgeons puncture the abdominal wall with spinal needles to mark the edges of the defect(s) and measure these needles intraperitoneally [3, 4]. Whatever method is chosen, it must be reproducible and accurate. This size will determine the dimension of the mesh and will greatly impact the rate of recurrence.

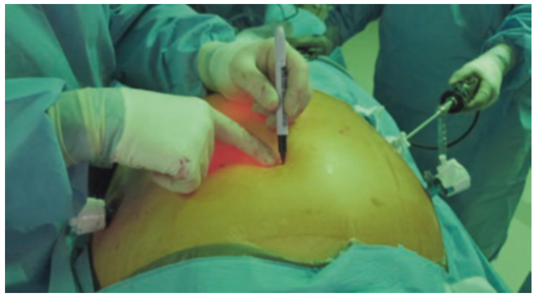


Fig. 27.5 External marking of the palpated fascial edges

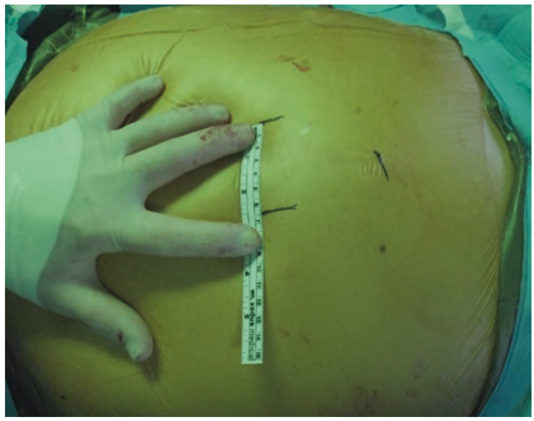


Fig. 27.6 Measurement of the vertical dimension

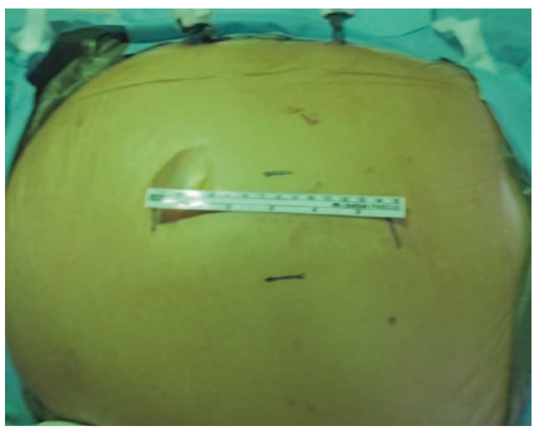


Fig. 27.7 Measurement of the transverse dimension

From the literature cited, there is level 2B, 3, and 4 evidence that the measurement if critical and the laparoscopic method is a very effective manner to accurately define the defect(s). Consequently, the Grade B recommendation is to use the laparoscopic intracorporeal method to successfully size the fascial defect.

27.6 Dissection Techniques

27.6.1 Adhesiolysis

Once the appropriate number of ports is introduced into the abdomen, adhesiolysis is commenced. Adhesiolysis is performed to include the areas of the entire scar of previous abdominal surgery and at least 5 cm around the hernia defect. The laparoscopic approach provides a view of the entire ventral abdominal wall so that occult hernias may be diagnosed and treated appropriately [10].

Iatrogenic enterotomy is one of the most serious complications of LIVHR, particularly if it is not recognized intraoperatively [11]. It follows that there should be increased awareness of the possibility of an iatrogenic enterotomy during bowel adhesiolysis. Cold scissors are the best means of performing adhesiolysis (Fig. 27.8) [12]. Electrocautery or any other energy source is best avoided during adhesiolysis to preclude the possibility of bowel injury. The omentum and the bowel are commonly adherent at the site of previous scar or around the hernial defect. In most patients, there exists an avascular plane between abdominal wall and viscera which may be accessed and developed for adhesiolysis. The advantage of remaining in this avascular plane is that the field of vision remains clear which in turn reduces the chances of enterotomy during adhesiolysis. In patients with dense bowel adhesions to the anterior abdominal wall, the parietal peritoneum may be incised well away from the bowel and adherent bowel reduced along with peritoneum wherever required.

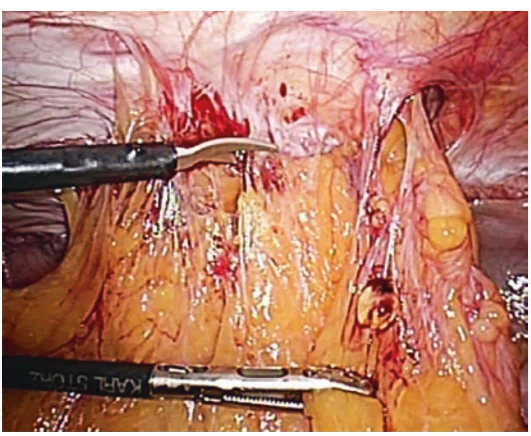


Fig. 27.8 Adhesiolysis with cold scissors

27.6.2 Reduction of Hernial Sac Contents

Omentum and bowel comprise the most common content of hernial sacs in incisional and ventral abdominal wall hernias. The hernial sac contents need to be reduced back to the abdominal cavity. It is important to ensure that the contents of the sac are completely reduced, especially omentum and extraperitoneal fat in epigastric hernia. Complete reduction of the contents can be confirmed by palpating the hernia on the abdominal wall for any residual omentum or fat (Fig. 27.9). Once the sac contents have been completely reduced, the light from the telescope transilluminates the skin on the abdominal wall at the site of the hernia. The omentum is reduced in continuity from the hernial sac. This ensures that the reduced omentum can be subsequently used as a sheet to cover the bowel surface at the end of surgery. This provides a natural protective adhesive barrier between mesh and underlying bowel at the end of surgery [5]. Any bowel that is present in the hernial sac is reduced back to the abdominal cavity. Atraumatic bowel forceps are used to handle and manipulate bowel. It is not unusual to find several loops of small bowel incarcerated within a hernia with a relatively narrow neck. The direction of

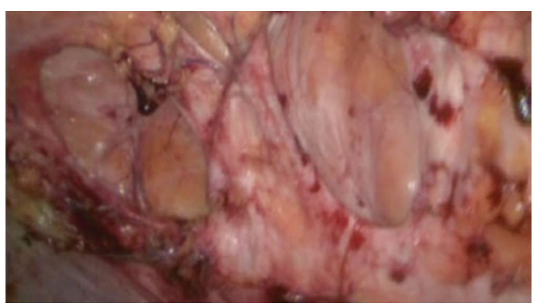


Fig. 27.9 Fully dissected incisional hernia

pull on the bowel needs to vary to achieve reduction of bowel when incarcerated. Great patience and delicate handling are required when bowel is being manipulated. Sometimes, traction on the abdominal wall at the site of the hernia aids in reduction of bowel.

Recommendations

- **Grade B**: Adhesiolysis should be limited to freeing the abdominal wall to enable adequate overlapping of the defect by the mesh.
- **Grade C**: Cold and sharp adhesiolysis is preferred to ultrasonic dissection. Bipolar coagulation is allowed, but monopolar coagulation should be avoided.
- **Grade D**: Adhesiolysis should be performed near the abdominal wall away from the adherent bowel.

27.7 Extent of Mobilization of the Abdominal Fatty Tissues

27.7.1 Introduction

The objective of the classical intraperitoneal onlay (underlay) mesh (IPOM) technique or the augmentation form of such repair with closure of the defect and additional intraperitoneal mesh (IPOM Plus) is to achieve full surface contact of the prosthetic material with the overlying abdominal wall. An adequate overlap of mesh over the area of the repair (in all directions not only the defect, but the whole scar) and adequate fixation (hernia size and hernia type dependent) should guarantee the future stability of the bridged repair (IPOM) or the augmentation repair (IPOM Plus). The majority of midline ventral/incisional hernias (M1–5) are surrounded by a fatty strip extending from the ligamentum falciforme hepatis and ligamentum teres hepatis over median and medial umbilical ligaments to the space of Retzius with the prevesical fat pad.

27.7.2 Problem

The durability of the interface between mesh and preperitoneal fat, e.g., posterior rectus sheath, is questioned. The tissue property, which promotes the ingrowth in macroporous mesh structure, and the tissue quality that serves as abutment for fixation could be of paramount importance for the outcome. These data are not available yet. Therefore the title question cannot be answered with evidence-based support but only with consensus-based suggestion.

27.7.3 Method

Extensive search of published data between 1993 (LeBlanc's first publication of laparoscopic IPOM) and August 2015 was conducted [13]. There are not only no RCTs or another high level of evidence data existing, but the very few comments regarding the disinsertion or resection of ligamentum teres and/or umbilical medial ligaments with the corresponding fatty street are of low or no evidence at all. The published comments on this topic (see Sects. 27.7.1 to 27.7.4) are very rare and only gut feeling based.

The International Hernia Collaboration (IHC) is a closed Facebook-based community of hernia interested/hernia expert surgeons, which counts in August 2015 1662 members. This group appreciates all advantages of social media to exchange opinions, share knowledge, share experience, or just ask for a professional advice and all that within hours. What a challenge to ask for "vox populi", to listen to a collective gut feeling of a community dedicated to hernia affairs. The IHC was asked whether they never remove (1), occasionally remove (2), or always remove the fatty street (3) in order to achieve better contact of mesh with a solid abdominal wall and accurate fixation.

27.7.4 Results

The "search" revealed only five statements on transsection, disinsertion, and resection of the abovementioned fatty complex in the last 14 years. The IHC reaction was overwhelming.

Within minutes and hours, many comments and personal opinions came from four continents. The prudent consensus reveals that the removal of fatty strip of the anterior abdominal wall is for vast majority obvious, the resection of it (extraction out of abdominal cavity) not always imperative.

27.7.5 Discussion

In 2010 Berger mentions in his description of IPOM technique that "structures like the space of Retzius, falciform ligament and the ligamentum teres hepatis must be dissected and the prevesical space must be opened to allow adequate fixation and incorporation of the mesh" [14]. Stirler comments in 2013 separately the adhesiolysis and the de-insertion of the ligamentum teres hepatis and removal of fat from the hernia sac in cases of epigastric and umbilical hernias [15]. Stirler states: "The ligamentum teres hepatis and fatty tissue were removed from the abdominal wall in preparation for placement of a mesh."

Misiakos states in 2015 "for hernias located in the upper midline, the falciform ligament should be dissected from the abdominal wall by using energy source" [16].

Chelala in 2015 summarizes briefly the main technical steps of laparoscopic augmentation ventral/incisional hernia repair, and one of the steps is "the preparation of a good "landing zone": in all cases, the proper excision of all fatty tissue or lax hanging peritoneum is performed to enable a secure fixation of the mesh to the healthy fascial layers, for better tissue ingrowth" [17].

In the Guidelines for Laparoscopic Ventral Hernia Repair of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) (▶ http://www.sages.org), there is a casual statement: "Dependent on the hernia location, the falciform and umbilical ligaments may need to be taken down and the space of Retzius dissected to identify occult hernia defects and allow adequate exposure of the abdominal wall for placement of an appropriately sized prosthetic" [18].

All responding IHC members (50 within 24 h) would transect the ligaments and remove the preperitoneal fat from the posterior rectus sheath in majority of cases in order to facilitate the best possible contact of mesh with abdominal wall. Several would refix the pedicle to the mesh, some would leave the pedicle in situ, and some would resect it and remove from the cavity.

It is remarkable that the importance of the "cleanup" of the "landing zone" was so rarely highlighted in the corresponding literature [13, 19–28].

27.7.6 Conclusion

The act of removing the fatty tissue from the area where the mesh is to be placed seems to be obvious and as such accepted in the hernia community despite missing evidence or strong recommendations from any guidelines or consensus conferences.

27.8 Closure of the Defect, Reconstruction of the Midline

27.8.1 Introduction

Abdominal wall hernias are common. Their surgical therapy, especially the traditional sutured repair, leads to high recurrence rate and frequent wound complications. The general introduction of prosthetic reinforcement in open repairs demonstrated to diminish the recurrence rate, but the infectious complications remained problematic. The laparoscopic intraperitoneal onlay mesh (IPOM) technique, as first presented by LeBlanc in 1993, reduced markedly the wound problems and shortened up the hospital stay, but the recurrence rate still had to be improved [13, 29–31]. The new technique brought up new morbidities especially related to difficulty of laparoscopic adhesiolysis and the risk of bowel injury. Appropriate selection of patients, awareness of the risk of thermic injury, improved technique of mesh fixation, and new materials (meshes, fixation devices) further decreased overall morbidity and recurrence rate [32]. In bigger hernias bulging, clinical eventration and frequent seroma formation are still unsatisfactory.

Unlike in laparoscopic groin hernia repair, acute postoperative and chronic pain after abdominal wall repair deserves substantial improvements. The standard IPOM is a bridging repair [33]. It may prevent a herniation, but the bridge is adynamic and doesn't solve the functional deficit. In midline hernias, straight muscle is displaced and lateral muscle complex retracted. The dead space in the former hernia sac predisposes to seroma formation. In contrary to a bridging repair is the primary closure of the defect and intraperitoneal onlay mesh an augmentation repair (IPOM Plus) [28]. The linea alba is an important structure as primary attachment of rectus muscle and secondary attachment of oblique muscle group. Linea alba is the central tendon of abdominal wall. Closing the midline defects reconstructs linea alba and restitutes the anatomy of the abdominal wall. The re-stretched lateral muscles regain its physiologic tension, which contributes to improved stability of the trunk. IPOM-Plus is a more solid repair. Fascial closure and the fixed mesh distribute the tension force more evenly; the eliminated gap allows bigger mesh overlap in order to neutralize the shear forces more efficiently [17, 24, 28, 34–41, 50, 62].

IPOM-Plus reduces the dead space by incorporating parts of the hernia sac in the aponeurotic suture if anatomically feasible. Decreased seroma rate is the consequence [28, 34–36, 50]. IPOM-Plus is not a tension-free repair. Nevertheless the expected elevated pain perception could not be confirmed in clinical practice [28, 34].

27.8.2 Indication

Not all ventral/incisional hernias can be repaired with IPOM-Plus technique. Size and type of the defect and elasticity of the abdominal wall are the most important predictors of feasibility. There is a belief that low BMI, female gender, and older age are more amenable for primary fascial closure [35]. Small defects don't require closure to improve physiology but may appreciate lower risk of recurrence. It is the relation between the abdominal wall surface and the width of the defect rather than the absolute size in cm. The next limiting factor may be the proximity of bony structures (suprapubic or subxiphoidal). The type of index operation and number of previous repairs with or without prosthetic material do certainly influence the tailoring and choice of repair technique. Although successful closures of defect up to 12 cm wide were reported, the width over 10 cm should raise the attention to proper choice of the repair strategy [34, 36]. The high hernia recurrence rate observed in larger defects W3 >10 cm reflects the significant risk factor of the "hernia width defect" irrespective of the technique, open or laparoscopy [62]. Additional endoscope-assisted component separation technique or hybrid procedure with defect closure through anterior approach with laparoscopic mesh placement can facilitate a difficult IPOM-Plus. In larger hernias and/or increased risk for recurrence open approach with anterior or posterior components, separation with/without appropriate preoperative preparation (progressive pneumoperitoneum and/or botulinum toxin A-induced relaxation of the lateral muscle complex) might be necessary.

27.8.3 Technique

The landing zone has to be prepared first. Thorough adhesiolysis with cold scissors or with prudent use of energy source helps to prevent inadvertent injury to adjacent structures. The extent of adhesiolysis must allow secure manipulation and placement of the adequate size of mesh overlapping the whole scar vertically by 5 cm and by 7 cm in transverse direction if the defect can be completely closed.

There are various techniques how to suture the defect.

The technically most demanding is the running intracorporeal suturing as described by Palanivelu. Robotic instruments facilitate this task. The intracorporeal interrupted sutures can be tied sequentially either with the help of Endo Stitch or extracorporeal knot-pusher. The disadvantage is the remaining necessary distension of the wall despite of the purposely lowered intra-abdominal pressure in order to maintain sufficient vision.

The transcutaneous transfascial suturing can be accomplished with curved needle or suture passer [24, 28]. The interrupted suture can be tied with completely desufflated abdomen with more realistic tension control. The tiny skin incisions allow sometimes placement of more than just one suture, but the multiple skin perforation increases theoretically the risk of infection. Therefore we repeat over and over the skin disinfection before any percutaneous manipulation. The suture material should be nonabsorbable. In patients with a thin subcutaneous layer, the knots have to be buried thoroughly, because the palpable "granulomas" can be bothersome. Lifting the skin after tying lets the knot dive deeper and helps to prevent unpleasant dimples.

To place, correctly orient, and finally secure the mesh, the intra-abdominal pressure has to be increased, but not necessarily over 8 mm of mercury. When closing larger defects, the extendibility of the abdominal wall will be limited. Less working space may make the mesh positioning more difficult.

27.8.4 Discussion

Franklin and Chelala reported early of closing the defect prior to intraperitoneal mesh placement [24, 36, 50]. Kukleta made a literature search in 2012 and identified 27 relevant articles about defect closure or augmentation repair. The overall evidence level was low or very low [28]. Nguyen published a systematic review on primary fascial closure with laparoscopic ventral hernia in 2014 [35]. Eleven articles met the inclusion criteria. He found no randomized controlled trial but three comparative studies, five of them retrospective and six prospective [34, 38, 39]. The comparative studies showed that IPOM-Plus resulted in lower recurrence rate (0–5.7% vs. 4.8–16.7%) when compared with non-closure IPOM. Seroma formation rates were lower in closure group (5.6–11.4% vs. 4.3–27.8%).

Clapp et al. examined additionally bulging, chronic pain, functional status, and patient satisfaction [34]. The bulging rate in closure – vs. non-closure groups – was 8.3 vs. 69.4%. The scores for patient satisfaction and functional status were higher in the closure group. Despite placing more sutures and increased tension on the abdominal wall, there was no difference in chronic or postoperative pain between the two patient cohorts. The difference in hernia recurrence after mean follow-up of 24 months (0.0% vs.16.7%; $p = 0.02$) was significant.

Chelala demonstrated in his large series of 1326 augmentation repairs that the ventral and incisional hernias should be evaluated separately. The recurrence rate of incisional ventral hernias is 3.45%, the one of primary ventral hernias 1.27% only [17]. With 0.82% conversions and 2.42% of no closures, he showed an unexpected high rate of feasibility of the suturing concept or augmentation technique reducing the overall morbidity with a low rate of recurrences.The recently published review of IPOM-Plus literature of Suwa et al. in 2015 identified 16 reports in which the recurrence rate, incidence of seroma formation, and incidence of mesh bulging were clearly lower in the defect closure group [42].

27.8.5 Conclusion

There is level 3 evidence that the reconstruction with permanent sutures of the linea alba improves the functionality of the abdominal wall and decreases the rate of wound complications. The augmentation of the anterior abdominal wall causes less pain in the early postoperative period than a bridging repair. The augmentation repair (due to the combination of defect closure and mesh overlap) results in a stronger repair than bridging alone.

Level 4 evidence suggests that the closure of the defect decreases the rate of seroma formation and mitigates against the postoperative bulging that can occur. Augmentation decreases recurrence rates. Finally, reconstruction of the linea alba without mesh reinforcement can lead to increased rates of hernia recurrence.

Therefore, the Grade B recommendations are that nonabsorbable sutures should be used to close the defect. Grade C recommends that defect closure with a mesh onlay should be used. Grade D recommendations are that the use of transfascial sutures to close the defect should incorporate the hernia sac to obliterate the dead space to prevent seroma formation.

27.9 Mesh Sizing, Manipulation, and Fixation

27.9.1 Mesh Sizing

Mesh size is a very critical component to successful laparoscopic incisional hernia repair. This is often discussed, but there are still gaps in the overall understanding of this factor. Accurate sizing of the fascial defect will determine the size of the mesh itself. It has long been known that the larger the mesh, the lower the incidence of recurrence. Past studies have demonstrated that the lack of transfascial sutures influences recurrence rates, but a larger overlap (5 cm vs. 3 cm) of the prosthesis was required if no sutures were used [43, 44]. Other studies have confirmed that the overlap beyond the fascial defect should be at least 4 cm [6]. A recent meta-analysis has confirmed this fact but found that even more overlap was preferred [7]. This paper evaluated nearly 9000 patients. There was a statistical difference in recurrence rates based upon the amount of overlap of the mesh. If the mesh overlap was <3 cm, the recurrence rate was 8.6%, but if the overlap was between 3 and 5 cm, the recurrence rate was 4.6%. However, when this overlap was 5 cm or greater, the rate of recurrence was only 1.4%. Consequently, this fact must be used in these repairs. It is also been noted that during the repair, the mesh should cover the entire scar where the hernia has developed to avoid the development of a subsequent hernia in the incision [45].

Recent publications have investigated the overall size of defect and the mesh to repair the defect as ratios (mesh/defect) to consider in the repair of these hernias [46]. In this particular study, if this M/D ratio was ≤12 and the defect overlap was less than 5 cm, the recurrence rate was 100%, but if the M/D ratio was ≤12 and the defect overlap was greater than 5 cm, there was still a recurrence rate of 22%. Increasing the M/D ratio to greater than 12 resulted in a recurrence rate of 4% with a < 5 cm mesh overlap and a 1% recurrence rate if the overlap was 5 cm or greater. This study indicates that mere overlap is an insufficient indicator of recurrence rates with the bridging laparoscopic technique for ventral and incisional hernia repair. It also suggests that with larger defects perhaps the laparoscopic repair should not be done if consideration is given to the M/D ratio. This article is recommended to the reader for further clarification.

Given these articles, there are levels of evidence from 2B to 4 that the overlap should be at least 4 cm but 5 cm is preferred, especially if no transfascial sutures are used. Level 4 evidence suggests that the M/D ratio should be considered in the typical bridge repair with a larger than 12 ratio being preferred. There is level 4 evidence to overlap the entire incision to prevent recurrence of the hernia. The Grade B recommendation is that the overlap should be 5 cm beyond the fascial defect. There is Grade C recommendation that the overlap should be 5 cm if no transfascial sutures are utilized to fixate the prosthetic material. Additional Grade C recommendation is that the M/D ratio should be used in the sizing of the mesh for the laparoscopic repair of these hernias.

27.9.2 Mesh Manipulation

The type of mesh and its stiffness will influence methods of mesh introduction and manipulation once the product is introduced (Fig. 27.10).

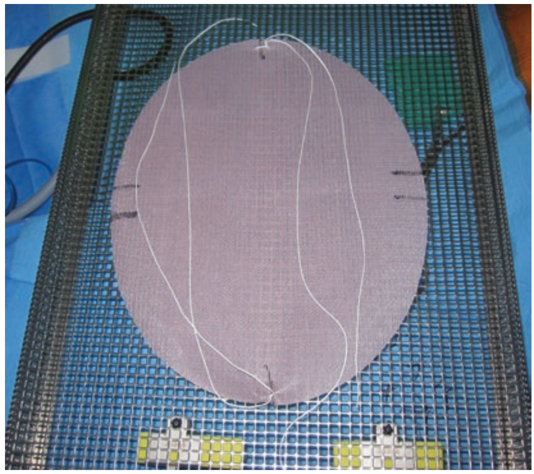


Fig. 27.10 Mesh with preplaced sutures and marks

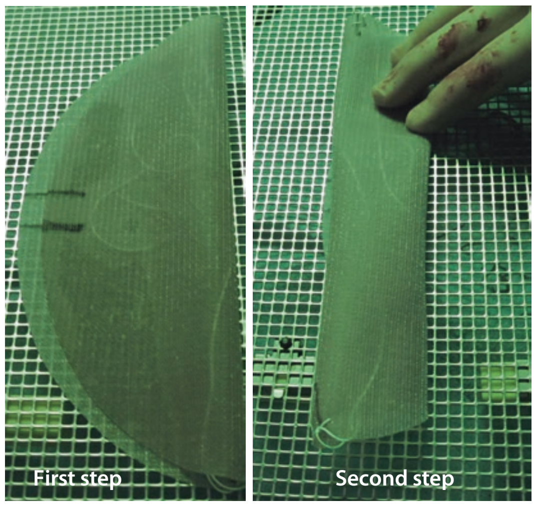


Fig. 27.11 Folding of the mesh

This latter fact will be affected by the pore size and thickness of the material. In general, the product will be rolled and introduced into the abdominal cavity via a 10 or 12 mm trocar (Figs. 27.11, 27.12, 27.13, 27.14, and 27.15) [47]. Hussain et al. use an additional 10 or 15 mm port placed in the center of the hernia to insert the mesh [48]. Other authors prefer to place a 2–3 cm incision at the hernia site through which the mesh is placed [49–52]. Some prefer to merely pull the mesh into the abdominal cavity through a 5 mm trocar site as long as the site is covered with an iodine impregnated drape [53]. It has been shown that it is best to avoid contact of the prosthetic material with the skin [10, 54, 55].

Fig. 27.12 Final rolled mesh prior to insertion

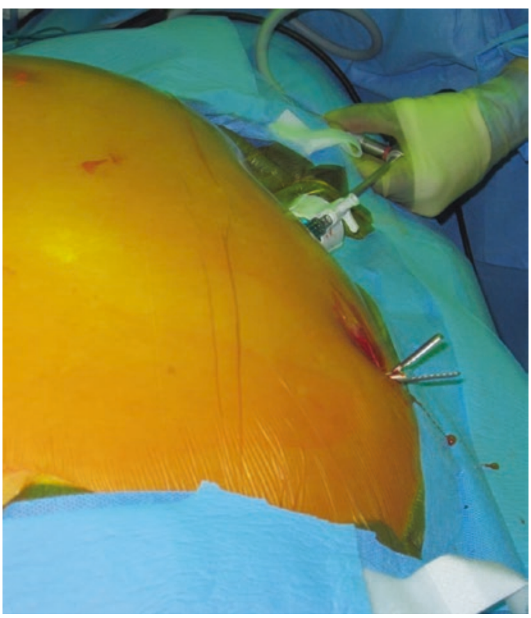


Fig. 27.13 Grasper through a trocar site to grasp the mesh

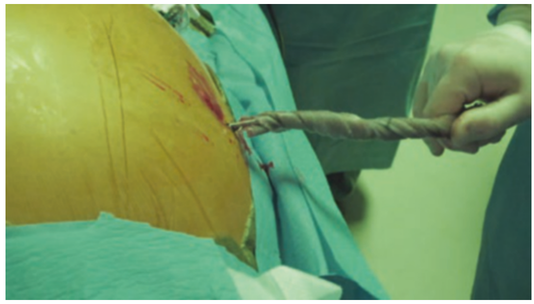


Fig. 27.14 Mesh being pulled into the abdomen (outside view)

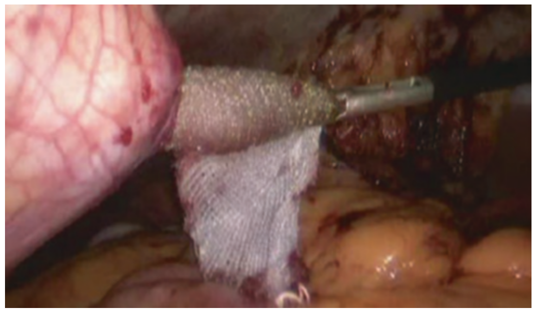


Fig. 27.15 Mesh being pulled into the abdomen (inside view)

There are various ways that this roll can be made such as a standard roll or some type of scroll. This roll can be held secure with the use of sutures placed prior to mesh insertion. Some will place one to four sutures to allow for the positioning of the prosthetic against the abdominal wall prior to fixation with a device of some type. These sutures will be placed transfascially and generally tied to fixate the mesh.

Therefore, there is level 3–5 evidence that the mesh can be brought into the abdominal cavity through a separate incision, through a trocar site, or through a trocar. The larger meshes, of course, will require larger orifices to introduce them. Level 5 evidence dictates that the mesh should not contact the skin. Given these data, there is a Grade B recommendation that the larger meshes should be tightly rolled for insertion. Grade C recommendation that the larger meshes should have larger trocar and/or incisions for introduction and that mesh to skin contact should be avoided.

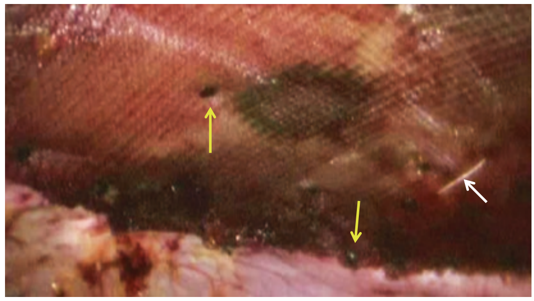
There are currently at least two different devices to which mesh if fixed to allow for positioning of the material. One incorporates a balloon assist device (Echo PS, Davol, Inc.), which is attached to the mesh, while the other has a frame to which the mesh material is attached (AccuMesh, Medtronic, Inc.). These products are quite different and are only available with the meshes of the manufacturer that produces the product. There are currently no publications that reveal levels of evidence to make any recommendation in their use. However, there many "expert" opinions that agree with the concept.

27.9.3 Mesh Fixation

Fixation is a critical component of successful hernia repair. There are a multitude of devices that allow the surgeon to achieve mesh fixation to the abdominal wall during the operation. The choice of these products should be based upon the thickness of the mesh utilized, the depth of penetration of the fastener, and whether or not the product is permanent or absorbable. Newer fasteners mimic this method of fixation and perhaps represent the future of fixation. The discussion of the various methods available to fixate these mesh products is beyond this chapter, and the reader should be aware of the options available.

There have been a number of studies that have evaluated the effectiveness of the fixation method used. A recent meta-analysis did not find any statistically significant difference in fixation relating to recurrence rates [4]. However there are at least 10 studies that have evaluated the use of sutures and tacks [8, 21, 56–63]. The recurrence rate in the 2211 patients that were in these studies was 3.65%. There have been two papers that evaluated the use of suture fixation alone [64, 65]. The recurrence rate was 1.05% in these 1121 patients. There have been at least 11 studies that evaluated the use of tack fixation alone [14, 15, 66–73]. There were 2473 patients in this group, and the incidence of recurrence was 4.5%. There is no statistical difference between the groups in either the length of follow-up or recurrence rate. This verifies the more recent evaluation of the data. There are a variety of variables that could affect the outcomes, the surgeon and his or her technique should simply be the best that be achieved. The amount of overlap of the fascial defect is more important than the method of fixation.

The statements that can be made are that at level 4, the method of fixation is no different in defining the rate of hernia recurrence. Also at this level of evidence is that the use of nonpermanent fixation devices achieves low recurrence rates. It is recommended that the sutures and/or tacks should be placed no more than 1.5 cm apart. Finally, the Grade B recommendation is that suture fixation with or without additional tacks is considered preferable (◘ Fig.27.16).



◘ **Fig. 27.16** Completed repair; transfascial sutures are marked with *white small arrow*; central row of tacks marked with *yellow up arrow*; *yellow down arrow* marks the outer row of tacks

27.10 Endoscopic Component Separation

The use of this technique has been advanced over the last several years as part of the armamentarium of the surgeon to repair complex hernias. Its use has become somewhat limited due to the fact that more patients seem to require the more extensive releases of the anterior abdominal wall fascia and musculature that ever before. This type of release accomplishes the incision of the external oblique fascia lateral to the rectus sheath. It can provide for a release of approximately 8 cm in some patients.

There are a variety of methods to approach this technique. The original method was to dissect below the costal margin near the midaxillary line to the external oblique fascia. This tissue is penetrated and dissected with either laparoscopic instruments or with the insertion with a dissection balloon of some type. The balloon is inflated to create a space between the planes of the internal and external oblique musculature. This is done under direct visualization with the laparoscope. Once this is accomplished, the external oblique fascia was divided with scissors. This may or may not require the placement of an additional trocar laterally. Some surgeons will use a single port technique near the costal margin to incise the fascia.

27

The use of this technique does eliminate the need for the dissection of large tissue flaps to expose these tissue layers, and because of this fact, the incidence of tissue necrosis due to the division of perforating vasculature is significantly decreased. Although this method does not provide the extent of mobilization of the tissue planes, as does the open method, it still allows for this to be done in certain patients. The use of the transversus abdominus release (TAR) either laparoscopically or robotically may reduce the adoption of this technique.

This technique can be combined with the laparoscopic or open intraperitoneal mesh placement or with the open sublay or onlay repair of complex hernias. Harth reported a retrospective study of open vs. endoscopic release and found that there was a statistically significant difference in wound morbidity with the open technique with no difference in rates of recurrence. However the recurrence rate was 32% (open) and 27% (endoscopic), which are very high [74, 75]. These results have been verified in other studies [76–79]. More recent publications have shown that the use of endoscopic release had no differences in the rate of wound complications between laparoscopic and open ventral hernia repair. Disturbingly, however, three patients in the total of 42 patients developed lateral hernias in the follow-up period of less than 4 years [80]. A systematic review and meta-analysis found that the recurrence rate was lower with the open component separation but was associated with higher wound complication rates [81].

The following statements can be made. The endoscopic component separation is associated with lower morbidity compared to the open method with level 3 evidence. There is also level 3 evidence that there is frequent lateral herniation with this method. Grade C recommendation is that the surgeon could utilize this intervention if they are able to do so and that the lateral compartment should be augmented.

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28.1 Introduction

In many areas of the United States, laparoscopic ventral hernia repair is an outpatient surgical procedure. As a matter of fact, the Center for Medicare and Medicaid Services considers laparoscopic ventral hernia repair an outpatient procedure, and the regulatory framework and financial reimbursements are matching that expectation. Within this framework, it is important to work with patients on the shared goal of swift recovery.

Traditionally, perioperative teams focused on understanding the operative indication and the patient's cardiovascular limitations for anesthesia. With the introduction of the enhanced recovery pathways in surgery, the surgical community is more deliberately sharing physical and cognitive preparation for surgery with our patients' before entering the operating room.

28.1.1 How I Do It

It is important for the patient to understand before surgery that they will be an outpatient and how their postoperative care and recovery can progress at home. In addition, it is important that the remainder of the perioperative team (nurses, desk staff, anesthesia team members, residents, physician assistants, pharmacists) also share and support this expectation to facilitate a successful pathway.

To set the patient on a path for an outpatient surgical course, we have applied the components of enhanced recovery after surgery (ERAS) to the laparoscopic ventral hernia repair. A discussion of postoperative pain control is part of the preoperative evaluation. We ask the patients to identify a friend or family member as a postoperative caregiver for the first night at home after surgery and to remain physically active and well hydrated. Carbohydrate loading can be a component of the preoperative diet the night before surgery. For adult patients, we limit solid food after midnight on the day of surgery; however, clear beverages up until 2 h prior to surgery are encouraged. These could be electrolyte- and carbohydrate-containing drinks or black coffee for habitual coffee drinkers to avoid dehydration and caffeine withdrawal headaches. We do not routinely employ a bowel preparation for ventral hernia repair, even if dissection of colon from the abdominal wall is anticipated.

On the day of surgery, the patient receives preemptive oral pain medication with a sip of water in the holding area prior to induction of anesthesia, usually 1000 mg of acetaminophen/paracetamol. A COX inhibitor could also be used. I personally find the acetaminophen to be easy to administer on a routine basis because of the safety profile and the few contraindications. The preemptive pain medication is ordered as part of our electronic surgical scheduling system, along with preoperative antibiotics and pharmacologic thromboembolic prophylaxis. Unless there is a special requirement, patients do not receive benzodiazepine premedication. Patients are prewarmed with hot air warming gowns in the holding area.

At the pre-procedural briefing, we review our plan for local anesthetics, ketorolac administration, and postoperative nausea prophylaxis with the team to ensure medications are available. After induction of anesthesia, we do not routinely place bladder catheters to prevent urinary tract infection and unintentional urethral injury. If the anticipated procedural length is less than 4 h, we ask the patients to use the restroom just prior to their entry into the OR. As the ERAS protocol involves limiting intravenous fluids during anesthesia to prevent postoperative nausea and vomiting, a full bladder at the end of the case is rarely observed. Patients with extensive bladder involvement in a ventral hernia may require a bladder catheter which is usually removed before extubation. For any patient with a left upper quadrant Veress needle entry, we will place an oral gastric tube that is removed at the end of the case. During the prepping of the operative procedure, attention is paid to maintenance of normothermia with limited skin exposure, room pre-warming, and heated insufflation gas. If the patient appears hypothermic, a plastic adhesive may be placed over the operative field.

During the procedure, we administer local anesthetic to the trocar incision sites and the sites of any transfascial sutures and tacks. Currently, we use a mixture of 30 cc of 0.25% bupivacaine (~4 h halftime) with 20 cc long-acting liposomal bupivacaine (halftime 48 h) for a total of 50 cc of local anesthetic to be applied to the abdominal wall. At the end of the procedure, if the patient has no contraindication to nonsteroidal anti-inflammatory drugs (NSAIDS), we will ask our anesthesia colleagues to administer 15 mg ketorolac i.v. prior to the patient being awakened. After wound closure, occlusive, water-proof surgical dressings are applied (Band-Aid plus clear plastic tape). We place an abdominal binder for patient comfort as the patient is transferred from the operating room table to the bed. If in the recovery room pain is not well controlled, an additional 15 mg ketorolac i.v. may be given if the patient has no contraindications. Alternatively (or in addition) intravenous acetaminophen is used if more than 6 h have elapsed since the preoperative dose and the patient is not yet able to take oral medications. Intravenous or oral narcotics may be necessary if pain control is still not adequate.

After the immediate postoperative recovery, the patient will return to an outpatient surgical floor. The nurses will assist the patient with ambulation and oral intake. Oral intake will be resumed within hours after anesthesia starting with liquids and advancing to a general diet as the patient tolerates. In the postoperative period, we recommend to go easy on any foods that will create significant bloating or constipation. We do not place prophylactic nasogastric tubes in the postoperative period relying on early postoperative oral intake to stimulate gastrointestinal tract activity.

In the postoperative period, we will rely heavily on oral medication. As the patient awakens, we prescribe scheduled nonnarcotic pain medication, using acetaminophen- and ibuprofen-based medication as much as possible. We will administer acetaminophen every 6 h on a scheduled basis for the next 48 h, as well as ibuprofen or other NSAID-based medication on a scheduled basis (unless there is a contraindication). The patient receives a schedule with the times of administration from the perioperative period and for the next 24 h so that it is easy to keep track (see table below). For example, if a 50-year-old, otherwise healthy patient received acetaminophen 1000 mg at 7:00 am in the preoperative holding area and ketorolac 15 mg i.v. at 10:00 am at the conclusion of the procedure, followed by an oral narcotic at 11:00 am, the patient would receive a schedule similar to this:

Medication	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00
Acetaminophen 1000 mg p.o. (q 6 h)	x						x		
Ibuprofen 600 mg p.o. (q 6 h)				x					x
Narcotic pain medication q 3–4 h, parentheses indicate as needed		(X)				(X)			

Should a patient not be able to take nonsteroidal anti-inflammatory medication, we will use scheduled tramadol, a low level narcotic, for the first 48 h. This medication would then replace ibuprofen/NSAIDS in the postoperative instructions. In addition to the non-opioid medication, we will offer oral narcotics (non-acetaminophen/NSAID containing) as needed. Patients with significant muscle cramping may also benefit from a benzodiazepine for muscle relaxation. Other adjunct measures include warm blankets, music, massage (e.g., foot massage for relaxation), and distraction.

Of note, it is important to remember that pain perception is different by gender and age. In general, patients less than 40 years of age will have a need for a higher dose of pain medication than patients older than 40. Women will frequently need more pain medication than men. Thus, in my practice I expect to prescribe more narcotic pain medication for a woman less than 40 years of age who is undergoing a hernia repair than for a man over the age of 70.

Intolerance of a certain pain medication (e.g., nightmares or nausea/vomiting after a certain narcotic) may prompt the patient not to take the prescribed medication only to then be readmitted to the hospital for poor pain control. It is important to discuss preoperatively which pain medications may have been successful for the patient in other circumstances. If a patient has had good experience with hydromorphone hydrochloride versus another opioid, we try to accommodate this. Matching the patients' preferred pain medication (within a reasonable framework – not to support an addiction) is important to achieving good pain control and patient satisfaction [1]. Again, we will reinforce that some of the recovery will indeed happen at home and that the patient is functional although limited by postoperative pain. The patient will return home with a phone number where they can reach the team 24/7 with any questions or problems.

With this regimen, we have significantly decreased our overall need for narcotic pain medication for patients undergoing laparoscopic ventral hernia repair [2]. In turn, this was associated with reduction in the length of stay (LOS) and the number of postoperative complications within 30 days postoperatively as measured by the ACS-NSQIP (American College of Surgeons National Surgical Quality Improvement Program) data. The GI function returns earlier. We aggressively pursue a bowel regimen to counteract the narcotic side effects on the GI tract. We recommend the patient take a laxative, not just a stool softener, for the duration of the time that they require narcotic pain medication, including tramadol. The patient can shower on postoperative day 1 and is asked to remove the surgical dressing 48 h postoperatively at home, following CDC guidelines.

After the patient is discharged, a member of the team will call the patient within 48 to 72 h after discharge to check on their wellbeing. The postprocedural phone calls often are helpful in discovering slow GI recovery, and medication can be adjusted or additional pain medication (such as a lidocaine cutaneous patch) provided.

28.1.2 Is What I am Doing Evidence Based?

Guidelines and studies specific to laparoscopic ventral hernia repair are few. Much of our current care pathway is based on enhanced recovery pathway publications in colorectal surgery, starting with the concepts as outlined by Kehlet and Morgenson in 1999 [3]. The components of ERAS are preoperative, intraoperative, and postoperative. Preoperatively, patient education, fluid and carbohydrate loading, avoiding bowel preparation, and prolonged fasting are included as well as antibiotic and thromboembolic prophylaxis. Intraoperatively, avoiding fluid overload and maintaining normothermia are important. Drains and tubes are limited, effective analgesia begins before induction. Postoperatively, effective non-opioid oral analgesia, early oral nutrition, stimulation of gut motility, and preventing nausea and vomiting are included.

Central to the enhanced recovery for patients undergoing laparoscopic ventral hernia repair is postoperative pain control [1, 4]. A review by Rawal [5] described acetaminophen/NSAIDS with infiltrative local anesthetics as the most effective components of multimodal analgesia for many surgical procedures. For laparoscopic ventral hernia repair, this is supported specifically by small randomized trials by Mitchell, Bellows, Gough, and Fields [4, 6–8]. Opioids will often still be necessary but should be given orally to maximize steady pain control. Intravenous pain medication, including patient-controlled analgesia, not infrequently leads to peaks and valleys in the pain curve and results in higher total opioid doses. In addition, elastic abdominal binders may aid in patient comfort [9, 10] as may lidocaine dermal patch application [11].

The other ERAS components have been nicely summarized in Steenhagen's 2016 [12] review for abdominal surgery. Below we highlight several factors included in this review that are important for patients undergoing laparoscopic ventral hernia repair:

- Preoperative personalized patient counseling is an independent risk factor for ERAS success [13].
- The entire team needs to be on the same page [14–17].
- Avoiding long starvation and administration of carbohydrate fluid minimize postoperative insulin resistance [18–20], which is associated with increased morbidity, mortality, and length of hospital stay [21]. A Cochrane database review found that aspiration pneumonitis was not reported in any patients; a small reduction in LOS however was found [22].
- Early postoperative feeding reduces the risk of infection and LOS [23–26].
- Postoperative laxatives counteract the opioid side effects and may promote early bowel function [27].
- Routine nasogastric decompression leads to increased pulmonary complications, delayed return of GI function, and longer LOS [28].

We have published the data resulting from our efforts integrating evidence-based enhanced recovery concepts for abdominal surgery in our laparoscopic ventral hernia practice in 2015 [2]. The efforts resulted in a decreased LOS, decreased use of narcotics, reduced complication rate, and a cost reduction of 10% for the health system. The effort to introduce the concepts in our system was accomplished over time and involved conversations with many practitioners and patients. We continue to evaluate and fine-tune the pathways as new pain medication and evidence become available.

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Complications, Pitfalls and Prevention of Complications of Laparoscopic Incisional and Ventral Hernia Repair and Comparison to Open Repair

Asuri Krishna, Virinder Kumar Bansal, and Mahesh C. Misra

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29

29.1 Introduction

LeBlanc and Booth in 1993 [1] first reported laparoscopic repair of a ventral and incisional hernia (LIVHR). With the development of newer prosthetic devices and fixation devices, laparoscopic repair has found its applicability not only in primary ventral and incisional hernia repair but also in parastomal and parapubic hernias. According to the recent IEHS guidelines, laparoscopic repair is considered the standard of care for management of patients with ventral and incisional hernia [2]. LIVHR is a very safe procedure and provides patients all the benefits of laparoscopic surgery like early return to activity and shorter hospital stay. However, unlike other laparoscopic procedures, although pain is less in laparoscopic repair as compared to open repair, still it is associated with considerable pain in the postoperative period because of the use of mesh fixation devices like tackers. LIVHR is associated with certain intraoperative and postoperative complications which are important to be diagnosed and managed [2].

29.2 Bowel Injury

The incidence of bowel injury during LIVHR has been reported to vary from 6% to 14.3% [3, 4]. These bowel injuries may result in mortality also which has been reported to range from 0.05% to 3.4% [3, 5–7]. However, in patients in whom the enterotomy is missed, the mortality rises significantly and ranges from 7.7% to 100% [3, 5–7]. In a recent review, several risk factors that increase the chances of enterotomy have been identified which include extensive adhesiolysis taking longer than 3 h, chronic obstruction, inflamed bowel, and mesh incorporation into bowel (acc. to Timoney, Rim, Ferzli in [2]).

LeBlanc et al. reported an iatrogenic enterotomy incidence of 1.78% with LIVHR and an overall mortality rate of 2.8% [5]. In the subset of patients whose injury was missed during the initial operation (18%), the mortality rate reached 7.7%. Predictably, the small bowel was injured in 92% of the reported cases. A recent Cochrane review showed an iatrogenic enterotomy rate of 1.5% with LIVHR versus 0.63% with the open approach [5, 8–11]. The risk of bowel injury exists with open repair also, but its recognition during laparoscopic repair is more difficult, and the injury may be missed which has got a worst prognosis. Comparison of bowel injury in open and laparoscopic repair has been reported in six RCTs, and pooled data from these six RCTs shows a bowel injury incidence of 0.1–4% vs 0.1–0.63% in laparoscopic repair compared to open repair [9, 12–16]. According to these studies, after laparoscopic procedures, the risk for an injury of the bowel seems to be increased; however, the difference is low (Rohr/Lang in [2]).

Injuries to the bowel during laparoscopic surgery can be divided broadly into three categories (Timoney, Rim, Ferzli in [2]):

1. Iatrogenic injuries recognized immediately by either from trocar insertion or during adhesiolysis
2. Missed injuries which are recognized in the early postoperative period (12–24 h)
3. Delayed injuries which are thermal injuries due to dissection with monopolar cautery or ultrasonic dissection which present after 5–7 days [17–19]

Avoiding bowel injury is of utmost importance during LIVHR. During access the pneumoperitoneum can be created either via an open or closed technique. Special techniques like optical trocars (VISI PORT) can also be used. However, there is level 1 evidence stating that there is no difference in the incidence of visceral injury following any of these techniques and surgeons' experience and preference is the key to choosing the method of access. Palmer's point (LUQ) is the preferred site for initial access for midline hernias as this has the minimum adhesions and the abdominal wall is thinnest here. One has to ensure that the stomach is completely deflated and there is no splenomegaly before using the Palmer's point. Sharp dissection should always be used in areas of dense adhesions (▣ Fig. 29.1). Again, the use of energy sources close to bowel may cause delayed injuries, with significantly increased morbidity and mortality. Dividing the peritoneum avoids injury to the bowel [17].

Management of intraoperatively detected bowel injuries is controversial (▣ Fig. 29.2). There are several options in such situations depending upon the extent of bowel injury, the part of bowel which is injured, level of contamination, and experience of the surgeon. Conversion to lapa-

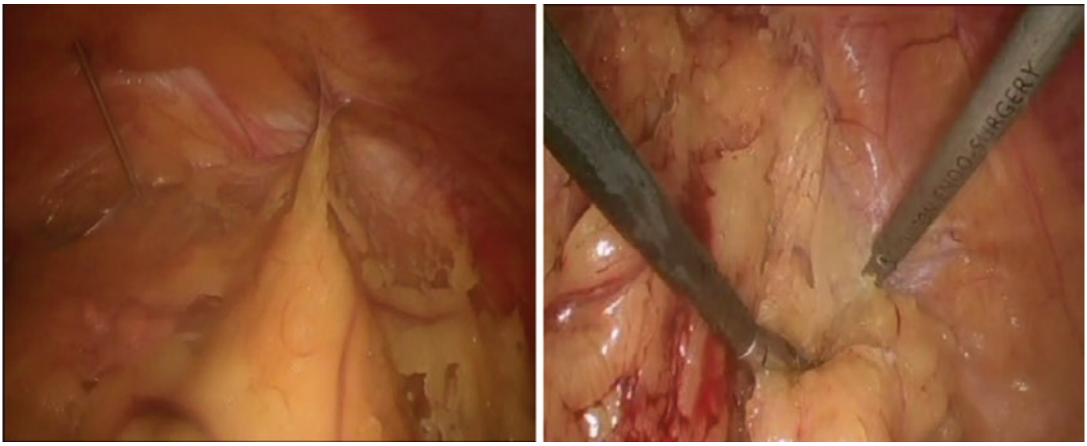

Fig. 29.1 Dense omental adhesions in incisional hernia

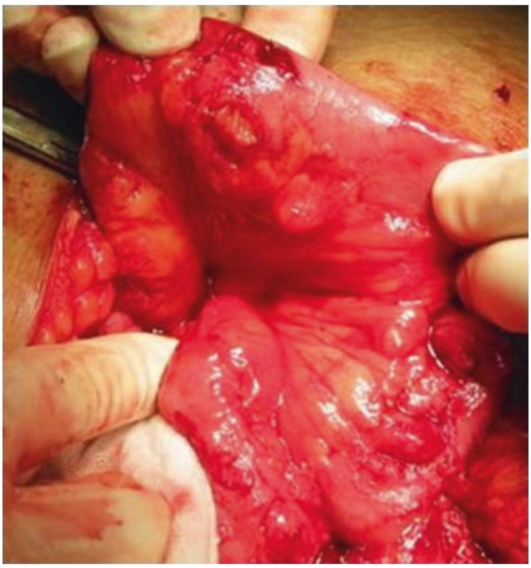

Fig. 29.2 Intraoperatively detected small bowel injury during laparoscopic IPOM

rotomy followed by bowel repair and anatomical closure is the safest option [11, 21]. If the contamination is minimal, a small incision can be given and bowel repaired extracorporeally followed by closure of the incision and laparoscopic mesh placement [11, 21]. Some studies also have reported either open or laparoscopic repair followed by a delayed repair of the incisional hernia after 7–10 days once the patient recovers and the intra-abdominal infection subsides [17, 20].

In 2010, Itani et al. [9] reported a series of 73 patients who underwent conversion to an open technique for bowel injury with minimal contamination during LVHR. In three patients, the enterotomy was repaired, and the herniorrhaphy was performed with polypropylene (PP) mesh laparoscopically. None of the patients who underwent conversion to laparotomy, including those in whom mesh was placed, experienced a surgical-site infection. Lederman and Ramshaw [17] reported a series of nine patients who sustained an iatrogenic enterotomy during LVHR. After repair of the injury, the patients were observed for an average of 3 days while receiving intravenous antibiotics. With this regimen, seven of the nine patients had successful completion of their LVHR [17].

Some authors prefer the use of biologic mesh over synthetic mesh for LIVHR in the presence of contamination. In 2004, Franklin et al. [22] described their experience with the use of porcine-derived prosthetic mesh in 43 patients who underwent successful LVHR in a contaminated field. Details of the contamination are vague but included bowel resection, strangulation, and prior mesh infection. One patient experienced a wound infection and a fistula. The authors report no recurrences, but for definite assessment the follow-up period is too short.

In the recently published "Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias" of the International Endohernia Society (IEHS) risks, management and prevention of injuries to the bowel are described and discussed in detail [2]. Regarding unrecognized enterotomies, Karl LeBlanc analyzed 174 papers and found a higher rate of this kind of injury in laparoscopy, but the difference to the open technique was statistically not significant [2, 8, 15, 23, 24].

Evidence-based statements and recommendations acc. to Timoney, Rim, and Ferzli in [2]*:*

(Only Level 1 and 2 studies as well as Grades A (must), B (should), and C (can) recommendations are given.)

"Statements"

- **Level 1**: The incidence of iatrogenic enterotomy during laparoscopic ventral hernia is 1.78%. The mortality rate for these patients is 2.8%

  In most cases (92%), the small bowel is injured

  The most frequent causes are rough adhesiolysis and the use of energized dissection close to the adherent bowel

"Recommendations"

- **Grade C**: Adhesiolysis should be performed close to the abdominal wall and not near the bowel

  Sharp dissection techniques should be preferred, and the use of energized dissection near the bowel should be avoided

  Conversion to laparotomy is advisable if the surgeon is not proficient with laparoscopic bowel repair techniques

  A primary open repair is advisable in the presence of gross spillage. An open prosthetic repair may be undertaken if conditions remain sterile

  A small laparotomy away from the hernia defect may be used to repair a bowel injury and may be followed by continuation of LIVHR

  If a bowel injury is repaired laparoscopically, LIVHR may be performed after an observation period of 3–7 days on parenteral antibiotic therapy if no evidence of infection is observed

  An LIVHR may be performed in the event of bowel injury repaired immediately with minimal spillage, but this option requires experience with laparoscopic repair of bowel injury

"Statements" regarding intraoperatively unrecognized bowel injuries acc. to LeBlanc and Rohr in [2]

- **Level 2A**: Among patients in whom the enterotomy is missed, the mortality rises significantly and ranges from 7.7% to 100%

  Reoperation will be necessary

  The safest approach is open repair, resection of the injured bowel segment, mesh explantation, and primary repair of the fascial defect

"Recommendations" regarding intraoperatively unrecognized bowel injuries acc. to LeBlanc and Rohr in [2]

- **Grade B**: Surgeons may use either open or laparoscopic approach to re-explore if there is a suspicion of a missed iatrogenic enterotomy or to repair the injury

  Resect the injured segment or create a stoma depending on the injured organ and the clinical situation
- **Grade C**: Mesh explantation should be performed

  According to the current evidence after mesh explantation, hernia should be repaired primarily if feasible

29.3 Infection

The infections following incisional and ventral hernia repair range from superficial surgical-site infections (SSI) (◘ Fig. 29.3) to mesh infections and deep organ infections (◘ Fig. 29.4). The presence of SSI significantly increases morbidity and mortality of an incisional and ventral hernia repair [25]. The superficial surgical-site infection usually manifests as pain, erythema, and tender swelling. They are managed with adequate drainage, dressing, and oral antibiotics. The overall incidence of infections following incisional hernia repair is 10–12% with higher rates following repair for recurrent hernias. The risk factors that predispose to infections can be broadly classified into patient-related and surgery-related factors.

Fig. 29.3 Marginal skin necrosis following open component separation repair of large incisional hernia

Fig. 29.4 Wound infection with exposed mesh following open repair of incisional hernia

29.3.1 Patient-Related Risk Factors

These include:

1. Age
2. Comorbidities like CAD (coronary artery disease), diabetes, and COPD
3. Malnutrition and immunosuppressed states
4. Obesity
5. Smoking
6. Steroid use

Gender and SSI are not correlated, but wound infection in 15- to 24-year-old patients averages 10% and increases significantly in patients older than 65 years [31, 32]. Dunne et al. [33] reported CAD, COPD, and low preoperative serum albumin as independent predictors for infection in elderly patients. Smokers and patients receiving immunosuppressant and steroids also have a greater risk of contracting infection.

The risk of infection increases fivefold for smokers and by 9% for patients receiving steroids [32]. Current smoking was 1.5 times more prevalent in subjects with postoperative wound infections than those without infections. Based on these findings, at least temporary smoking cessation prior to elective hernia repair should be considered, especially in complex hernia procedures.

Diabetes and malnutrition also are significant risk factors for infection [34]. Obesity decreases the blood circulation in fat tissue and increases the risk of infection [35]. Other factors such as history of infection, high ASA grades, hypoxia, hypothermia, radiation, and peripheral vascular disease also contribute to an increased risk of SSI [36–39] in patients undergoing incisional and ventral hernia repair.

29.3.2 Surgery-Related Risk Factors

These include:

1. Technique of part preparation
2. Operation time
3. Requirement for blood transfusions
4. Bowel injuries
5. Mesh-related factors

The preoperative factors increasing the risk of infection include shaving of the surgical site, short duration of scrubbing, antiseptic use, and blood transfusion. The SSI rate was 5.6% for patients who had hair removed by razor compared with 0.6% for patients who either had their hair removed by depilatory agents or had no hair removal [40]. Blood transfusion increases the risk twofold [41]. Long operating time also predisposes to the risk of infection. Procedures longer than 3–4 h increase the risk [36]. Also, blood loss during surgery is a significant risk factor. Postsurgery complications such as seroma, thromboembolism, pulmonary embolism, postprocedure pneumonia, and anemia make the patient more susceptible to infection [46].

The reported incidence of infection is 10% for open procedures and 1.1% for laparoscopic procedures [26]. Many single-site studies have reported lower infection rate following laparoscopic repair as compared to open repair. Laparoscopic procedures lower the risk of infection by reducing wound size, hospital stay, operative time, and the probability of bacteria entering the subcutaneous space [27–30]. Sauerland et al. [8] in a meta-analysis reported lower local wound infection rate following laparoscopic repair as compared to open repair (3.1 versus 13.4%, $p = 0.00001$). In a pooled data analysis by Pierce et al. [47], wound infections were found in 1.3% of cases after laparoscopic repair, whereas after open operation, the wound infection rate was 10.9% ($p = 0.0001$).

To prevent infection, management of these risk factors is important. The risk factors that can be modified should be addressed and managed by adherence to established guidelines and protocols. Cessation of smoking before the surgery reduces the risk of postoperative SSI in addition to other cardiovascular and respiratory benefits. Strict preoperative glycemic control with maintenance of intraoperative normothermia is necessary. Remote infection, especially when mesh is being implanted, should be treated and resolved completely before the surgery. Preoperative hair removal should be avoided, and clipping should be performed instead. Prophylaxis with broad spectrum antibiotics at induction and second dose repeated after six hours is recommended. During surgery, careful attention to proper surgical technique and timely completion of the operation also reduce the risk of SSI.

Evidence-based statements and recommendations acc. to Chowbey in [2]:

"Statements"

- **Level 1**: Preoperative transfusion may increase the risk of surgical-site infection (SSI)

  Laparoscopic operations lead to a lower incidence of SSI than open operations because the total length of the incisions is shorter, reducing the risk of bacteria entering the subcutaneous space
- **Level 2**: In elderly patients, chronic obstructive pulmonary disease (COPD) and low preoperative serum albumin are independent predictors of wound infections; coronary artery disease (CAD), COPD, low preoperative serum albumin, and steroid use are independent predictors of a longer hospital stay

  Patients who undergo LIVHR with a simultaneous bowel resection show a higher incidence of infectious and non-infectious complications with mesh use

  Wound infection is lower in laparoscopic hernia repair than in open repair due to the decreased extent of tissue dissection

  Mesh, wherever possible, should not be brought in contact with skin to avoid contamination by skin flora. Polyester meshes are associated with the highest incidence of infection, fistualization, and recurrence

  Patients given a prophylactic antibiotic have a lower incidence of SSI

"Recommendations"

- **Grade A**: Laparoscopic repair is associated with a lower risk of SSI and thus is preferred over the open approach

  Before surgery, known risk factors for SSI must be treated if possible

  The operation time and hospital stay must be as short as possible
- **Grade B**: Smoking cessation, glycemic control, and treatment of remote infections should be done before surgery

  Prosthetic mesh insertion with simultaneous bowel resection should be avoided
- **Grade C**: Preoperative clipping of hair is recommended

  Weight loss before the operation may be considered

29.4 Mesh Infection

Mesh infection is one of the most dreaded complications following an incisional hernia repair which can cause a significant morbidity and even mortality. This can manifest not only as subtle SSI (Fig. 29.5) but also open nonhealing wounds (Fig. 29.6). The reported incidence of mesh infection after laparoscopic repairs is 0–3.6% [43]. A mesh infection rate as low as

Fig. 29.5 Mesh infection presenting as chronic discharging sinus following open mesh repair of incisional hernia

Fig. 29.6 SSI and mesh infection following open mesh repair of incisonal hernia

0.78% after laparoscopic repair was reported in a systematic review by Carlson et al. [24]. Polyester meshes and meshes positioned subcutaneously are associated with a high incidence of infection [43, 44]. The use of prosthetic mesh with bowel resection or injury increases the risk of infection manifold [45].

An important advantage of the laparoscopic intraperitoneal onlay mesh (IPOM) technique over open repair of incisional and ventral hernias is the lower rate of wound and mesh infections. This can be attributed to several factors such as lesser mesh handling, as the mesh is introduced via trocars hence a lesser chance of coming in contact with the skin. Karl LeBlanc demonstrated that laparoscopic repair of incisional and ventral hernias significantly is attended by fewer wound infections and less need for mesh removal (Fig. 29.7) [20]. In the meta-analysis by Sauerland et al. [8], a local infection requiring mesh removal was found in 0.7% of the laparoscopic group and 3.5% of the open group (p = 0.09). In a pooled data analysis by Pierce et al. [47], after laparoscopic repair, mesh infections were found in 0.9% of the cases, whereas after open operation, the mesh infection rate was 3.2% (p = 0.0001). In a large clinical case series and case analyses, mesh infections were detected after laparoscopic IPOM in 0.78% (n = 6206) [24], 0.90% (n = 4.582) [47], and 0.70% (n = 850) [11] of the patients.

In addition to the patient- and surgery-related factors outlined above, type of mesh is a

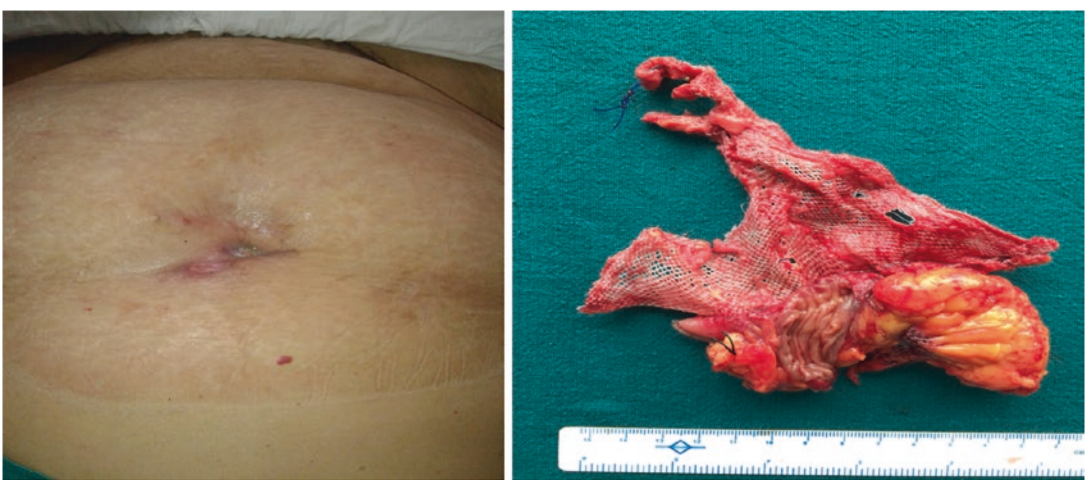

Fig. 29.7 Mesh infection following lap IPOM presenting as discharging sinuses resulting in mesh explantation

significant predictor of mesh infection. This correlates not only with mesh infection but also the salvageability once mesh infection sets in.

In a comparative study, Hawn et al. [106] demonstrated that in contrast to plypropylene (PP) mesh, PTFE-associated mesh infection was rare but when it occurs it cannot be eradicated and invariably results in explantation of the mesh. They have reported significantly less need to remove a PP mesh than a PTFE mesh because of a mesh infection (*p*\0.0001). Morris and Hughes [48] published a review on the use of intra-abdominal nonabsorbable mesh in clinical and experimental settings and showed that polypropylene and polyester meshes were found to be better incorporated into tissues than ePTFE which appeared to be related to pore size. Polypropylene showed a lower incidence of infection than ePTFE or polyester meshes.

In a literature review, Finan et al. [42] observed that absorbable mesh, which is likely a surrogate marker for a more complex hernia repair, was associated with a fourfold increased rate of wound infection, whereas permanent mesh use was associated with an increased risk of wound infections.

How can these mesh infections be prevented? As outlined previously patient-related modifiable factors need to be addressed preoperatively. Remote infection should be treated and resolved completely before the surgery. Preoperative hair removal should be avoided, and clipping should be performed instead. Prophylaxis with broad spectrum antibiotics at induction and second dose repeated after six hours is recommended. During surgery, careful attention to proper surgical technique and timely completion of the operation also reduce the risk of mesh infection. The mesh should be handled as less as possible. The surgeons should change his gloves before handling the mesh. The mesh should not be opened at the beginning of surgery but only when the dissention is completed. Various authors have also advocated dipping of mesh in bactericidal solutions like 10% betadine and chlorhexidine solution to decrease mesh infection. However, there have been conflicting reports and lack of level I evidence advocating such maneuvers.

In the literature, case reports on the treatment of mesh infections after laparoscopic repair of incisional and ventral hernias discuss both mesh removal [49, 50] and mesh salvage [51, 52]. For interventional and conservative treatment of a mesh infection after laparoscopic repair of incisional and ventral hernias, Aguila et al. [51] and Trunzo et al. [52] advocate percutaneous drainage of accumulated pus around the mesh and insertion of a drain through which irrigation with gentamycin 80 mg in 20 ml saline solution three times daily together with intravenous antibiotic treatment. Treatment of mesh infection also depends on the material used. Sanchez et al. [54] reported mesh infection in 8.1% of patients after the use of ePTFE and in 3.9% after the use of PP. They further reported that infected ePTFE mesh salvage was not possible in any patient, in contrast to infected PP mesh which could be salvaged in all patients. Hence, the chances of mesh salvage after infection are greater with PP meshes than with ePTFE meshes, which usually have to be explanted. If an interventional conservative attempt at treating a mesh infection after laparoscopic IPOM proves unsuccessful or if from the outset the circumstances no longer allow preservation of the mesh, various options can be used for mesh infections after mesh repair of incisional and ventral hernias, including [53–56]:

- Mesh removal and primary skin closure, with the repair repeated after 6–9 months
- Mesh removal, repair using the component separation technique, with the skin left open and vacuum-assisted wound closure or open wound dressing applied (Fig. 29.8)
- Mesh removal, repair of the defect with a biologic mesh, leaving the skin open and applying vacuum-assisted wound closure or open wound dressing (Fig. 29.9)
- Mesh salvage, with the skin left open, and vacuum-assisted wound closure or open wound dressing applied

The treatment options available in the literature relate only to individual cases or to small case series; currently, no concrete evidence-based recommendation can be made for the optimal management that gives the best results. Instead, the surgeon must decide in the individual case which option is best for the individual patient. Further studies are definitely required in this difficult area.

Evidence-based statements and recommendations acc. to Köckerling, Chowbey, and Misra in [2]:

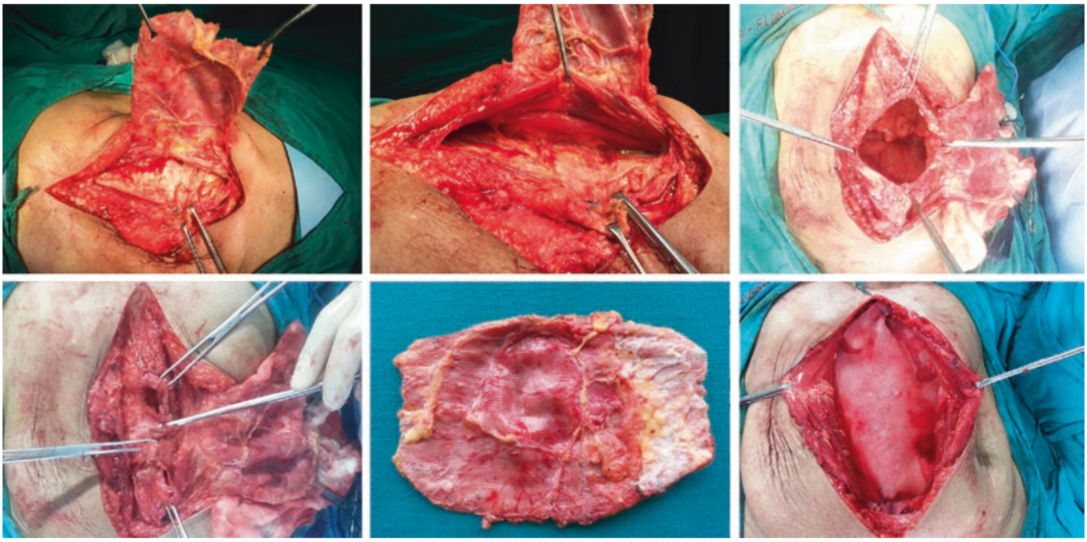

Fig. 29.8 Mesh removal and component separation with mesh repair for recurrent incisional hernia following open repair

Fig. 29.9 Mesh infection presenting as discharging sinus following open onlay mesh repair

"Statements"

- **Level 1A**: The rate of mesh infections after laparoscopic ventral and incisional hernia repair is low (1%)
  The mesh does not need to be removed in all cases of wound infection after laparoscopic ventral and incisional hernia repair
- **Level 2**: Infected expanded polytetrafluorethylene (ePTFE) meshes require removal significantly more often than PP-based meshes

"Recommendations"

- **Grade B**: An infected ePTFE mesh after laparoscopic ventral and incisional hernia repair should be removed

29.5 Seroma

Seroma is a collection of serous fluid in the hernia sac following incisional and ventral hernia repair. The development of a seroma is so common after a laparoscopic incisional and ventral hernia repair that many surgeons do not believe it to be a real complication. However, this seroma is not only cosmetically disfiguring for the patient but also gives a feeling of recurrence or surgical failure to the patient. Seroma as a complication is unique to laparoscopic repair and very rare following open repair. It is probably due to the fact that in laparoscopic IPOM repair after the contents are reduced, the hernia sac is left in situ which creates a potential space for blood, lymph, and reactionary fluid to accumulate and take the form of a seroma.

29.5.1 Risk Factors

29

The following risk factors have been identified for seroma formation following incisional and ventral hernia repairs: an irreducible hernia, an increased number of prior abdominal incisions, a large defect (Fig. 29.10), and obesity. The major cause for seroma formation is most likely the large dead space between the mesh and the abdominal wall.

The reported incidence of seroma after LIVHR varies widely from 3% to 100%, with a peak presentation at 7 days postoperatively and almost complete resolution by 90 days after surgery [23, 57–61]. One study reported that the incidence of seroma formation was 100% in all the patients that were followed with ultrasonic studies [59]. An overall review of the current literature calculates this incidence of clinically significant seromas to an average of 4–5% of patients after LIVHR. According to the current literature, up to 35% of patients with seroma will become symptomatic with pain, pressure, or erythema [61] and few patients will develop a chronic seroma (Fig. 29.11).

There is no technique/method described in the literature which will prevent seroma formation. The transabdominal preperitoneal repair for primary ventral and umbilical hernias may decrease the likelihood of seroma formation [61]. Randomized trials yield conflicting results regarding the likelihood of seroma formation with laparoscopic or open repair [23, 62]. Kirshtein attempted to pierce the biomaterial with the Veress needle but found that omitting this step did not have any appreciable effect upon the incidence of seromas [63]. Others have used the DualMesh with holes (W.L. Gore & Associates, Inc., Flagstaff, AZ, USA), but this, too, is associated with a postoperative seroma rate of nearly 12% [21]. Therefore, perforation of the mesh or even the use of polypropylene offers any benefit in the prevention of seromas [62, 64, 65].

Some authors have tried to use preemptive measures, such as the application of electrocautery, or the ultrasonic energy to the sac with the use of a single

Fig. 29.10 Large incisional hernia in a 50 year old lady with H/O open hysterectomy

Fig. 29.11 Large seroma 2 weeks following laparoscopic incisional hernia repair

suture in the center of the hernia defect to fixate the prosthetic material [66, 67]. A small randomized study found that if the hernia sac was cauterized by electrocautery or ultrasonic energy, the seroma frequency was decreased from 25% to 4% [66]. Other similar trials have reported that placing a quilting stitch or double-crown stapling to decrease the dead space did not affect seroma formation [67, 68]. Another technique which has been used is the closure of defect with shoelace technique prior to mesh placement. However, this is restricted to small defects (<5 cm in size). Most of the studies suffer from small numbers. Many surgeons will place an abdominal binder or a compression dressing over the defect site while the patient is still on the operating table. This will be worn for at least 3–14 days, depending upon the initial size of the protruding hernia. The size of the binder, the length of time that it is used, and whether a bulky dressing is used have not been standardized, but these seem to decrease both the size and duration of the seromas that are clinically significant by as much as 50% [65]. The importance of applying a pressure dressing has been supported by only one study with methodologic limitations [72].

Most surgeons believe that majority of these seromas will resolve usually within 3 months [63, 66, 69, 70]. Aspiration is indicated only when the patient remains symptomatic for longer than 6 months and the ultrasonic evidence does not reveal any significant resolution of the seroma. If the patient is obviously symptomatic with a degree of pain, this will be necessary earlier than that time. It must be remembered that strict sterile technique is necessary, as bacteria can be introduced into the fluid collection [71, 72].

It is best recommended that the patients should be informed about the possible occurrence of seromas and the expectation that the majority will resolve spontaneously. Given the clinically important consequences of mesh infection as a possible complication of repeated seroma aspiration, this recommendation also may be considered stronger (Fig. 29.12).

Evidence-based statements and recommendations acc. to Bingener and Rohr in [2]*:*

"Statement"

- **Level 2B**: Up to 30% of patients who experience development of seroma become symptomatic

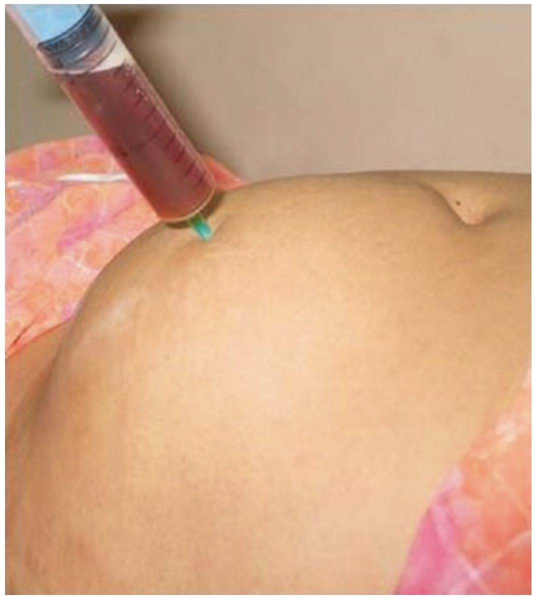

Fig. 29.12 Seroma being aspirated 6 weeks following laparoscopic IPOM

"Recommendation"

- **Grade B**: Patients should be informed on the possibility of both asymptomatic and symptomatic seroma formation

"Statements"

- **Level 2B**: Trial about the incidence after laparoscopic and open repair presents with opposing results
- **Level 2B**: Nonreducible hernia is a risk factor
- **Level 2B**: The incidence increases with the number of prior abdominal incisions
- **Level 2B**: Cauterizing of the hernia sac may lead to less seroma formation
- **Level 2B**: Placement of a quilting stitch does not affect seroma formation
- **Level 2B**: Double-crown stapling does not decrease seroma formation

"Recommendations"

- **Grade C**: Surgeons can attempt cauterization of the hernia sac to prevent seroma formation

- **Grade C**: Surgeons may place a pressure dressing in an attempt to reduce the incidence of seroma

"Statements"
- **Level 2B**: The majority of seromas resolve spontaneously
- **Level 2B**: The length of abdominal binder use does not affect seroma formation

29

29.6 Pain

Unlike other laparoscopic procedures, LIVHR is associated with considerable pain in the postoperative period mainly because of the use of fixation devices like tackers. Different theories have been proposed for the genesis of this pain:
1. Local muscle ischemia because of the full-thickness transfascial sutures.
2. Irritation of nerve fibers in parietal peritoneum by the tackers.
3. Nerve entrapment in the tackers and sutures.
4. The efficacy of mesh repair is based on the formation of a strong mesh aponeurotic scar tissue complex (MAST complex). But inflammation beyond the optimum range may entrap neural structures, leading to chronic pain.

The pain due to tackers is different from port site pain. This pain is usually most severe in the immediate postoperative period and tends to decrease over a period of time. The pain is usually exaggerated by movements which put the abdominal muscles into contraction like coughing, sneezing, and getting up from bed. However, one must remember that the perception of pain is very subjective and varies between individuals. The pain can present as an acute pain or as a chronic pain (persisting for more than 3 months). Various factors responsible for chronic pain have been cited including type of mesh fixation, defect closure, recurrent incisional hernias, and type of mesh.

29.6.1 Pain and Type of Fixation: Suture or Tacks

The pain in laparoscopic incisional and ventral hernia repair is related to mesh fixation with either tacks or sutures. The pain due to fixation differs from that at port sites. Wasseneaar et al. [73], in a randomized trial of three types of mesh fixation methods (Tacks + absorbable sutures vs tacks + nonabsorbable sutures vs only tacks), reported no significant differences among the groups in VAS scores at any assessment time or in the change in VAS score from preoperative to postoperative evaluations.

Beldi et al. [74], in their randomized controlled trial, reported significantly higher pain following suture fixation at 6 weeks, but no difference was found after 6 months. Pain after mesh fixation with transfascial sutures is likely due to nerve irritation or entrapment and the relatively small distance between individual sutures. They explained it could be in response to desensitization of entrapped nerve fibers or in response to resolution of local inflammation. So they suggested surgical revisions due to nerve irritation not earlier than 6 months postoperatively.

However, Bansal et al. [75] in their randomized controlled trial showed persistently higher pain scores in the patients who had undergone tacker mesh fixation in the early postoperative period (1, 6, and 24 h) as well as during follow-up, and the difference between the two groups was statistically significant at all time intervals.

However, Schoenmaeckers et al. [76] published a study comparing 40 patients who underwent a "free-tacking" double-crown fixation without specific efforts to minimize the number of tacks used with a prospective cohort of 40 consecutive new patients who underwent double-crown fixation using the minimal number of tacks considered to provide an adequate fixation of the mesh. They reported significant difference in postoperative pain only at the 3-month postoperative assessment (VAS score of 5.78 vs 1.80; $p = 0.002$) and concluded that although postoperative pain differed significantly at the 3-month follow-up assessment, both VAS scores were so low that from a clinical point of view, the difference seemed irrelevant. So fewer tacks do not create less pain nor do more tacks create more pain. The absence of a correlation between the number of tacks used and postoperative pain may indicate that pain after laparoscopic repair of small ventral hernias is possibly generated according to some "threshold" principle rather than according to a cumulative effect created by more points of fixation.

Sharma et al. [77] in a single-center retrospective review of 1242 patients who had underwent laparoscopic ventral/incisional hernia repair showed 14.7% (182 patients) developed chronic pain, and the highest incidence of chronic pain was seen in patients in whom transabdominal sutures and tacks were used together. However, the association was not significant ($p = 0.078$). Chelala et al. [78], in their study of 400 patients who underwent transabdominal suture fixation and closure of the defect with a follow-up of 28 months, published that 97.5% of their patients were pain-free, with no residual pain from either the transabdominal suture fixation or closure of the defect. Seven patients (1.75%) reported chronic pain, which gradually resolved, and three cases (0.75%) required the excision of a neuroma at the site of suture fixation. They tied the free ends of the sutures softly on the aponeurosis after all complete deflation to reduce the incidence of postoperative residual pain. They believed that hard deep fixation of the knot under total pneumoperitoneum may lead to increased postoperative pain.

The reported incidence of chronic pain after closure of the defect in two large studies by Chelala et al. [78] and Franklin et al. [44] has been 2.5% and 3.1%, respectively. This may indicate that closure of the defect with subsequent traction may even contribute to chronic postoperative pain.

The mesh material also may play an important role in the causation of pain. Bansal et al. [75, 79] investigated the association of acute and chronic pain with the type of mesh and did not find any difference in pain scores between heavyweight PP mesh and lightweight barrier-coated meshes. Currently, large numbers of lightweight composite meshes are available that are claimed to produce optimum fibrotic reaction and to decrease the incidence of chronic pain. However, not many available studies have compared the composite meshes with the PP meshes.

Two systematic reviews of RCTs report on acute postoperative pain after laparoscopic versus open incisional hernia repair. The Cochrane review [8] (meta-analysis of 10 RCTs), comprising 880 patients, included 4 RCTs (Asencio et al. [12], Barbaros et al. [80], Misra et al. [81] and Pring et al. [82]) that measured pain after surgery, and in all RCTs, the intensity of pain was similar between the open and laparoscopic repair groups. Sajid et al. [83] analyzed five RCTs and reported similar findings of no difference in overall postoperative pain between laparoscopic and open repairs ($p = 0.84$).

The incidence of chronic pain after laparoscopic incisional and ventral hernia repair is reported to range from 1% to 3% [84]. Only two RCTs reported on chronic pain in laparoscopic ventral hernia repair versus open repair. Asencio et al. [12] reported no significant difference in mean pain scores in follow-up assessments at 3 months and 1 year. Also Itani et al. [9] reported that the mean worst pain after 1 year was significantly less in the laparoscopic group (15.2 mm lower on a visual analog score of 0–100 mm), but the mean pain score values for both groups were not included.

Reviews by Pierce et al. [47] (review of 14 paired and 31 unpaired studies), Müller-Riemenschneider et al. [85] (review of 14 comparative studies), and Cassar et al. [86] (review of 19 studies) included a total of 9244 patients (2102 open and 7384 LIVHR procedures) followed up for a mean period of 24 months after open repair and 17.3 months after laparoscopic ventral hernia repair. Pierce et al. [47] and Müller-Riemenschneider et al. [85] reported no difference in chronic pain between laparoscopic and open repairs. Cassar et al. [86] reported the mean incidence of chronic pain to be 1.8% in 4 of 19 studies. In other non-comparative studies, the incidence of chronic pain for 4236 patients during a follow-up period ranging from 6 months to 64 months varied from 1% to 14.7% [21, 48, 83, 87–95].

In summary LIVHR is not associated with significantly more pain compared to open repair in the postoperative period.

Evidence-based statements and recommendations acc. to Bingener, Reinpold, and Chowbey in [2]:

"Statements"

- **Level 2A**: The LVHR technique results in chronic pain for 2–4% of patients
- **Level 2C**: Recurrence is associated with chronic pain (open and laparoscopic)
- **Level 2B**: Local anesthetic at suture sites during surgery significantly decreases acute early pain
- **Level 2B**: Pain pump placement makes no difference in acute or chronic pain
- **Level 2B**: The visual analog scale (VAS) shows no difference between absorbable and permanent fixation sutures at 3 months, but quality-of-life (QOL) differences (physical activity) are experienced
- **Level 2B**: Pain is not correlated with the number of tacks

- **Level 2A**: Transfascial sutures and tacks do not result in higher pain scores than tacks only
- **Level 2B**: Pain frequency after permanent suture fixation at 6 months is similar to that for tack-only fixation
- **Level 2B**: A permanent corner suture plus double-crown tacks results in higher VAS scores than permanent sutures only in hernias with a defect size <5 cm

"Recommendations"

- **Grade B**: Patients should be informed that laparoscopic ventral hernia repair may lead to prolonged pain
- **Grade B**: Surgeons should strive to limit acute pain as a risk factor for chronic pain
- **Grade B**: Surgeons should use intra-operative suture-site injection of local anesthetic

"Statement"

- **Level 2B**: The lidocaine patch does not significantly reduce postoperative acute or chronic pain

"Recommendations"

- **Grade C**: Injection of local anesthetic at suture sites can be considered in the treatment of chronic pain
- **Grade C**: Removal of suture, tacks, or mesh can be considered in the treatment of chronic pain
- **Grade C**: Multimodality pain treatment may be necessary in the treatment of chronic pain

29.7 Recurrence

Recurrence is considered the "Achilles' heel" of any hernia repair and is a measure of the effectiveness of the repair. The ultimate goal of any hernia repair is to achieve a recurrence rate as low as possible. The use of prosthetics for defects larger than 2 cm size has reduced the recurrence rate as demonstrated in multiple studies. The recurrence rate after primary tissue repair of incisional hernia has been reported from 25% to 52%. In a prospective study evaluating primary tissue repair, Luijendijk et al. showed unacceptably high 5-year recurrence rate of 44% for defects 3–6 cm and 73% for defects 6–12 cm in size; the use of meshes has dramatically reduced these numbers [96].

Majority of the recurrences occur during the first 1–3 years of repair (Hasselink et al. found that the vast majority of recurrences occurred during the first 3 postoperative years; [97]). The recurrences following incisional and ventral hernia repair tend to occur either through the mesh or at the edges of the mesh or from "occult" defects missed at primary surgery.

29.7.1 Risk Factors

The causes of recurrence following incisional and ventral hernia repair include patient-related factors such as high BMI, large defect size (Figs. 29.13 and 29.14), and technical errors like inadequate overlap. Inadequate number of tackers and sutures, poor quality mesh resulting in "mesh fractures", missed defect, displacement of the mesh, mesh contraction, invagination into the hernia defect, and improperly placed transfascial sutures together with large suture bites of mesh cause excessive tension and ultimately a hole in the mesh, which result in recurrence [98], type of fixation, and wound infections.

Fig. 29.13 Large subcostal defect following open cholecystectomy

Itani et al. attributed recurrence to postoperative surgical-site infection. Cassar et al. reviewed 19 prospective comparative studies comprising a total of 1896 patients (1598 laparoscopic and 298 open repairs) and found higher recurrence rates for large hernias and patients with a wound infection.

BMI > 40 kg/m^2 has been shown to increase the risk of recurrence around fourfold. The pathophysiology of this is complex, but increased intra-abdominal pressure, tissue laxity, and large amount of subcutaneous tissue contribute to hernia repair failure. This higher intra-abdominal pressure creates more strain on the mesh increasing the incidence of hernia recurrence in these individuals. Some patients are more susceptible to recurrence due to inherently weak native tissue and a proven defect of collagen synthesis [30, 108]. Patients with underlying disorders such as obesity, chronic COPD, chronic cough, or diabetes mellitus are more prone to recurrence. Smokers with earlier failed repair attempts [99] or patients with a history of previous failed repair also contribute to the recurrence rate [69].

Fig. 29.14 Subxiphoid defect

The recurrence rate increases with the size of the primary hernia defect: the larger the size (10 cm), the higher is the risk of recurrence (Chowbey in [2]).

Another recognized cause of recurrence is missed defects (Fig. 29.15). The laparoscopic approach offers the advantage to completely define the margins of the defect and detect additional defects not clinically apparent and can be missed at open surgery. Sharma et al. noted that 47% had more than one defect and 16% had satellite defects located >3 cm away and could be detected only laparoscopically [79]. This is the reason why in patients presenting with an incisional hernia, always, the whole scar must be protected by the mesh. Ceccarelli et al. [100] in a comparison of 94 patients with laparoscopic repair and 87 patients with open repair found a significantly lower recurrence rate after laparoscopic repair (p[0.05) and postulated that the recurrence rate was lower because laparoscopy helps to identify defects not clinically identifiable.

Laparo-endoscopic abdominal wall hernia repair works according to the principle of Pascal (pressure = forces/surface) like in inguinal hernia repair. The balance of these forces keeps the mesh in place and prevents recurrences. In order to maintain this equilibrium, the mesh must overlap the fascia sufficiently in all directions. The exact amount of this overlap is not known but must be around 4–5 cm in all directions. Misra et al. [81] attributed recurrence to inadequate space for mesh fixation in a low-lying defect, whereas Olmi et al. [15] attributed recurrence to inadequate mesh overlap, and they also found that staples alone were inadequate for fixation of mesh and that the interval between two staples should be less

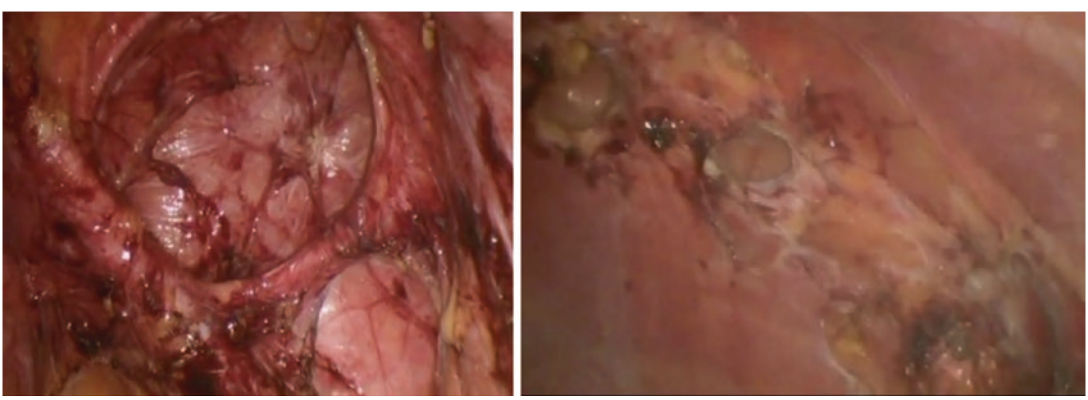

Fig. 29.15 Swiss cheese defect

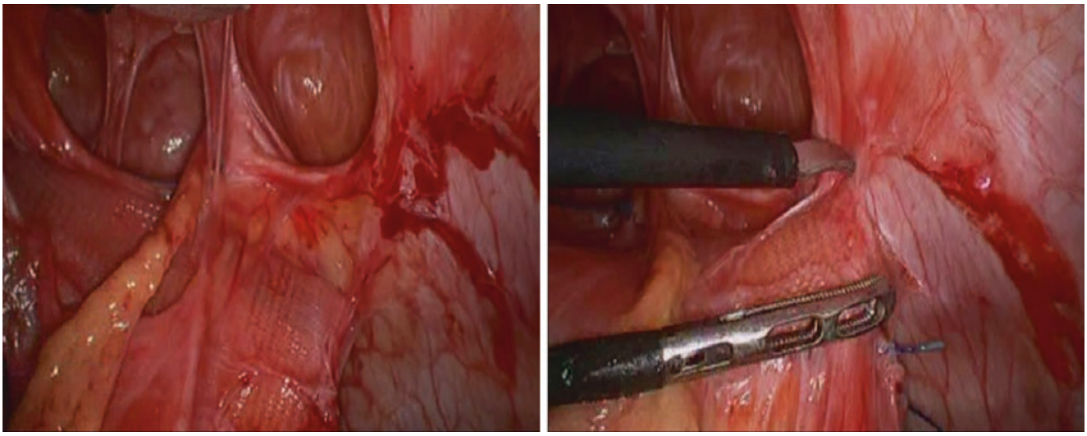

Fig. 29.16 Recurrent incisional hernia with folded mesh

than 1 cm. Bedi et al. [101] stated that recurrence decreases with the use of transfascial sutures and with experience. Ceccarelli et al. [100] postulated that the causes for recurrence in laparoscopic repair were rolling up of mesh (Fig. 29.16), incomplete stretching of mesh, and incomplete covering of the defect. Misra et al. [81] analyzed 56 case series involving laparoscopic repair for 8677 patients and found recurrence rates ranged from 0% to 20% during a follow-up period of 1–84 months. It has been noted that recurrences commonly occur at the mesh margins along the mesh-tissue interface mainly due to insufficient overlapping. In many studies, a mesh overlap of 3–5 cm or more has been used, and reports have shown recurrence rates to be less than 5%, but the quality of most of the studies is debatable. LeBlanc [102], reviewing the literature on fixation techniques, recommended that the minimum mesh overlap should be 4–5 cm if transfascial sutures are not used and at least 3 cm when transfascial sutures are used.

McKinlay et al. [103] compared laparoscopic repair for 69 recurrent hernias and 101 primary hernias. The recurrence rate was comparable (7% vs 5%), but the mean time to recurrence was shorter in the recurrent hernia group ($p = \0.0001$).

Mesh size in relation to the extension of the scar is equally important. Wassenaar et al. [104] stated that the mesh should cover not only the defect but also the entire incision to prevent recurrence.

Mesh fixation is an important determinant of recurrence rates. While well-placed tacks or anchors provide adequate fixation in astatic abdominal wall during surgery, they have reduced holding strength compared to sutures at about 2.5 to 1 ratio. Although greater number of tacks may divide the tension forces among fixation points, transfascial placement of sutures in hernia is important. Variable recurrence rates have been reported in the literature with the use of different mesh fixation techniques. Three RCTs comparing various fixation devices and techniques were identified (in [2]). None of them showed a significant difference in terms of the recurrence rate between suture only, suture with tacks, and tack-only fixations. Similarly, two systematic reviews with a total of 6824 patients also were identified, which showed no significant difference between suture and tack fixations but in some way conflicting results [102, 105]. LeBlanc et al. in a review of literature on mesh fixation with sutures only and tacks alone reported that fixation with sutures only resulted in the lowest recurrence rate (0.8%) when compared with that of tacks only (1.5%). Surprisingly mesh fixation with tacks and sutures resulted in worst recurrence rate of 3.5% with a mean follow up of 22 months. Majority of studies have reported use of tacks and four corner sutures for mesh fixation. In a RCT, Bansal et al. [75] randomized 106 patients to compare suture and tack fixation. They reported two recurrences, both in the tack fixation group, during a mean follow-up period of 31 months.

Heniford et al. [11] published the largest series (850 patients) of laparoscopic hernia repair with tacks and suture mesh fixation. A higher recurrence was noted in the patients who had undergone a previous open repair. The overall recurrence rate was 4.7% during 20 months of follow-up evaluation. LeBlanc et al. [89] in a series of 200 patients (43 patients with multiple defects) reported a decreased rate of recurrence, from 9% to 4%, when they combined tacks with suture fixation. Franklin et al. [44], in a retrospective series of 384 patients, found 11 recurrences (2.9%) during a mean follow-up period of 47 months for patients, most of whom had mesh fixation with tacks and sutures. The findings showed that most of the recurrences ($n = 8$) occurred for patients in whom transfascial sutures were not used.

On the other hand, there are several observational studies using tack fixation in "single-crown" or "double-crown" technique only, which also report very low recurrence rates of 1–4% [62, 63, 65]. Wassenaar et al. [73] published a randomized controlled trial comparing mesh fixation using double-crown tacks alone, tacks with nonabsorbable sutures, and tacks with absorbable sutures and found no difference in the recurrence rate at 2 weeks, 6 weeks, and 3 months postoperatively among the three groups ($p = 0.38$, 0.76, and 0.41, respectively). Chelala et al. [78] analyzed 400 cases in which mesh was fixed with transfascial suture only. No recurrent hernias were detected during a mean follow-up period of 28 months.

In conclusion, all different fixation devices may be successful in preventing recurrent hernias provided the surgeon has the appropriate expertise. But it must be noted critically that all these fixation systems are less standardized; therefore, evidence is too low for definite recommendations. But basically it must be emphasized that the best fixation device cannot compensate an insufficient overlapping of the defect by the mesh.

What about the comparison of the open with the laparoscopic technique in order to find the best technique to prevent recurrences? Three meta-analyses [8, 12, 82] comprising 880 patients (446 laparoscopic and 434 open repairs) have compared recurrence rates for laparoscopic and open repairs. None demonstrated a significant difference in recurrence rates ($p = 0.58$) after 2–68 months of follow-up evaluation. Forbes et al. [23] in a meta-analysis of 8 RCTS consisting of 517 patients found no significant difference in recurrence rates between laparoscopic and open repairs during a mean follow-up period of 23 months. The overall recurrence rate was low due to the small hernia size in most of the studies and the lack of a uniform definition for recurrence. Carbajo et al. [21] and Barbaros et al. [80] have also showed a lower recurrence rate with laparoscopic repair. In eight systematic reviews [52, 84, 85, 107–109] of prospective studies comparing laparoscopic and open repairs for 19,421 patients, the recurrence rates ranged from 0% to 20.7% in the laparoscopic group and from 0% to 35% in the open group during follow-up periods of 1–85 months. Only Pierce et al. [47] showed a significantly lower recurrence rate for laparoscopic repair. These authors published a pooled data analysis of 45 studies during a period of 12 years comparing laparoscopic and open ventral hernia repairs. In these 45 studies, representing 5340 patients (4582 laparoscopic and 758 open repairs), laparoscopic repair was associated with a significantly lower recurrence rate (p\0.0001).

Patients with conditions such as COPD and chronic cough should be treated preoperatively, and for morbidly obese patients, larger mesh should be used. Although at present there are some advantages of laparoscopic repair over open repair with respect to recurrence rates but it is difficult to predict what kind of operation will become standard for repair of ventral and incisional hernias in the future because of lack of good evidence because of the poor quality of the most of the studies. New techniques are being developed (see ► Chaps. 34 and 35) which take operating field away from the abdominal cavity to within the abdominal wall, thus avoiding a large skin incision and the placement of large amounts of foreign materials (mesh and tackers) into the abdominal cavity which provoke a lot of problems due to adhesions to the bowel and pain due to fixation. Moreover, in laparoscopic surgery, it must be taken into consideration that there are much higher costs for the special meshes suitable for the intra-abdominal use and expensive fixation systems. Basically a generous overlapping of the defect by the mesh (rule: the larger the defect, the larger the mesh has to be) and a careful fixation are necessary. Furthermore the location of the defect is important. When dealing with a hernia in the upper abdominal wall the lg. teres hepatis incl. the peritoneums has to be completely dissected from the posterior rectus sheath, and in the presence of a hernia in the lower abdomen the same must be done with the umbilical ligamentes. In order to achieve an optimal ingrowth of the tissues, there has to be a close contact between the mesh and the posterior rectus sheath. The mesh should be placed in the preperitoneal space behind the urinary bladder and fixed to the pubic bone. In addition the whole incision and not just the hernia must be repaired to reduce risk of recurrence. In conclusion, applying proper technique and addressing the patients' underlying risk factors can significantly reduce hernia recurrence.

Evidence-based statements and recommendations acc. to Chowbey und Misra et al. in [2]:

"Statements"

- **Level 1**: The existing literature does not document the superiority of any one mesh fixation technique in relation to recurrence
- **Level 2**: Size of the hernia (≥10 cm), body mass index (BMI) (≥30 kg/m^2), history of previous open repair or failed hernia repair, and perioperative complications including SSI are risk factors for hernia recurrence irrespective of the technique

"Recommendations"

- **Grade B**: Risk factors predisposing to recurrence after laparoscopic ventral or incisional Hernia repair should be eliminated before surgery as far as possible
- **Grade B**: Insufficient incision scar coverage with mesh, SSIs, and gastrointestinal complications should be avoided

"Recommendations"

- **Grade B**: A strictly standardized technique to avoid failures such as mesh overlap less than 3 cm, improper fixation, and mesh contraction and invagination into the hernial defect should be used
- **Grade C**: Optimal preoperative treatment for patients with increased intra-abdominal pressure in conditions such as COPD, chronic cough, and obesity should be considered

"Statements"

- **Level 1**: Recurrences can be prevented by using increased overlap of the biomaterial and dual methods of fixation (tacks and transfascial sutures)
- **Level 3**: Incisional and ventral hernias larger than 2 cm are preferably repaired using a prosthesis because primary repair has a high rate of recurrence

"Recommendations"

- **Grade B**: A mesh repair should be used in all eligible patients with a hernia defect larger than 2 cm
- **Grade B**: For suprapubic hernias, the whole preperitoneal space should be dissected, a mesh overlap of at least 5 cm should be achieved, and fixation of the lower margin of the mesh under direct vision to Cooper's ligaments should be performed
- **Grade B**: Sufficient overlap of the mesh from the hernia margin and dual methods of fixation should be used
- **Grade A**: The recurrence rates for laparoscopic and open ventral hernia repair are similar
- **Grade B**: Suture and tacks fixation are equally effective, but all suture fixation for small- and medium-sized defects is more cost-effective

29.8 Miscellaneous Complications

Pneumonias and other pulmonary complications are common to all surgical procedures. While these can sometimes be prevented, they cannot completely be eliminated. Adequate preoperative preparation of the patient with a history of pulmonary disease should help to minimize the risk. However, the need for general anesthesia and the placement of the fixation devices that result in splinting of the abdominal wall, as well as the frequent postoperative ileus that is seen in these patients, predispose them to pulmonary complications. Respiratory failure or pneumonia can be seen in 0.49–3.5% of patients [77]. However, the majority of reported series have found that there is a lack of respiratory problems with this operation. The appropriate management of these complications will be dictated by the clinical condition of the patient, similar to that seen following other surgical interventions.

Although quite rare, the development of a pneumothorax has been reported [109]. This developed subsequent to the passage of subcostal transfascial suture that traversed the pleural space. This is successfully managed by closed-tube drainage.

Urinary complications, such as retention or infection, can be seen with some frequency following this operation, an occurrence well known to hernia repair. These have been reported in 0.74–3.6% of these individuals [21], commonly male. Given the usual age of these patients, this type of problem is not unexpected. The usual treatment will be given to those afflicted.

Trocar hernias were more commonly seen in the early period of the development of this operation. The usual site of this complication is at the location of the trocars that are larger than 5 mm. This has been reported in 0.25–3% of these operations [72, 88]. The larger trocars were used almost exclusively in the past, but now there are more of the smaller sizes that are used. Some surgeons will use only the smaller trocars for the entire procedure [20]. Prevention of these hernias can be aided with the use of one of the trocars that are not of the cutting variety but that are more dilating. This results in a smaller defect than that of the cutting type. At the completion of the operation, the larger trocar sites should be closed with the same suture-passing instrument that places the fixating sutures. Additionally, any trocar site that has been significantly manipulated during the procedure may have become larger so that closure of these also will be prudent. The repair of these hernias can be either with an open or laparoscopic technique. A small hernia in a thin patient could be more easily approached from the anterior surface than a larger hernia in an obese patient. The exact sizing of the defect can be difficult, if not impossible, in many of these cases. Whichever method is chosen, the use of a prosthetic biomaterial is recommended. These patients have demonstrated a propensity for hernia formation and may have a collagen deficiency, which predisposes them to hernia development. A tension-free repair will afford the best long-term result in these patients. A possible exception can be the development of a hernia in the immediate postoperative period. In that situation, the use of transfascial suturing will be easy and reliable [88].

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Education and Learning Curve in Ventral Hernia Repair

Davide Lomanto and Sujith Wijerathne

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Minimally invasive surgery has evolved with the intent of minimizing surgical trauma and to achieve better postoperative pain control and better cosmetic outcome. To achieve these goals with minimal perioperative complications and acceptable clinical outcome, a surgeon needs to have an adequate training and experience in any surgical procedure, which demands specialized skills. In some cases, the curve to reach the proficiency may be a stepwise process. Surgery for ventral hernia has advanced over the years incorporating the minimally invasive techniques and demands a technically challenging learning curve in the current surgical practice.

After the first successful laparoscopic ventral hernia repair in 1993 by LeBlanc and Booth [1], today several successful reports show the advantages of laparoscopic repair over open hernia repair in terms of complications and recurrence rates [2–5]. Laparoscopic ventral hernia repair is based on the tenets of the open Rives-Stoppa repair and also based on Pascal's principle of hydrostatics such that the forces that cause hernia are currently used to hold the mesh in place, thus decreasing the chance of recurrence and offering the potential benefits of minimally invasive surgery which are smaller scars, less postoperative pain, shorter hospital stay, fewer infectious complications, and less overall cost [3–6]. The fundamental surgical steps in laparoscopic ventral hernia repair involve access, adhesiolysis, closure of the defect if possible, intraperitoneal placement of the mesh (IPOM), and fixation of the mesh. All these steps can be challenging for an inexperienced surgeon. Obese patients, recurrent hernias, multiple defects, defects larger than 10 cm in size, lower or upper abdomen location, lateral hernia, etc. need to be addressed differently to the standard approach. When we discuss about overall proficiency or learning curve, we should take into account parameters like operating time, recurrence, and postoperative complications.

There are few studies in the literature where the "learning curve" in laparoscopic ventral hernia is evaluated.

In a study published in 2004, Bencini et al. have analyzed their data on 64 consecutive patients who underwent attempted laparoscopic ventral hernia repair [7]. They have divided the patients into two groups: group 1 included the first 32 patients and group 2 included the second 32 patients. Demographic characteristics, types of hernia, preoperative records, and hernia defects were well matched between the groups. Four patients (12%) in group 1 required conversion to laparotomy for bowel injuries, whereas no conversion was required in group 2. The operative times and complication rates were similar in both groups, but bowel injuries were significantly more common in group 1 (19% versus 0%, $p = 0.02$). Group 1 also had three recurrences, while no recurrences were reported in group 2. They concluded that a learning curve is needed to decrease conversions and bowel injuries during laparoscopic ventral hernia repair and improved experience could permit the treatment of larger defects laparoscopically [7]. But this study did not specify a minimum number of cases required to achieve stability in the surgical performance with a minimal and an acceptable complication rate.

In 2014, we published our own experience and data on the learning curve of laparoscopic ventral hernia repair [5]. In our study we had a total of 181 (141 females and 40 males) patients who underwent laparoscopic ventral hernia repair by three surgeons. After analyzing the operative time for each of the surgeons, we noticed that a plateau is reached in the operative time by all three of them within the first 20 cases. When we compared the first 20 patients of each surgeon with the total number of cases they have performed during the study period, we noticed that there was a significantly higher complication rate (5%) during the first 20 cases ($p < 0.03$). To assess the learning curve, the operative time was evaluated for each surgeon and plotted on a graphical scale. According to the plot, 12 cases seem to be necessary to achieve a plateau in the laparoscopic ventral hernia repair performance with a comparable clinical outcome [5].

30.1 Education and Training Program

The surgical education is undergoing a paradigm shift in the twenty-first century from the traditional experience-based model to a structural program that requires documentation of proficiency. The old Chinese proverb "I hear, I forget… I see, I remember… I do, I understand" had emphasized the importance of learning by doing, ages ago.

In view of the abundance of resources available to patients to acquire knowledge and the increase of the number of medico-legal trials and also due to the complexity of the ventral hernia in the current practice, it is necessary to provide the trainees and the surgical residents an up-to-date knowledge and surgical training with a well-structured education. Several aspects should be considered in establishing a training program:

1. Teaching faculty
2. Interactive classroom teaching
3. Practice at surgical technique
4. Proctorship/supervised surgery
5. Monthly case report/research projects
6. Residents' operative logbook
7. Length of surgical training
8. National and international surgical conferences/workshops

1. Teaching Faculty

The teaching faculty, program director, or primary teacher of a hospital-based hernia training program should be a fully trained, thoroughly experienced general surgeon with credentials from a recognized international surgical society. He/she should be qualified and experienced in different types of hernia surgery both open and laparoscopic. He/she should be passionately committed to training young doctors to become qualified general surgeons. The program director should arrange for qualified visiting faculty so that trainees get exposure of different surgeons from different hospitals.

2. Interactive Classroom Teaching

The classroom teaching should focus on clinical and technical aspects like:

- Detailed anatomy in both open and laparoscopic
- Clinical presentations of ventral hernias
- Preoperative assessment
- Informed consent
- Instrument requirements
- Technology of meshes and their characteristics
- Knowledge of aseptic technique
- Complications and their management

3. Practice at Surgical Technique (Fig. 30.1).

Patients expect to be treated by an experienced surgeon, who is well trained in the field of their practice. Before practice, trainees should go through different surgical techniques by different surgeons with themes including how to do, what to do, and what not to do in hernia surgery.

Fig. 30.1 Practice at surgical technique on an animal model

Practical sessions should be encouraged on live tissues and/or virtual reality simulators. Both types of training sessions provide learning in a structurally controlled environment using inanimate strategies and modalities similar to learning in a patient without compromising patient safety (Fig. 30.2a, b). With the use of autonomous "teaching and assessing" work stations, the efficiency of educational side of medicine will increase, and more trainees can be trained in a shorter time period.

It was demonstrated at the author's own training center that participants needed about 30% less time to complete preselected tasks after hands-on training [8] (Figs. 30.3 and 30.4).

4. Proctorship/Supervised Surgery

Only after the residents have demonstrated adequate proficiency that they should be allowed to operate on actual patients under direct expert supervision of a consultant/surgical specialist. When trainees operate with adequate supervision, results comparable to consultants have been reported in literature for colorectal surgery [9], upper gastrointestinal surgery [10], and pancreatic repair under expert supervision [11–13]. When unsupervised, junior trainees had significantly higher recurrence rates for open mesh and open sutured repairs than consultants [14].

5. Monthly Case Reports or Research Projects

Trainees at all levels learn more quickly and completely if they discover things by themselves. Monthly written case reports or research projects help residents to find answers themselves to problems they encounter during their training. They

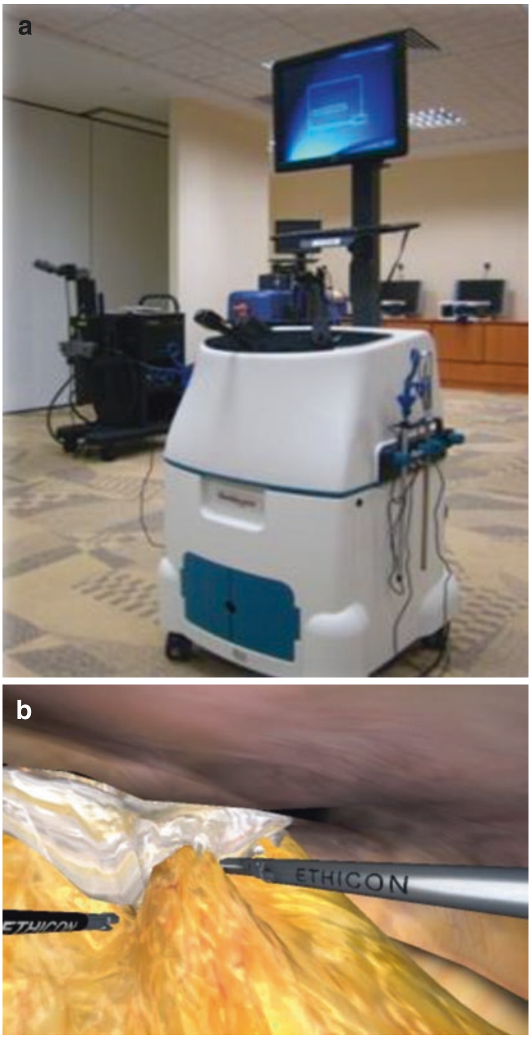

Fig. 30.2 **a** Virtual reality simulators. **b** Practice on virtual reality simulators

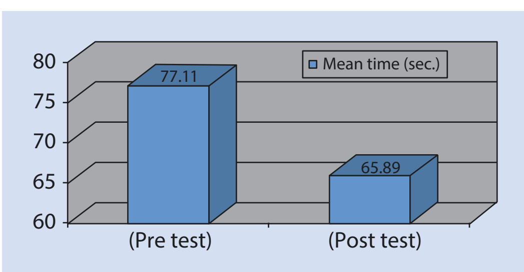

Fig. 30.3 Trainee results on an endoloop task

can be given projects like comparison of different types of prosthetic materials used, fixation or no fixation, or recovery after laparoscopic versus open ventral hernia repair. It is the program direc-

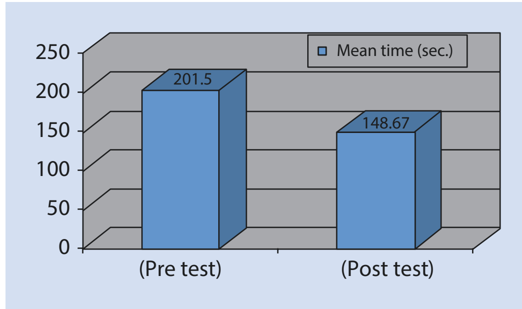

Fig. 30.4 Trainee results on an intracorporeal suturing task

tor's responsibility to develop a surgical library equipped with requisite textbooks and journals and to make it available so that residents may read and research whenever needed.

6. Resident's Operative Logbook

Residents should also be required to keep a log of all the hernia operations (both open and laparoscopic) they assist, perform, or teach to younger residents. This will enable the program director to keep track of areas that need more attention.

7. Attending National and International Surgical Conferences/Workshops

Attending regional and international conferences enables trainees to network with other surgeons, gain experience in critiquing papers that are presented, present their own papers, and learn from others. It also legitimizes well-conceived and organized hernia programs and also allows other surgeons to share experience and learn from surgeons in training.

30.2 Discussion

In the last decade, ventral hernia surgery made a great leap forward, from the simple suture repair to the prosthetic repair either open or laparoscopic to the latest use of robotic devices. Therefore, in this era of rapid development, the role of training and retraining (both open and laparoscopic) becomes more and more important. Therefore, it is important to stress the important role of a well-structured hernia training program to provide adequate knowledge on the insight and challenges in ventral hernia repairs. Surgical workshops (both open and laparoscopic) are useful, effective, and indispensable tools for continued surgical education but must be adequately structured. The use of virtual reality simulator is an objective way of evaluating surgical trainees and eliminates potential for actual patient morbidities. New technology (OT suite, telementoring/proctoring) is helpful in improving the outcomes *together with d*eliberate and continuous practice which is crucial to overcome the initial difficulties and steepness of the learning curve. The role of the proctorship and supervision is essential to guide the learners and trainees through the complexity and surgical steps in order to achieve proficiency in a shorter time.

Laparoscopic ventral hernia repair has its own challenges: challenges of any other minimally invasive procedure, familiarity of new instruments (meshes, tackers, suture passers, energy devices, etc.), and familiarity of laparoscopic anatomy (though minimal for an experienced laparoscopic surgeon). The exact definition of learning curve in laparoscopic procedures is unclear and will need more structured education programs to assess and define it. The possible factors which may influence learning curve can be surgeons' experience with other laparoscopic procedures and instrumentation, knowledge of laparoscopic anatomy, standardization of surgical technique, and stabilization of operative time and complication rate.

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Complex Ventral and Incisional Hernias

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A clear definition of "complex abdominal wall hernia" is missing, though the term is often used [1]. The aim of a consensus meeting was to reach consensus on criteria used to define a patient with "complex" hernia [1]. Consensus was reached on 22 patient and hernia variables for "complex" hernia criteria inclusion which were grouped under four categories:

1. Size and location
2. Contamination/soft tissue condition
3. Patient history/risk factors
4. Clinical scenario

The criteria for definition of a complex abdominal wall hernia are listed in Table 1.

Recurrent hernia after an earlier mesh repair, a large-sized abdominal wall hernia with a defect of ≥10 cm in width or loss of domain of ≥20%, a parastomal hernia, and obese patients are all criteria fulfilling the definition of a "complex" abdominal wall hernia.

In particular, the management of complex patients was addressed only by limited discussion in a consensus conference [2]. There were several areas where high-quality data were lacking, and the consensus could be reached by the panel [2]. Further high-quality studies are needed to better assess the management of ventral and incisional hernias in these complex patients [2].

Criteria for Definition of a Complex Abdominal Hernia (Patient) (Slater et al.) [1]

1. *Size and location*
   - Large-sized abdominal wall hernia, ≥10 cm in width
   - Parastomal, lumbar, lateral, and subcostal locations of hernias
   - Loss of domain ≥20%
2. *Contamination and soft tissue condition*
   - Wound environment with surgical wound class III ("contaminated") or IV ("dirty")
   - Full-thickness abdominal wall defects
   - Loss of substance(e.g., after tumor resection, trauma, infection)
   - Distorted anatomy (e.g., after multiple previous procedures)
   - Denervated muscles
   - Skin grafts
   - Wound ulcers/nonhealing wound
   - Open abdomen
   - Disease related (omphalocele, necrotizing fasciitis)
   - Presence of enterocutaneous fistula
3. *Patient history and risk factors*
   - Recurrent hernia after an earlier mesh repair or component separation
   - Comorbidities/risk factors that impair wound healing: obesity, diabetes, old age, steroid use, or poor nutritional state (albumin <30 g/dl)
   - Increased intra-abdominal pressure: obesity, COPD
   - Previous wound dehiscence
   - Previous mesh infection
4. *Clinical scenario*
   - Emergency operation with bowel resection
   - Intraperitoneal mesh removal
   - Multiple hernia defects (e.g., "battle-scarred abdomen")

31.1 Recurrence After Previous Open Repair

Worldwide rates of operations for recurrent incisional hernias are 10–15% despite all therapeutic improvements [3]. Conventional open repair of primary incisional hernias entails an overall failure rate of 30–56%, whereas recent reviews point out that laparoscopic repair seems to decrease the recurrence rate to 3–4% [3].

Reoperations for recurrence of ventral and incisional hernias are challenging [4]. After open mesh repair, reoperation by the laparoscopic approach has certain advantages [4]. First, the repeat operation is performed at a different site/level of the abdominal wall [4]. Second, in all instances, the entire incisional scar can be covered by a mesh. Usually, it is not necessary to remove the previously inserted mesh, hence avoiding an extensive dissection of the abdominal wall [4]. The Consensus Development Conference-based guidelines [5] also recommend laparoscopy for the treatment of recurrent ventral hernias.

Ferrari et al. [3] reported about 69 Patients with a recurrent incisional hernia who underwent laparoscopic repair. The operative technique has been standardized and provides onlay placement of an ePTFE mesh fixed with titanium tacks. The mean operative time was 147.6 ± 71.2 min and mean hospital stay was 5.8 ± 1.8 days. No conversion occurred, while five intraoperative complications (7.2%) were recorded: three bowel injuries treated by laparoscopic sutures, one omentum bleeding, and one epigastric vessel lesion. Postoperative mortality was null, while overall morbidity was 13% (nine patients) with a prevalence of seroma lasting over 8 weeks in six patients (8.7%). Along a mean follow-up of 41 months (range 6–119), recurrence rate was 5.7% (four patients). Univariate analysis for width of defects and BMI showed no significant influence on patient outcome [3].

Uranues et al. [6] reported about 85 consecutive patients aged 55 years (range 29–93 years) with laparoscopic recurrent incisional hernia mesh repair with previous failed repairs. Fascia defect was 255 cm^2 (range 48–416 cm^2); mesh size, 600 cm^2 (range 285–884 cm^2); and operating time, 145 min (80–210 min). There was one conversion. Length of stay was 2 days (1–9 days). A 15.2% adverse event rate included 1% port-site cellulitis, 7% seroma, and 7% persistent pain. Hernia recurrence rate was 3.5% at 41-month (range 24–61 months) follow-up. The authors concluded that laparoscopic recurrent hernia mesh repair resulted in a low rate of adverse events and a risk of recurrence similar to the rates associated with first-time hernia repair [6].

In a study by McKinlay et al. [7], patients with laparoscopic recurrent incisional hernia repair ($n = 69$) were compared to patients with laparoscopic primary incisional hernia repair ($n = 101$). The patients with laparoscopic recurrent incisional repair had a mean of 1.9 ± 1.3 previous repairs, higher body mass index (BMI) (34 ± 6 kg/m^2 vs 33 ± 8 kg/m^2, $p = 0.46$), larger defect size (123 ± 115 cm^2 vs 101 ± 108 cm^2, $p = 0.06$), and longer operative time (119 ± 61 min vs 109 ± 44 min, $p = 0.11$). The complication rate was higher in the recurrent group (28% vs 11%, $p = 0.01$), but the recurrence rate was not different (7% vs 5%, $p = 0.53$). The mean time to recurrence was significantly shorter in the recurrent group (3 ± 2 months vs 14 ± 7 months, $p < 0.0001$). The mean follow-up interval was 19 ± 18 months in the recurrence group and 27 ± 20 months in the primary group. Although laparoscopic repair of recurrent incisional hernia resulted in a higher recurrence and complication rate than laparoscopic repair of primary incisional hernia, the rates were lower than those reported for conventional repair of recurrent incisional hernia. The authors concluded that laparoscopic repair of recurrent incisional hernia is an effective alternative to conventional repair [7].

Verbo et al. [8] prospectively analyzed data from 41 consecutive patients with recurrent incisional hernia, who were submitted to a laparoscopic repair procedure with an expanded polytetrafluoroethylene Dual Mesh. All of the patients underwent clinical follow-up at 1, 6, and 12 months and then yearly. An ultrasound scan of the abdominal wall was performed at 6 and 12 months after the procedure. The defects were usually localized along midline laparotomies. The mean mesh size was 400 cm^2, the mean operating time was 68 min, and the mean length of hospital stay was 2.7 days. Complications were encountered in 17% of patients. The mean follow-up was 38 months (range, 18–54). Recurrence was reported in one case only (2.4%), which occurred within the first 6 months after the operation.

The authors concluded that the laparoscopic repair of recurrent incisional hernia seems to be an effective alternative to the conventional approach, as it can give lower recurrence and complication rates [8].

On the basis of the above mentioned literature, the International Endohernia Society gives the statement in their guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias [4] that some evidence indicates reoperation for recurrence after open repair is better performed laparoscopically (Level 4 Oxford criteria of evidence-based medicine).

As recommendation Grade C, some cases of recurrence after open repair can be better managed laparoscopically provided the surgeon has sufficient experience in laparoscopic ventral hernia repair.

31.2 Recurrence After Previous Laparoscopic Repair

All meta-analyses did not find a difference in the recurrence rates between open and laparoscopic ventral and incisional hernia repair [9–12]. In the guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias of the International Endohernia Society, the risk factors for recurrence are analyzed [13]. The existing literature does not document the superiority of any one mesh fixation technique in relation to recurrence. Size of the hernia ≥10 cm, body mass index (BMI) ≥30 kg/m^2, history of previous open repair or failed hernia repair, and perioperative complications including surgical site infections are risk factors for hernia recurrence irrespective of the technique. The risk factors for recurrence include patient status, underlying disease, and perioperative factors, i.e., surgical techniques, postoperative complications, deep abscesses, and early reoperations. Smokers with previous failed repair attempts have a higher risk of recurrence. Postoperative mesh infection requiring removal of mesh is a predictor of recurrence [13].

The mechanisms for recurrence of laparoscopic ventral and incisional hernia repair described in the literature in decreasing order of frequency are infection, lateral detachment of the mesh, inadequate mesh fixation, inadequate mesh size, inadequate mesh overlap, missed hernias, raised intra-abdominal pressure, and trauma [13]. The guidelines recommend a strictly standardized technique to avoid failures such as mesh overlap less than 3 cm, improper fixation, and mesh contraction and invagination into the hernia defect.

In the Danish Ventral Hernia Database, the cumulative recurrence rate during a median observation time of 40 months was between 18% and 28.5% for the patients with a laparoscopic incisional hernia repair [14].

Studies or case series on re-laparoscopic repair of a recurrence following laparoscopic ventral and incisional hernia repair does not exist. Misiakos et al. [15] report about their clinical experience with re-laparoscopic recurrent ventral and incisional hernia repair. Before surgery it is useful to have CT imaging to help guide the approach. The old mesh can be left in place if it is well incorporated. If the mesh is bulky or has a curled edge, it may be excised partially. If the mesh is palpable externally and bothersome to the patient, the surgeon may have to use an open approach to excise the mesh. If a portion of the mesh is densely adherent to the bowel, a small piece of it should be excised and left attached to the bowel, to prevent deserosalization or opening of the bowel wall, most often with an open approach [15]. The need to remove previously placed prosthetic mesh may represent a contraindication to laparoscopic repair [16].

31.3 Giant Hernias: Loss of Domain

The guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias of the International Endohernia Society recommend that surgical treatment of a symptomatic ventral and incisional hernia is indicated. The laparoscopic technique for ventral and incisional hernias should preferably be reserved for defect sizes smaller than 10 cm in diameter [17].

In the SAGES guidelines for laparoscopic ventral hernia repair, it is strongly recommended that special situations such as loss of domain or large abdominal wall defects may represent a contraindication for laparoscopic repair [18]. In a loss of domain situation, the laparoscopic approach to ventral hernia repair may be problematic and associated with higher conversion rates and potentially suboptimal outcomes [18]. In the literature large defects (>10 cm in diameter) increase the complexity of laparoscopic ventral and incisional hernia repair [18].

Ferrari et al. [19] reported about 36 patients with laparoscopic management of incisional hernias with abdominal wall defects ≥15 cm. The wall defect was ≥20 cm in eight cases. None had loss of domain. Body mass index (BMI) for 18 patients was ≥30 kg/m^2. The mean duration of operations was 195 ± 28 min (range 75–540). One patient needed conversion for ileal injury and massive adhesions. Postoperative complications occurred in nine patients; there were six surgical complications. Morbidity in obese and nonobese patients was not statistically different ($p > 0.005$). There was no postoperative death. Mean hospital stay was 4.97 ± 3.4 days (range 2–18). Mean follow-up was 28 months (range 2–68) and only one hernia recurrence was observed.

The authors concluded that minimum-access procedures can provide good results in the repair of giant incisional hernia. Obesity is not a contraindication to laparoscopic repair. Further studies need to confirm these promising results [19].

31.4 Parastomal Hernias

A parastomal hernia is an incisional hernia related to the presence of an enterostomy [20]. For colostomies, the incidence ranges from 3% to 39%, whereas for loop ileostomy, its incidence is reported between 0% and 6% [20]. Most of the parastomal hernias are asymptomatic and therefore can be treated conservatively.

Indications for surgery are ill-fitting appliances causing leakage, pain, discomfort, and cosmetic complaints. Treatment is mandatory when incarceration or strangulation of hernia content occurs [20].

In a systematic review and meta-analysis comparing extraperitoneal versus transperitoneal colostomy placement, it was observed that extraperitoneal colostomy leads to a lower rate of parastomal hernias and stoma prolapse [21].

In a meta-analysis of randomized trials, the role of prophylactic mesh in end-colostomy construction was evaluated [22]. Prophylactic placement of a mesh at the time of a stoma formation seems to be associated with a significant reduction in the incidence of parastomal hernia and reoperation related to parastomal hernia after surgery for rectal cancer, but not the rate of stoma-related morbidity. However, the results should be interpreted with caution because of the heterogeneity among the studies [22].

In a systematic review, Fortelny et al. [23] found for prevention of a parastomal hernia by biological mesh reinforcement that the majority of studies revealed significant better results in terms of parastomal herniation and without any mesh-related complications in comparison.

In a systematic review by Hansson et al. [20], 30 studies were included with the majority retrospective. Suture repair resulted in a significant increased recurrence rate when compared with mesh repair (OR 8.9; 95% CI, 5.2–15.1; $p < 0.0001$). Recurrence rates for mesh repair ranged from 6.9% to 17% and did not differ significantly.

In the laparoscopic repair group, the Sugarbaker technique had less recurrences than the keyhole technique (OR 2.3; 95% CI, 1.2–4.6; $p = 0.016$). Morbidity did not differ between techniques. The overall rate of mesh infections was low (3%) and comparable for each type of mesh repair. The authors concluded that in laparoscopic repair the Sugarbaker technique is superior over the keyhole technique showing fewer recurrences [20].

Another meta-analysis of laparoscopic parastomal hernia repair by DeAsis et al. [24] found for the modified laparoscopic Sugarbaker approach a recurrence rate of 10.2%, whereas the recurrence rate was 27.9% for the keyhole approach. The authors concluded that laparoscopic intraperitoneal mesh repair is safe and effective for treating parastomal hernia. A modified Sugarbaker approach appears to provide the best outcomes [24].

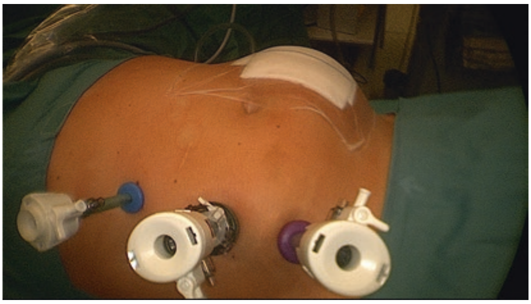
In a systematic review about parastomal hernia repair with biologic grafts, the findings was that the use of reinforcing or bridging biologic grafts during parastomal hernia repair results in acceptable rates of recurrence and complications [25].

The guidelines of the International Endohernia Society recommend that a laparoscopic approach for parastomal hernia repair should be considered a difficult technique with larger operating time, more intraoperative complications, and more difficult adhesiolysis than standard laparoscopic ventral hernia repair [26]. Results of laparoscopic repair of parastomal hernias could not be compared to the general results of laparoscopic ventral hernia repair because the rates of recurrences and morbidity are higher. Laparoscopic repair of a parastomal hernia is a more complex technique because a concomitant midline hernia present in a high percentage of patients must also be repaired [26]. The same laparoscopic technique can be performed for a hernia occurring with a colostomy, ileostomy, or urostomy or due to an ileal conduit [26].

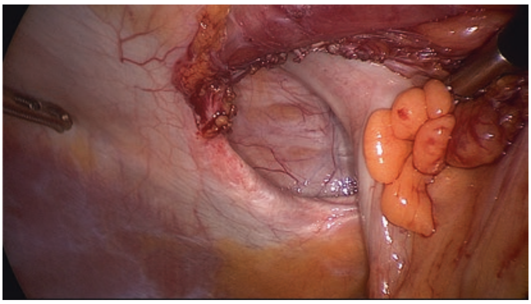
As a classification of parastomal hernias is needed to compare different populations described in various trials and cohort studies, the European Hernia Society proposed a classification based on the defect size (small is ≤5 cm; large is >5 cm) [27].

Muysoms [28] and Hansson et al. [29] described the modified Sugarbaker technique.

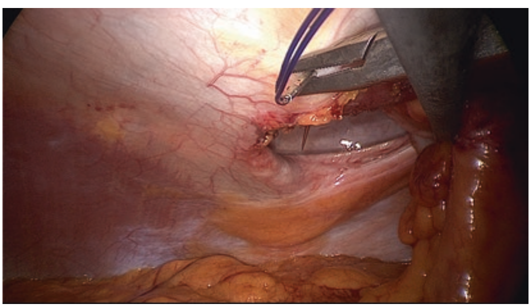
The patient is operated on while in the supine position with both arms placed along the body. The surgeon and the assistant stand at the contralateral site of the stoma. After application of pneumoperitoneum following open placement of the camera trocar, one 5 mm and one 10 mm working trocars are introduced (◘ Fig. 31.1). A careful adhesiolysis is performed. After freeing the adhesions, the stoma loop is completely dissected free from the fascia and the peritoneum (◘ Fig. 31.2). Defect size reduction by the use of a running loop suture (◘ Fig. 31.3) and transfascial pullout of the two sutures (◘ Fig. 31.4) and knotting on the fascia supports the optimal defect closure (◘ Fig. 31.5). The trephine opening is covered with an intraperitoneally placed mesh.



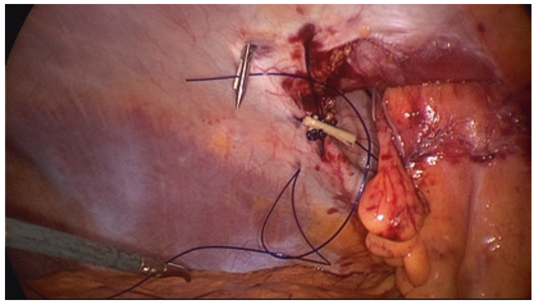
■ Fig. 31.1 Application of three trocars on the opposite site of the parastomal hernia



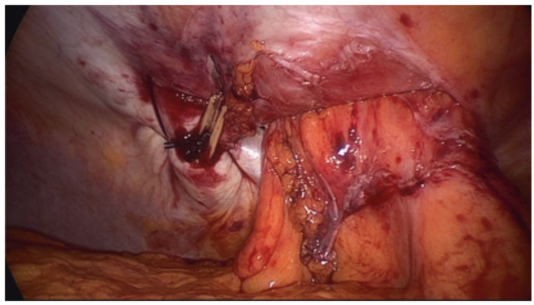
■ Fig. 31.2 The stoma loop is completely dissected free from the fascia and the peritoneum



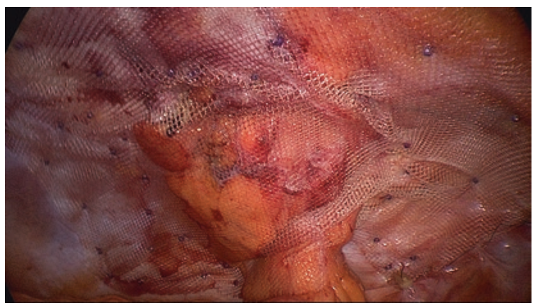
■ Fig. 31.3 Defect size reduction by the use of the running loop suture



■ Fig. 31.4 Transfascial pullout of the two sutures



■ Fig. 31.5 Optimal defect closure



■ Fig. 31.6 Coverage of the stoma opening with the intraperitoneally placed mesh (TiMesh strong, pfm medical, Cologne, Germany)

(TiMesh strong, pfm medical, Cologne, Germany). The bowel is lateralized, passing from the hernia sac between the abdominal wall and the prosthesis into the peritoneal cavity. In this way a tunnel is created between the abdominal wall and the prosthesis (■ Fig. 31.6). It is of utmost importance to prevent narrowing of the bowel in the tunnel and angulation of the bowel when entering the abdominal cavity and the hernia sac. The prosthesis is fixed to the abdominal wall using the double-crown technique [29]. This technique can also be used to prevent parastomal hernias during laparoscopic abdominoperineal resection [30].

31.5 Obese Patients

In the SAGES guidelines for laparoscopic ventral and incisional hernia repair, obesity belongs to the factors reported in the literature that increase the complexity of laparoscopic ventral and incisional hernia repair [31]. But all meta-analyses comparing open versus laparoscopic ventral and incisional hernia repair clearly demonstrate superiority of the laparoscopic approach in terms of wound infection and wound complications [32–35]. Therefore, the International Endohernia Society recommends in the guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias [36] for obese patients presenting with a ventral or incisional hernia the laparoscopic approach, because it reduces the wound infection rate and complications. In obese patients, the defect sizes are significantly larger, something that must be considered when the laparoscopic approach is advised [36]. For obese patients (BMI ≥30 kg/m^2) with a defect size greater than 8–10 cm, there may be a need for additional technical steps (greater mesh fixation, more overlap, suture closure of the defect) when the laparoscopic approach is indicated.

The Consensus Development Conference-based guidelines [37] also recommend laparoscopy for the treatment of ventral and incisional hernia repair in obese patients.

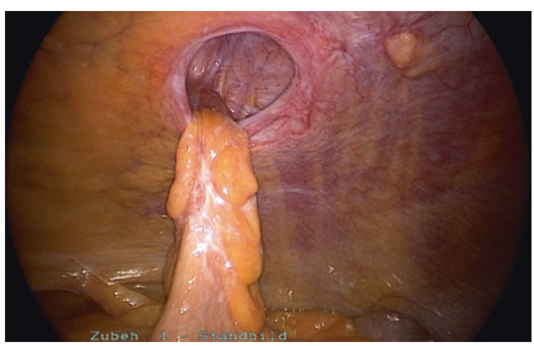
A study of Pernar et al. [38] aimed to determine at what body mass index (BMI) threshold postoperative complications increase. Patients were divided into five groups based on BMI: group 1 (< 25 kg/m^2), group 2 (25–29.99 kg/m^2), group 3 (30–34.99 kg/m^2), group 4 (35–39.99 kg/m^2), and group 5 (≥40 kg/m^2). The adjusted odds of complications in group 5 was 2.89 times greater compared to group 1 (OR 2.89; 95% CI = 1.22–6.84), while there were no significant differences in odds of postoperative complications for group 2, 3, or 4 compared to group 1. BMI category was also significantly associated with undergoing recurrent ventral hernia repair, with 28,7% of patients in group 5 having a recurrent repair compared to 14% in patients in group 1 ($p = 0.03$).

The authors concluded that after ventral hernia repair, complications are most likely to occur in patients with BMI ≥ 40 kg/m^2. This subset of patients also had a significantly higher risk of undergoing surgery for a recurrent hernia [38].

In an analysis of the American College of Surgeons National Surgery Quality Improvement Program (ACS NSQIP), a total of 12.004 patients who underwent ventral hernia repair were included. Of the patients with body mass index (BMI) > 30 kg/m^2, 3–4% developed superficial surgical site infections in the open ventral hernia repair group compared with 0.72% of the patients in the laparoscopic ventral hernia repair group ($p < 0.01$) [39].

In another study of the American College of Surgeons National Surgery Quality Improvement Program (ACS NSQIP) database, patients with elective ventral hernia repair were stratified by BMI (20–25, 25–30, 30–35, 35–40, and ≥40 kg/m^2) and 30-day surgical site occurrence evaluated across BMI groups for laparoscopic vs open ventral hernia repair [40]. A total of 106.968 patients met inclusion criteria, with 60% patients obese. Laparoscopic ventral hernia repair decreased surgical site occurrence for all patients (Odds ratio 0.4, CI 0.19–0.60). Obesity classes I/II/III have increased odds of superficial surgical site infections, deep surgical site infections, and dehiscence for open compared with laparoscopic ventral hernia repair. The authors concluded that obese patients are overrepresented in ventral hernia repairs. Thirty-day postoperative wound complications increase with higher BMI. Laparoscopic ventral hernia repair minimizes both surgical site infection and surgical site occurrence, especially in higher obesity classes (◘ Figs. 31.7, 31.8, 31.9, 31.10, 31.11, and 31.12).

◘ **Fig. 31.7** Laparoscopic incisional hernia repair in an obese patient with BMI 45 kg/m^2 following open repair of a gastroduodenal perforation



◘ **Fig. 31.8** 4 × 4 cm defect in the lateral part of the horizontal incision

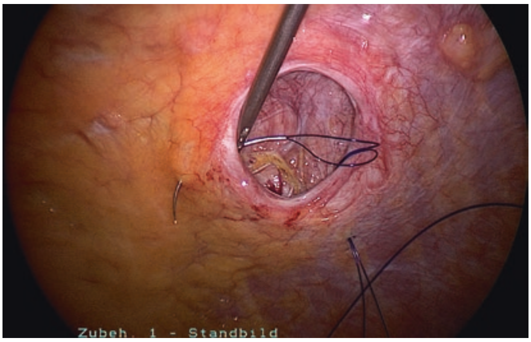


Fig. 31.9 Defect closure with the use of a nonabsorbable loop suture

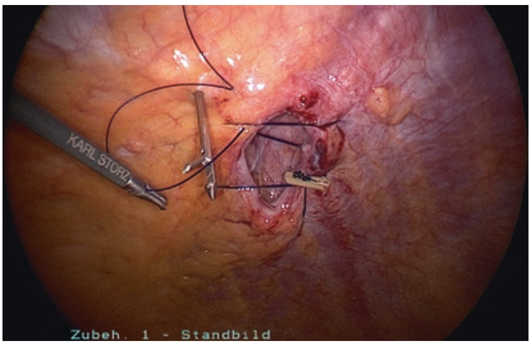


Fig. 31.10 Transfascial extraction of the two ends of the loop suture

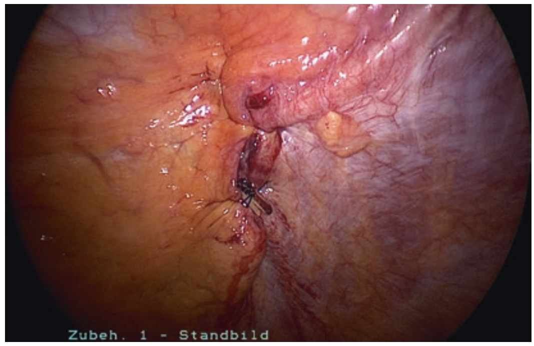


Fig. 31.11 Closed defect after knotting of the two ends of the loop suture on the fascia

Fig. 31.12 Placement of a 20 × 15 cm synthetic mesh (TiMesh strong, pfm medical, Cologne, Germany) over the closed defect and fixation with absorbable tackers

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Giant Hernias: Loss of Domain

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Ventral and Incisional Hernias Mesh Technology

Ferdinand Köckerling and Bruce Ramshaw

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32.1 Pure Polypropylene (PP), Polyester, PVDF, PTFE, Titanized PP, Synthetic Absorbable, Biologicals

In the guidelines [1] for laparoscopic ventral hernia repair of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), no recommendation can be made about a specific prosthetic, since there are few data available directly comparing the long-term outcomes of different prosthetics in humans [1]. Selection of the prosthetics is typically based on surgeon's experience, intraoperative handling characteristics, and the purported features associated with the prosthetic [1]. Post-market, continuous evaluation in terms of patient-centered outcomes of all prosthetics is needed [1].

When meshes are inserted intraperitoneally during laparoscopic intraperitoneal onlay meshes (IPOM), they must meet stringent requirements because they directly contact intestines [2].

32

Eriksen et al. [3] formulated the following characteristics for an optimal mesh to be used for laparoscopic repair of ventral and incisional hernias:

- Minimal adhesion formation
- Excellent tissue ingrowth
- Minimal shrinkage
- No infection or fistula formation
- Minimal pain
- Minimal seroma formation
- No change in abdominal wall compliance
- Low price
- Easy to manipulate

Typically, meshes are made of the basic materials PP, polyester, polyvinylidene fluoride, or PTFE. The use of pure PP meshes and polyester meshes is not recommended for laparoscopic IPOM [2–5]. It is accepted that PP and polyester meshes are coated either with a protective membrane or a protective film (absorbable or nonabsorbable) or with a titanium layer (Figs. 32.1 and 32.2) to protect the viscera [2]. These composite meshes, as they are known, and ePTFE meshes are generally recommended for intraperitoneal use [2–4, 6, 7]. It is assumed that the use of these meshes reduced adhesion formation and hence lowered the risk of intestinal damage and fistula formation (Table 32.1). Therefore, the International Endohernia Society recommended in their guidelines on the evidence level Grade C that for laparoscopic incisional and ventral hernia repair, only materials approved for use in the abdominal cavity (PTFE, PVDF, and composite meshes) should be used [2]. In a systematic review by Shankaran et al. [4] of the implants available for treatment of incisional and ventral hernias, biological meshes are listed as a possible alternative. In this respect, biological meshes can be used in an extraperitoneal as well as an intraperitoneal position [2]. The main advantage cited for biological meshes in their suitability for use in contaminated and infected surgical fields [2, 8] (Table 32.2).

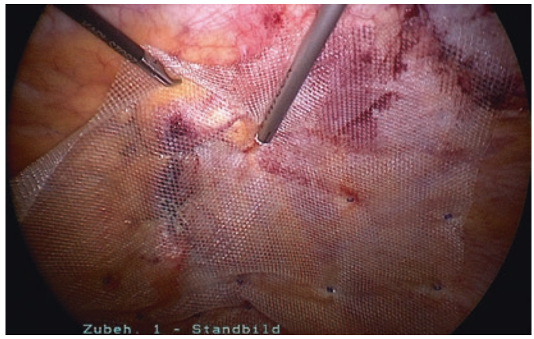

Fig. 32.1 Titanium-coated composite mesh (TiMesh strong) in laparoscopic IPOM

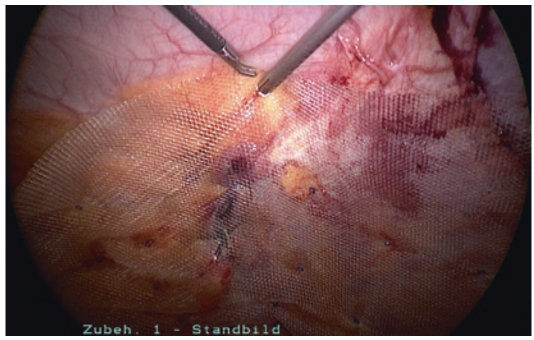

Fig. 32.2 Fixation of the titanium-coated composite mesh (TiMesh strong) with absorbable tackers following defect closure in laparoscopic IPOM

According to a statement on evidence level 1b in the guidelines of the International Endohernia Society, the use of non-cross-linked biological

Table 32.1 Meshes approved for use in the abdominal cavity

Group	Name of mesh	Material	Company name
PTFE	Mycromesh	ePTFE	W. L. Gore
	DualMesh	ePTFE	W. L. Gore
	Dulex	ePTFE	C. R. Bard
	MotifMESH	ePTFE	Proxy Biomedical
	Omyramesh	cPTFE	Aesculap AG
PVDF	Dynamesh	PP/polyvinylidene fluoride	FEG Textiltechnik/Dahlhausen
Composite mesh with absorbable barrier coated	Glucamesh	PP with beta glucan coating	Genzyme
	Proceed	PP with ORC layer	Ethicon
	Sepramesh	PP with resorbable layer	Genzyme
	Parietene composite	PP with collagen coating	Medtronic
	Parietex composite	Polyester with collagen coating	Medtronic
	Symbotex	Polyester with collagen coating	Medtronic
	Ventralight ST	PP with absorbable hydrogel barrier	C. R. Bard
Composite mesh with permanent barrier coated	TiMesh	PP with titanium coating	pfm medical AG
	Composix	PP/ePTFE	C. R. Bard
	Ventrio hernia patch	PP/ePTFE	C. R. Bard
	Intramesh T1	PP/ePTFE	Cousin Biotech
	Intramesh W3	Polyester mesh with silicone layer	Cousin Biotech

Modified after Eriksen et al. [11]
PTFE polytetrafluoroethylene, *ePTFE* expanded PTFE, *cPTFE* condensed PTFE, *PVDF* polyvinyl difluoride, *PP* polypropylene, *ORC* oxidized regenerated cellulose

meshes for elective laparoscopic bridging repair of incisional ventral hernias shows a high recurrence rate [2]. So the Grade A recommendation is that elective laparoscopic repair of incisional and ventral hernias should not be performed with the use of non-cross-linked biological mesh with a bridging technique [2].

The International Endohernia Society gives a statement on evidence level 4 that laparoscopic repair of incisional and ventral hernias in an infected or potentially contaminated surgical field can be performed with non-cross-linked biological meshes but the defect should be closed with sutures [2]. The guidelines recommended a Grade D level that laparoscopic repair of incisional and ventral hernias with non-cross-linked biological meshes in an infected or potentially contaminated surgical field may be a viable option if the hernia defect is closed primarily (Abb. 3–5). But the very high costs of the biological meshes limit their use in routine practice (Figs. 32.3, 32.4, and 32.5).

Biosynthetic absorbable meshes could be in the future an upcoming alternative to biological meshes in contaminated or potentially contaminated ventral and incisional hernias. Studies in laparoscopic ventral and incisional hernia repair are missing. In a first multicenter, prospective, longitudinal study with 104 patients with

Table 32.2 Biological meshes on the market

Name	Manufacturer	Tissue source	Material	X-linking
AlloDerm	LifeCell	Human	Acellular dermis	No
AlloMax	Bard	Human	Acellular dermis	No
FlexHD	Ethicon/MTF	Human	Acellular dermis	–
DermaMatrix	MTF	Human	Acellular dermis	No
Permacol	Covidien	Porcine	Acellular dermis	Yes
CollaMend	Davol/Bard	Porcine	Acellular dermis	Yes
Fortiva	Tutogen	Porcine	Acellular dermis	No
Strattice	KCI/LifeCell	Porcine	Acellular dermis	No
XenMatrix	Brennan Medical	Porcine	Acellular dermis	No
Surgisis	Cook	Porcine	Small intestine submucosa	No
Surgisis Gold	Cook	Porcine	Small intestine submucosa	No
Lyosis	Cook	Porcine	Lyophilized small intestine submucosa	No
FortaGen	Organogenesis	Porcine	Small intestine submucosa	Yes
SurgiMend	TEI bioscience	Bovine	Fetal dermis	No
Periguard	Synovis	Bovine	Pericardium	Yes
Veritas	Synovis	Bovine	Pericardium	No
Tutomesh	Tutogen	Bovine	Pericardium	No
Tutopatch	Tutogen	Bovine	Pericardium	No

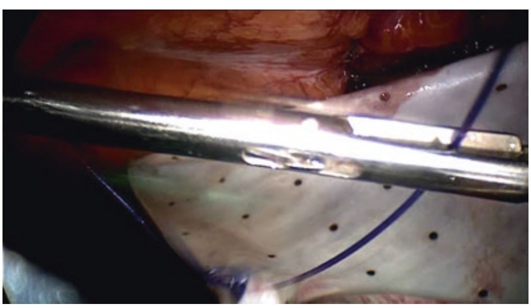

Fig. 32.3 Laparoscopic IPOM with defect closure and use of a biological mesh for treatment of an incarcerated epigastric hernia. Placement of transfascial sutures

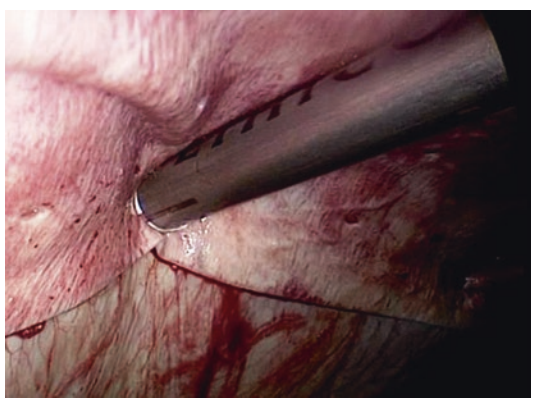

Fig. 32.4 Fixation of the biological mesh with absorbable tackers

a contaminated or clean-contaminated operative field and a hernia defect at least 9 cm^2 had a biosynthetic mesh (open, sublay, retrorectus, or intraperitoneal) repair with fascial closure [9]. Biosynthetic absorbable mesh showed efficacy in terms of long-term recurrence and quality of life and offers an alternative to biologic and permanent synthetic meshes in these complex situations [9].

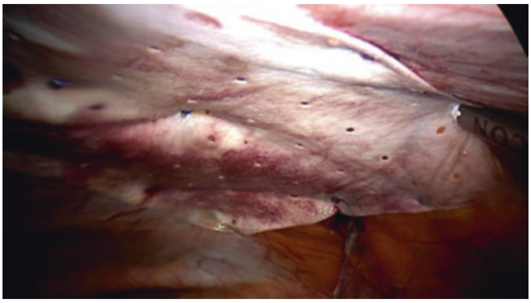

Fig. 32.5 Final view of the laparoscopic IPOM with defect closure and biological mesh

32.2 Mesh Infection: What Should Be Done?

An important advantage of the laparoscopic intraperitoneal onlay mesh (IPOM) technique over open repair of incisional and ventral hernias is the lower rate of wound and mesh infection [10]. Meta-analyses demonstrated that laparoscopic repair of incisional and ventral hernias significantly is attended by fewer wound infections and less need for mesh removal (level 1A) [11–16].

In the meta-analysis of Sauerland et al. [14], the local infection rate in the laparoscopic groups was 3.1% versus 13.4% in the open group ($p < 0.00001$). A local infection requiring mesh removal was found in 0.7% of the laparoscopic group and 3.5% of the open group ($p = 0.009$). Only one third of wound infections did result in mesh removal [10]. So the statements on level 1A in the guidelines of the International Endohernia Society were that the rate of mesh infection after laparoscopic ventral and incisional hernia repair is with 1% low. The mesh does not need to be removed in all cases of wound infection after laparoscopic ventral and incisional hernia repair [10].

In the literature, case reports on the treatment of mesh infections after laparoscopic repair of incisional and ventral hernias discuss both mesh removal and mesh salvage [17–19].

For interventional and conservative treatment of a mesh infection after laparoscopic repair of incisional and ventral hernias, the authors advocate percutaneous drainage of accumulated pus around the mesh and insertion of a drain through which irrigation with gentamycin 80 mg in 20 ml saline solution is carried out three times daily together with intravenous antibiotic treatment [18, 19].

Treatment of mesh infections also depends on the material used [10]. In a comparative study (level 2B), Hawn et al. [20] demonstrated less need to remove a polypropylene mesh than a PTFE mesh because of a mesh infection ($p < 0.0001$). Petersen et al. [21] also showed that for mesh repair of incisional hernias, with which mesh infection occurring in 8.1% of cases after the use of ePTFE and in 3.9% after the use of polypropylene, in no case was it possible to salvage the infected ePTFE mesh, whereas all the infected polypropylene meshes were preserved [10].

The guidelines of the International Endohernia Society recommended on Grade B level that an infected ePTFE mesh after laparoscopic ventral and incisional hernia repair should be removed. A further Grade D recommendation is that preservation of an infected composite mesh after laparoscopic ventral and incisional hernia repair can be attempted using percutaneous drainage, drain irrigation with gentamycin, and intravenous antibiotics [10].

If an interventional conservative attempt proves unsuccessful, various options can be used [22–25].

- Mesh removal and primary skin closure, with the repair repeated after 6–9 months
- Mesh removal using the component separation technique, with the skin left open and vacuum-assisted wound closure or open – wound dressing applied
- Mesh removal, repair of the defect with a biologic mesh leaving the skin open, and applying vacuum-assisted wound closure or open – wound dressing
- Mesh removal, repair of the defect with an intraperitoneally placed biologic mesh, close the defect over the biologic mesh, and close the skin (Figs. 32.6, 32.7, 32.8, 32.9, and 32.10)
- Mesh salvage, with the skin left open, and vacuum – assisted closure or open – wound dressing applied

Because the treatment options available in the literature relate only to individual cases or to small case series, currently, no concrete evidence-based recommendation can be made for the optimal management [10]. The use of a biological mesh for replacement resulted in a high recurrence rate, if bridging was required. Biological mesh seems to work as a replacement, when fascial closure can be achieved [26]. But the high costs of the biological meshes limit their routine use.

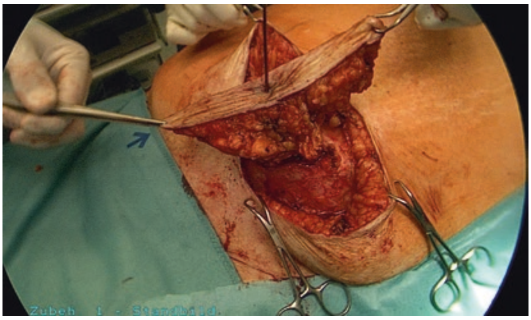

Fig. 32.6 Mesh infection with fistula formation to the mesh after laparoscopic IPOM. Excision of the fistula and the chronically infected soft tissue

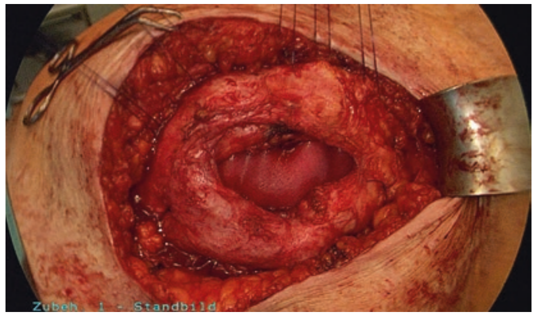

Fig. 32.9 Repair of the incisional hernia defect with a porcine dermis biological mesh (Fortiva) in open IPOM position

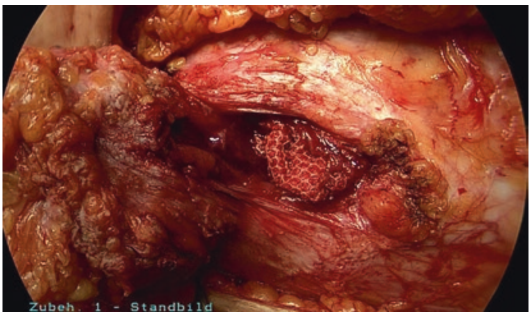

Fig. 32.7 Incisional hernia defect with infected composite mesh still in place

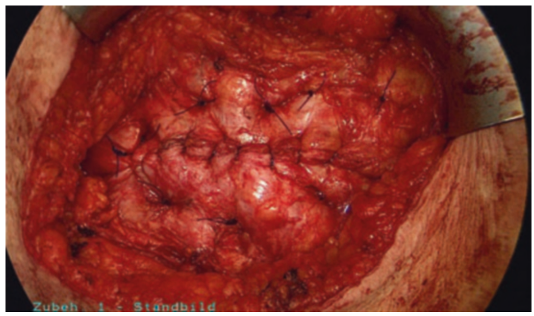

Fig. 32.10 Closure of the incisional hernia defect with nonabsorbable running suture and primary skin closure

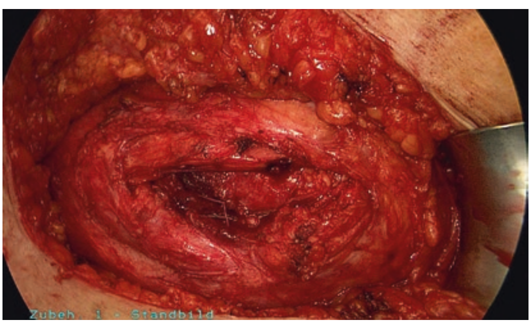

Fig. 32.8 Incisional hernia defect after removal of the chronically infected soft tissue and the mesh

32.3 Long-Term Results of Laparoscopic Ventral Hernia Mesh Repair

The use of prosthetic materials in repair of abdominal wall hernias can lower the risk of hernia recurrence. Therefore, large numbers of meshes are used worldwide every year. All types of meshes on the market have the potential to cause certain complications, such as fistula formation, migration, infection, and rejection [27].

In a series of 225 laparoscopic ventral hernia repairs, Sasse et al. [28] reported over a period of 42 months following surgery of 9.7% of patients dissatisfied because of mesh sensation and pain. Fourteen patients (6.22%) experienced postoperative ileus requiring hospital stay >48 h.

In a randomized controlled trail including 194 patients with laparoscopic or open incisional hernia repair with a mean follow-up of 35 months, a recurrence rate of 18% for the laparoscopic and 14% for the open group was found [29].

In a prospective comparative study, the recurrence rate for the laparoscopic group after a mean follow-up of 30 months was 12% and for the open group after a mean follow-up of 36 months 9% [30]. As in incisional hernia repair 65% of the recurrences appear within in first 3 years, a final recurrence rate of 30% following laparoscopic incisional hernia repair must be expected [31].

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Incisional and Abdominal Wall Hernia Repair with Minimally Invasive Extraperitoneal Synthetic Mesh Implantation Using MILOS Technique (Mini and Less Open Sublay Surgery)

Wolfgang Reinpold

33.1 Summary – 363

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R. Bittner et al. (eds.), *Laparo-endoscopic Hernia Surgery*,
https://doi.org/10.1007/978-3-662-55493-7_33

Incisional hernia is the most common complication after abdominal surgeries at 10–30% worldwide [1, 2]. Abdominal wall hernias never heal spontaneously. The risk of incarceration and strangulation is 1–2% per year. The main cause seems to be genetically determined insufficient cross-links between the collagen molecules.

Since the advent of synthetic mesh [3], recurrence rates could be reduced from 25–60% to below 15%.

The open sublay mesh implantation based on techniques of Jean Rives and René Stoppa and the laparoscopic intraperitoneal onlay mesh plasty (lapIPOM) are the internationally leading procedures for the treatment of incisional hernias [4–7, 11–16] (◘ Fig. 33.1a, b).

In open sublay surgeries, the stabilising synthetic mesh is introduced through a large skin incision outside the abdominal cavity between the peritoneum and the abdominal wall. The disadvantages of the procedure are the more invasive access trauma and, according to the literature, the higher infection rate.

Despite the advantages of the small skin incisions in lapIPOM surgery, the pain level is not low. A further concern is the implantation of a foreign body in the abdominal cavity, which is a risk factor for adhesion formation to the gut and injuries to the viscera [16]. In addition the mesh has to be fixated with many staples, clips, tacks or extensive sutures to the pain-sensitive peritoneum [8–11] (◘ Fig. 33.1a). Expensive implants with adhesion barriers on the area facing the gut have to be used. Reoperations have shown that all IPOM prostheses can lead to massive adhesions and do not provide secure protection against adhesion. Another disadvantage of lapIPOM repair is the fact that the hernia defect is often not fully closed but only bridged by the synthetic prosthesis. This often leads to a persisting protrusion that frequently regresses slowly or not at all. Current data from the German hernia register "Herniamed" show significantly more 1 year recurrences after lapIPOM hernia repair than after open sublay operations.

Because of the disadvantages of the established surgical procedures and in order to minimise complications and pain in abdominal wall hernia repair, we developed a new minimally invasive concept – the mini/less open sublay (MILOS) repair. The MILOS repair permits placement of a large mesh in the retromuscular/preperitoneal space and anatomical reconstruction of the

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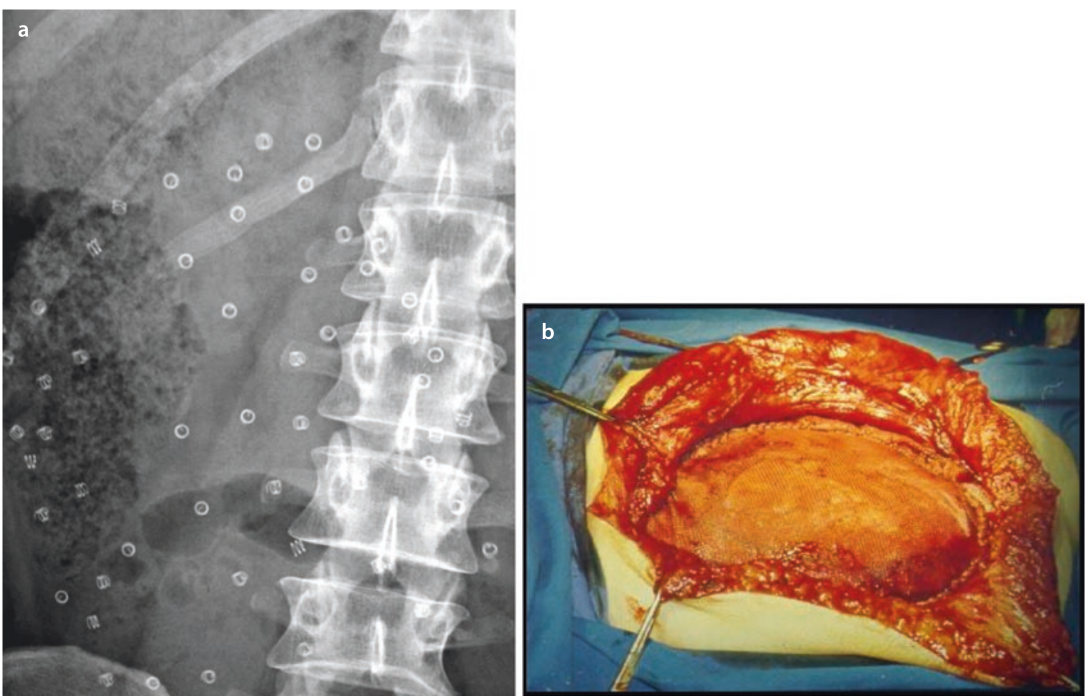

◘ **Fig 33.1** **a** Extensive tack fixation of the lap IPOM mesh. **b** Large incision in open sublay surgery

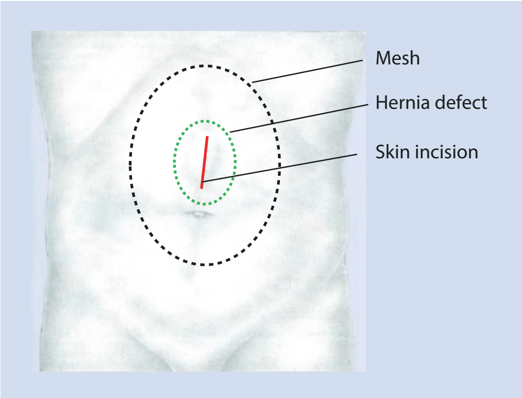

Fig. 33.2 Incision of 2–6 cm directly above the hernia defect. Showing synthetic mesh (*black interrupted line*), hernia defect (*green*), incision (*red*)

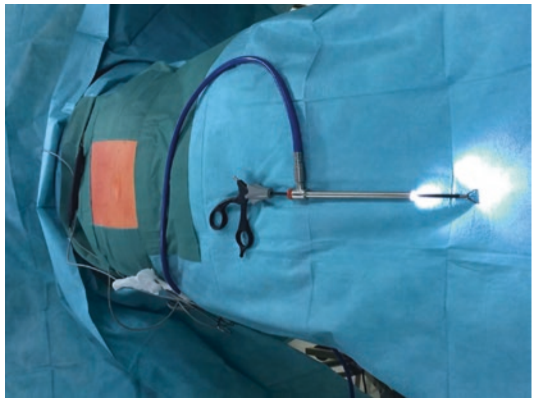

Fig. 33.3 Laparoscopic forceps armed with light tube – Endotorch TM

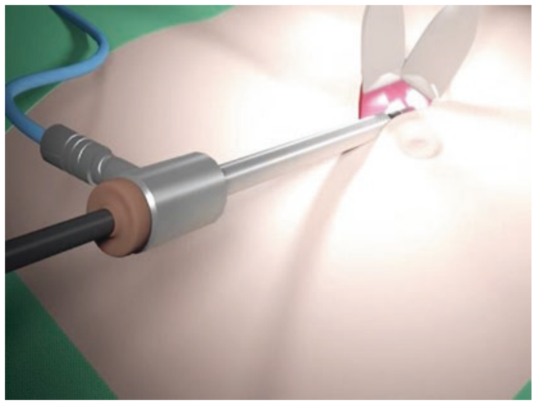

Fig. 33.4 Transhernial dissection with endotorch under direct vision

abdominal wall via a small transhernial incision. Using the MILOS technique, major trauma to the abdominal wall and entering the abdominal cavity is avoided. The MILOS operation can be performed mini open with light-armed laparoscopic instruments either under direct vision or endoscopically assisted. Today, in our institution, all primary and incisional abdominal wall hernias are operated on with the MILOS concept. Exceptions are small hernias with an hernia defect diameter smaller than 2 cm and extremely large hernias.

Every MILOS operation starts with an incision of 2–6 cm directly above the centre of the hernia defect (Fig. 33.2). The abdominal wall is lifted with retractors. The preparation is carried out in "mini-open" technique under direct vision or endoscopically assisted (Figs. 33.3 and 33.4). After transhernial mini-open preparation of an extraperitoneal space of at least 8 cm diameter and closing of the abdominal cavity, the procedure can be continued as total extraperitoneal gas endoscopy [TEP of the abdominal wall (endoscopic minimally open sublay repair (EMILOS))] using either standard trocars (Fig. 33.5) or a transhernial single port (Fig. 33.6) [17, 18].

The MILOS/EMILOS technique enables the extraperitoneal preparation of the whole rectus compartment and both lateral compartments. Very large synthetic meshes can be implanted (Fig. 33.12) minimally invasively if the size of the hernia requires it.

The steps in the surgery:

1. Small incision directly above the centre of the hernia defect (Fig. 33.2).
2. Hernia sac preparation.
3. Small incision of the peritoneum for diagnostic laparoscopy.
4. Resection of the hernia sac.
5. Complete and precise exposure of the fascial edge of the hernia orifice.
6. While the abdominal wall is lifted with rectangular retractors, transhernial extraperitoneal dissection around the hernia gap is performed using laparoscopic instruments armed with a light tube specifically designed by the company WOLF and us (Endotorch TM, Figs. 33.3 and 33.4). Via a 4 cm incision, the Endotorch TM allows circumferential dissection of the extraperitoneal plane with a radius of up to 20 cm from the fascial border of the hernia gap.

Fig. 33.5 MILOS operation: gas endoscopy with standard trocars

Fig. 33.6 MILOS operation: gas endoscopy with transhernial single port

Transhernial longitudinal incision of the posterior rectus sheath is performed in all quadrants to correspond with mesh size (Figs. 33.7 and 33.8). Figure 33.9 depicts the endoscopic incision of the cranial section of the left posterior rectus sheath.

7. Closure of the abdominal cavity with peritoneal suture.
8. Transhernial and extraperitoneal implantation of synthetic mesh. In the midline, the mesh is placed in the preperitoneal space and on both sides laterally in the retromuscular position (Fig. 33.10).
9. Mesh fixation is only necessary in cases where the hernia defect cannot be closed with low tension (bridging of large hernia defects). The intra-abdominal pressure fixates the mesh between the peritoneum and supporting abdominal wall. We use large pore standard polypropylene or polyvinylidenfluoride meshes, which cover the hernia defect with a radius of 5–20 cm (Figs. 33.11 and 33.12) according to the hernia defect size.
10. The hernia defect is closed anatomically with nonabsorbable or long-term absorbable suture.

The MILOS technique is also appropriate for lateral abdominal wall hernias. In the case of large incisional hernias, the surgery is carried out in “less open” technique (skin incision >6 cm–12 cm).

From January 2010 to December 2015, we carried out 715 MILOS surgeries for surgical hernias and an approximately equal number of primary abdominal wall hernias. Data on all patients were documented in the “Herniamed” register.

The hernia orifices and the size of the mesh are given in Tables 33.1 and 33.2. Postoperative consumption of analgesics is comparably low. The standard postoperative pain medication is metamizol 4 × 1 g p.o. Additional opioids are necessary in only 10% of the cases. Even in the case of large incisional hernias, a peridural analgesic catheter is dispensable.

In 36 cases of hernia surgery, the MILOS technique was combined with posterior or anterior endoscopic component separation (hybrid procedure) in order to achieve a low-tension anatomical closure of the large hernia defect after the insertion of a large extraperitoneal synthetic mesh.

The average operating time of MILOS repair is 103 min, 8 and 21 min longer than open sublay (95 min) and lapIPOM repair (82 min), respectively. The complication rate after MILOS incisional hernia repair is very low (Tables 33.3 and 33.4). There was only one enterotomy. Two superficial wound infections healed preserving the synthetic mesh. In four patients, revision was carried out with haematoma evacuation. To obtain

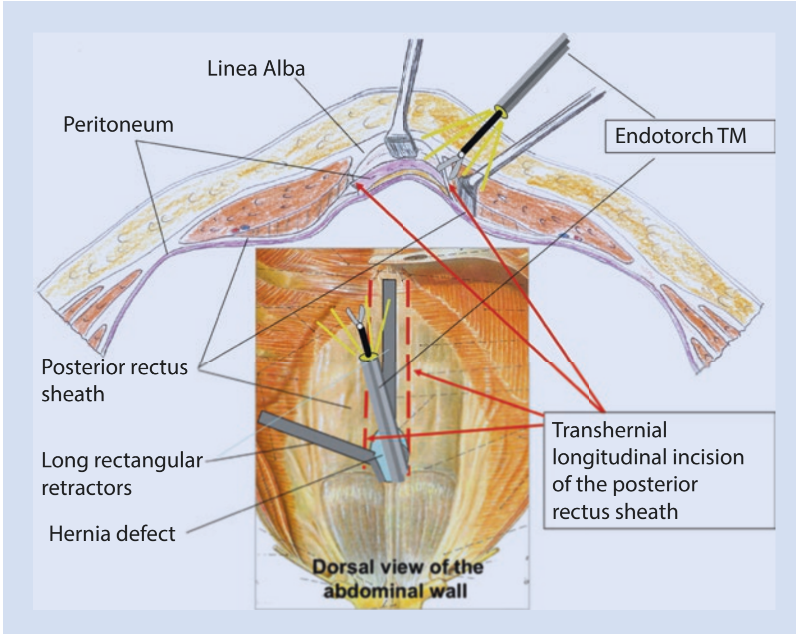

Fig. 33.7 Transhernial longitudinal incision of the posterior rectus sheath with light armed laparoscopic scissors

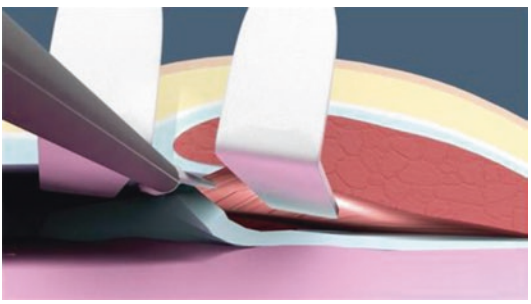

Fig. 33.8 Incision of the posterior rectus sheath 1 cm lateral to the medial border of muscle

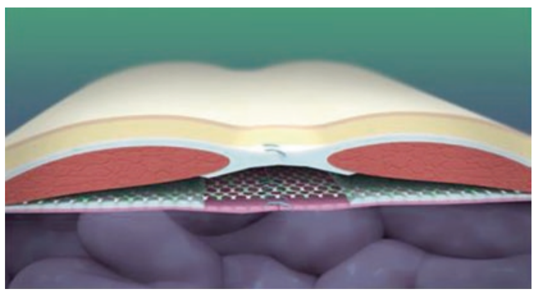

Fig. 33.10 Retromuscular/preperitoneal mesh position; hernia defect is anatomically closed

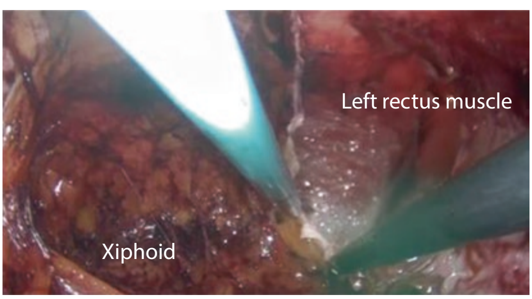

Fig. 33.9 Single port TEP: incision of the upper left posterior rectus sheath

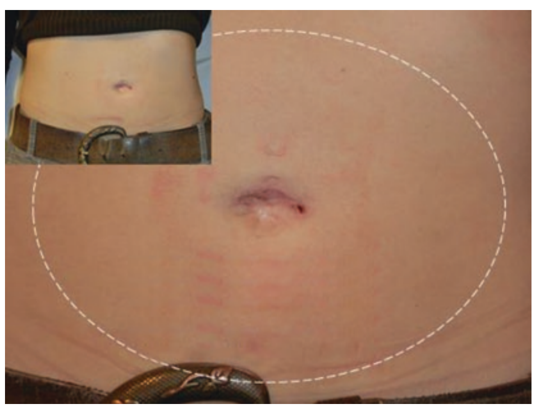

Fig. 33.11 Young woman with 3 cm incisional hernia after suture closure of an umbilical hernia. MILOS repair with 3 mm instruments, 5 mm endoscope and 2 cm incision. Implantation of a 15 × 15 cm standard synthetic mesh

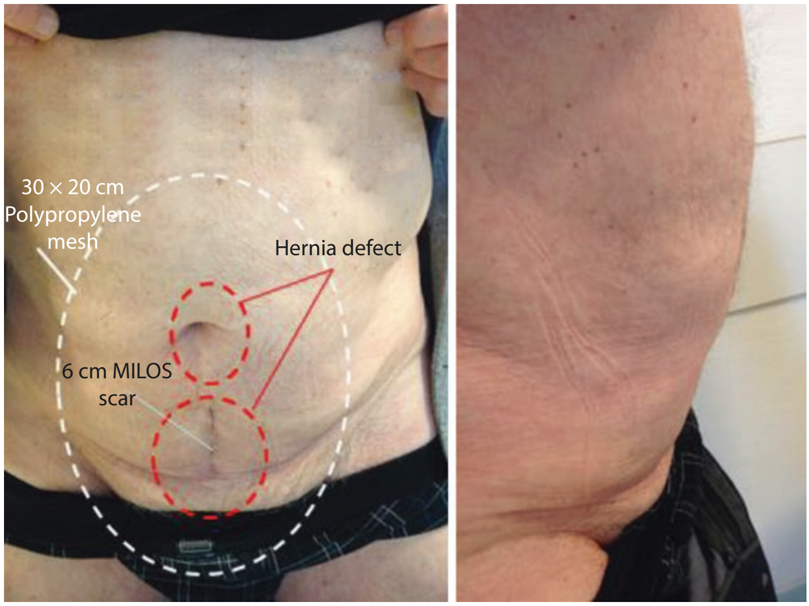

Fig. 33.12 Abdominal wall after MILOS operation of the fourth recurrence of an incisional hernia after open prostatectomy: multiple defect 15 × 9 cm hernia gap marked in *red broken line* and 30 × 20 polypropylene mesh (marked in *white broken line*)

Table 33.1 Size of hernia gap in incisional hernias (MILOS-OP; *n* = 715)

Area (in cm²)	0–5	5–10	10–20	20–50	50–100	100–200	> 200
Number	79	55	91	137	112	150	91
Area (in cm²)							

Table 33.2 Size of mesh in incisional hernia operations (MILOS-OP; *n* = 715)

Area (in cm²)	0 bis 50	50 bis100	100 bis 200	> 200
Number	0	8	77	630
Area (in cm²)				

statistically valid results of patients with comparable hernias and comorbidity, a propensity score matching of 601 MILOS, lapIPOM and open sublay operations of the German Herniamed registry, was carried out. After MILOS operation, there were significantly fewer postoperative complications, cases of bleeding requiring revision, general complications and chronic pain compared to lapIPOM and open sublay repair.

One year after MILOS operation, the rate of chronic pain induced by physical activities was highly significantly lower than after open sublay and lapIPOM repairs. Moreover, the infection rate was highly significantly lower after MILOS repair compared to open sublay operations. The rate of infection after MILOS repair was even lower than after lapIPOM operations but not at a statistically significant rate.

Table 33.3 MILOS incisional hernia repair at Gross-Sand Hospital ($n = 715$) vs. all incisional hernias in the Herniamed register (23.682)

	MILOS incisional hernia operations % ($n = 715$)	All incisional hernia operations in Herniamed register (23.682)
No complications	96.0	86.0
Total number of complications	4.0	14.0
Surgical complications	2.3	9.6
Haemorrhage/postoperative haemorrhage	0.7	1.9
Intestinal injury/suture insufficiency	0.1	0.5
Impaired wound healing	0.3	0.7
Seroma	0.8	4.1
Infection	0.3	1.2
Ileus	0.1	1.2
Revision surgeries	1.8	4.1
General complications	1.6	4.1
Mortality	0.1	0.3

Table 33.4 MILOS incisional hernia operations at Gross-Sand Hospital ($n = 600$) vs. all incisional hernias operations documented in Herniamed register ($n = 12.621$) with follow-up of 1 year

	MILOS incisional hernia surgeries ($n = 600$)	Incisional hernias in Herniamed register ($n = 12.621$)
	%	%
Recurrence after 1 year	1.3	5.5 (6.8 lapIPOM; 3.9 open sublay)
Pain at rest	3.8	10.0 (9.9 lapIPOM; 3.9 10.1 open sublay) 3.9
Chronic stress-induced pain	6.5	18.5 (19.9 lapIPOM; 17.1 open sublay)
Chronic pain requiring therapy	3.0	7.3 (7.7 lapIPOM 6.9 open sublay)

33.1 Summary

Our experience with over 1400 MILOS surgeries in abdominal wall and incisional hernias showed the following advantages of using this technique:

1. Minimally invasive extraperitoneal implantation of (large) standard synthetic meshes without traumatic mesh fixation.
2. Closure of hernia gaps and anatomical reconstruction of the abdominal wall. Protection of viable abdominal wall structures including nerves.
3. After MILOS operations, there were significantly less postoperative surgical complications, general complications and less chronic pain than after open sublay and lapIPOM repair. There were significantly less infections after MILOS repair compared to open sublay and significantly less recurrences than after lapIPOM repair (Herniamed register).
4. The MILOS technique allows minimally invasive treatment of rectus diastases.
5. The MILOS technique can be combined with endoscopic anterior and posterior component separation.
6. Good cosmetic results.
7. In comparison with lapIPOM operations, there is a saving of around 1.200 € in material costs per operation.

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Endoscopic Mini/Less Open Sublay (EMILOS) Technique: A Variation of the MILOS Operation in the Therapeutic Spectrum of Primary and Secondary Ventral Hernias

Reinhard Bittner and Jochen Schwarz

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34.1 Introduction

The optimal operative treatment of primary and secondary hernias of the abdominal wall is still debatable. Traditional open techniques are burdened with a high rate of infection [1], whereas the laparoscopic intraperitoneal onlay mesh (IPOM) repair carries an increased risk for intraoperative lesions to the bowel, adhesions, and bowel obstructions [2–4]. Despite great progress in mesh technology and development of expensive meshes promising less formation of adhesions between the mesh and the intestine, the potential risk of an intraperitoneal foreign body has not yet been solved [5]. Furthermore, the IPOM technique typically requires expensive fixation devices and, more important, fixation with tacks or sutures causes severe acute and chronic pain. In order to avoid these disadvantages of current open and laparoscopic techniques, the MILOS (mini/less open sublay) concept was developed by W. Reinpold (▶ Chap. 33). The aim of this novel technique is to keep the mesh out of the abdominal cavity. Following the MILOS concept, the surgeon is able to place a large mesh into the retromuscular plane through a small skin incision (2–6 cm = mini open; 6–12 cm = less open). The MILOS operation is an open procedure, using endoscopic dissection instruments and a novel specifically designed light tube which facilitates exposure, visualization, and retraction (Endotorch, Wolf TM). Despite this new innovative device, the technique which is extensively described in ▶ Chap. 33 may be technically challenging especially not at least because the assisting surgeon's view is limited. Therefore, in order to increase utilization of the "MILOS concept," we developed the endoscopic mini/less open sublay (EMILOS) operation which is essentially a reversed total extraperitoneal(TEP) procedure [6]. This variation of the original MILOS operation is a true hybrid technique which consists of two parts, the first steps (step 1–4) are identical to the MILOS operation, then immediately after opening of the rectus sheath, the operation continues with endoscopic dissection "reversed TEP" of the total retromuscular space.

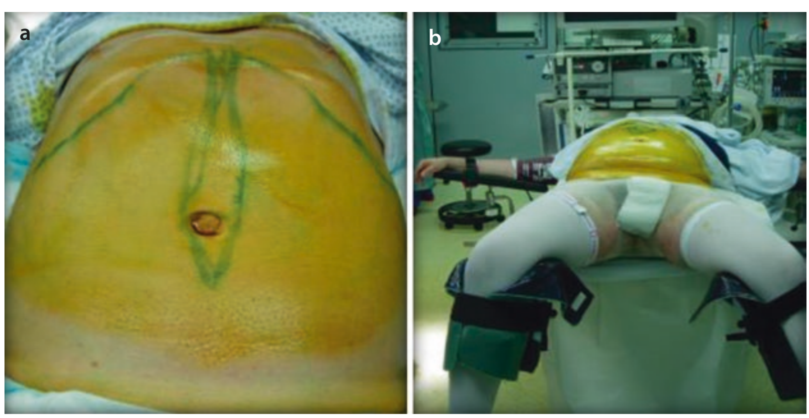
34.2 Operative Technique

After initiation of general anesthesia, the patient is placed flat on the operating table with the legs in the French position like performing a laparoscopic cholecystectomy (◘ Fig. 34.1a, b).

During the endoscopic part of the operation, the surgeon will stand between the legs of the patient. No special instruments are needed except a self-constructed low-cost indigenous balloon [7, 8] used to develop the preperitoneal space just proximal to the pubic bone as in TEP. Steps 1 to 4 are identical to the MILOS operation (see ▶ Chap. 33).

Step 1 The endoscopic part (E) of the MILOS operation begins with a small incision of the posterior sheath of the rectus muscle on one side. The rims of the opened fascia are marked with holding sutures.

Step 2 Introducing of a curved sponge forceps (Kornzange) into the rectus sheath and pushing down directly on the back wall of the sheath in caudal direction toward the symphysis.



◘ **Fig. 34.1** **a** Typical patient for an EMILOS operation: umbilical hernia with rectus diastasis. **b** Position of the patient on the operating table

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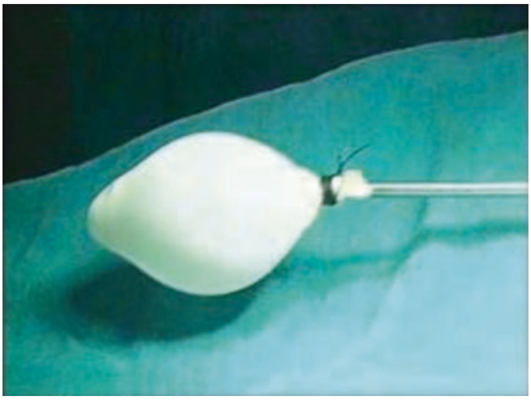


Fig. 34.2 Indigenous balloon [7, 8]

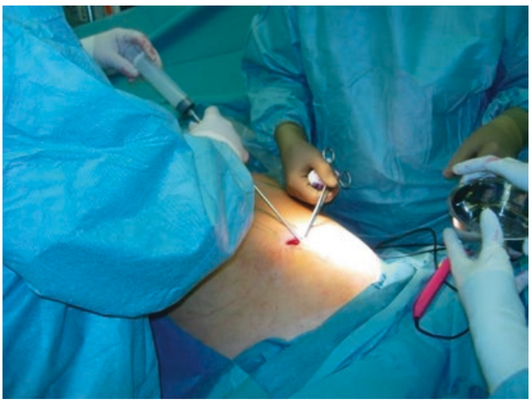


Fig. 34.3 The balloon is pushed down into the suprapubic extraperitoneal space

Fig. 34.4 Replacement of the balloon by a camera port with a 10 mm optic

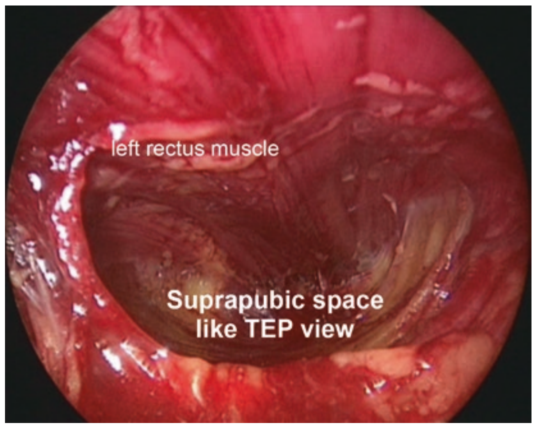


Fig. 34.5 Suprapubic retromuscular plain

Step 3 Removal of the forceps and replacement by an indigenous balloon-like in TEP [7, 8]. The balloon is prepared by capping the tip of a 5 mm suction irrigation cannula with the middle finger of a number 8 latex glove (Fig. 34.2). The finger of the glove is tied tightly onto the tip of the cannula with some bandage material or some sutures. Before introducing into the retromuscular/preperitoneal space, the patency or any leak from the side of the glove finger should be checked by inflating with normal saline solution and aspiration.

Step 4 The balloon is pushed down into the extraperitoneal space (Fig. 34.3) just in front of the symphysis and inflated with about 300 ml of saline solution to create a space for safe introduction of a 12 mm camera port later on. After aspiration of the fluid, the cannula is withdrawn and replaced by a camera port with a 10 mm optic (Fig. 34.4).

Step 5 Insufflation of carbon dioxide into the already preformed preperitoneal space. In order to avoid loss of gas during this step, the previously mentioned holding sutures at the entrance to the rectus sheath are fixed to the port.

Step 6 After a complete creation of the space under direct visualization (Fig. 34.5), the 12 mm port may be safely inserted and will accommodate the camera and will be used to introduce the mesh after a complete dissection of the retromuscular space (Fig. 34.6).

Step 7 Removal of the 10 mm port which had been introduced through the wound at the umbilicus. Now, the opposite side of the posterior sheath of the rectus muscle is also incised. These incisions of the posterior wall of the rectus sheath on both sides are continued caudally and cranially as far as it is convenient in relation to the small skin incision. Note: The linea alba must be preserved; therefore, first, the preperitoneal fat and the peritoneum attached to the midline should be pushed down before safe longitudinal incision of the posterior rectus sheath is possible.

Fig. 34.6 The suprapubic camera trocar is placed (*arrow*)

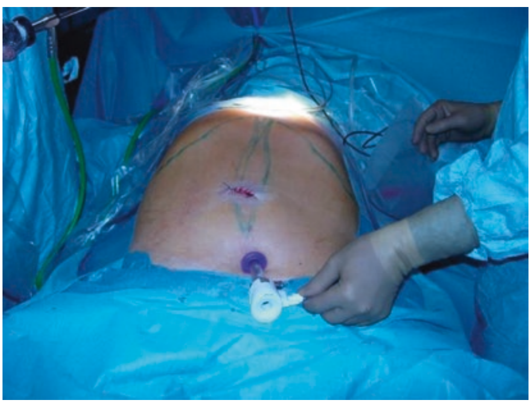


Fig. 34.7 The skin incision at the umbilicus is provisionally closed

Step 8 Gentle blunt detachment of the posterior sheath of the rectus muscle using the curved sponge forceps as far as it is possible, which is very easy to do.

Step 9 Provisionally tight closure of the skin incision. Introducing the 10 mm optic (30°) via the 12 mm port into the preperitoneal space proximal to the symphysis (Fig. 34.7). Insufflation of the carbon dioxide up to a pressure of 14 mmHg.

Step 10 Endoscopic visualization of the retromuscular space with the surgeon standing between the legs and the video tower behind the head of the patient. Starting the endoscopic dissection (reversed TEP) after introducing a 5 mm working trocars on each side laterally to the midline in the medio-clavicular line and about 3–5 cm above of the umbilicus under direct view (Fig. 34.8).

Continuation of the incision of the posterior rectus sheath cranially up to the costal margin and the xiphoid (Fig. 34.9). The space behind the costal margin as well as behind the sternum (fatty triangle) is easily dissected and opened for later mesh placement. It is important to preserve the linea alba (Fig. 34.9). Complete blunt detachment of the fascia from the rectus muscle while carefully preserving the vessels and the nerves perforating the fascia laterally.

Step 11 Introducing a 5 or 10 mm optic trocar about 5–7 cm superior to the working trocars under view through the rectus muscle (Fig. 34.8). Afterward, continuation of the incision of the posterior rectus sheath downward to the linea arcuata. The space of Retzius will be opened and the dissection may be proceeded down to the pubic bone and below of the 12 mm trocar(Fig. 34.10).

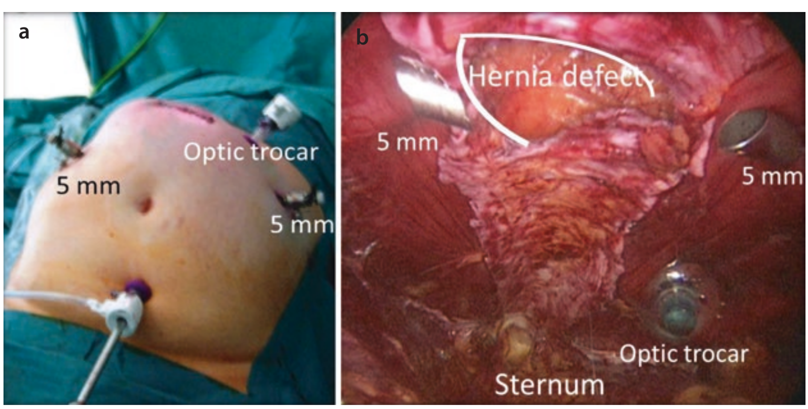
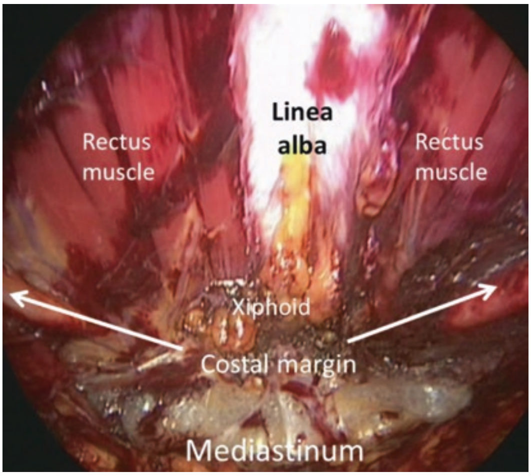
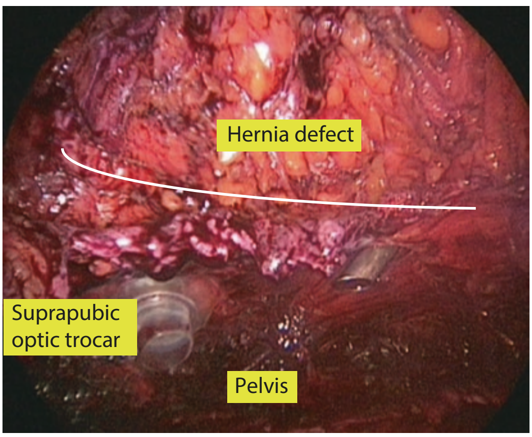


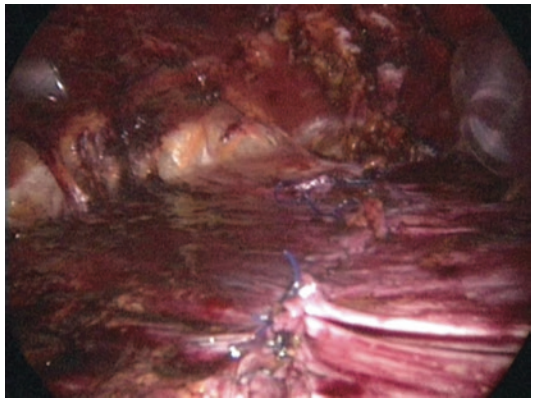
Fig. 34.8 Placement of the working trocars, later followed by a second optic trocar for precise dissection of the suprapubic region. **a** View from outside. **b** View from inside



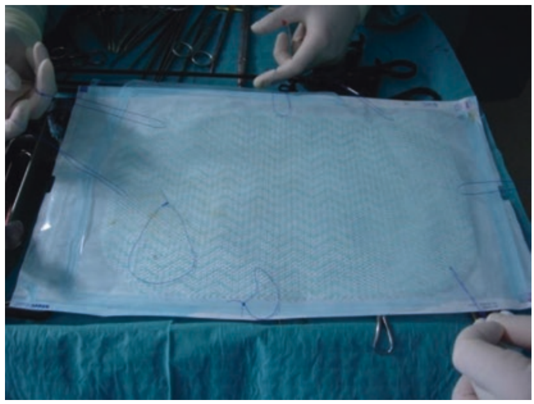
■ **Fig. 34.9** Dissection of the upper retromuscular space is completed



■ **Fig. 34.10** Dissection of the suprapubic region



■ **Fig. 34.11** Suture of the posterior sheet of the rectus muscle



■ **Fig. 34.12** Placement of the holding loops

Step 12 After completion of the dissection of the retromuscular space, it is possible to suture the posterior sheet in patients who want an ideal reconstruction of the abdominal wall without any bulging in the later course (■ Fig. 34.11).

Step 13 Preparation of a large mesh (20 × 30/40 cm, macroporous) prefixed with 4–6 holding loops placed in the middle of the upper and the lower rim as well as laterally 1–2 cm away from the border of the mesh in order to facilitate subsequent positioning of the mesh (■ Fig. 34.12). The holding loop at the top of the mesh should be about 50 cm in length. The mesh is then formed from each side as a double roll fixed by three sutures.

Step 14 Introduction of the cephalad holding loop via the lower 12 mm trocar in direction of the sternum under view of the upper optic. The loop is caught by a grasping needle introduced in the angle between the xiphoid and the costal margin. The double-rolled mesh is then introduced through the 12 mm trocar and pulled to the retrosternal region.

Step 15 After cutting the fixation sutures, the mesh is unrolled and placed flat within the retromuscular space with the help of the holding loops (■ Fig. 34.13).

Two Redon drains are introduced via the 5 mm working trocars, carbon dioxide is drained off, and trocars and holding loops are removed.

Step 16 The skin is reopened, the wound lavaged with an antiseptic solution, and the hernia defect is closed with a nonabsorbable running suture in small bite technique. The wound is closed and dressed, and an abdominal binder is placed.

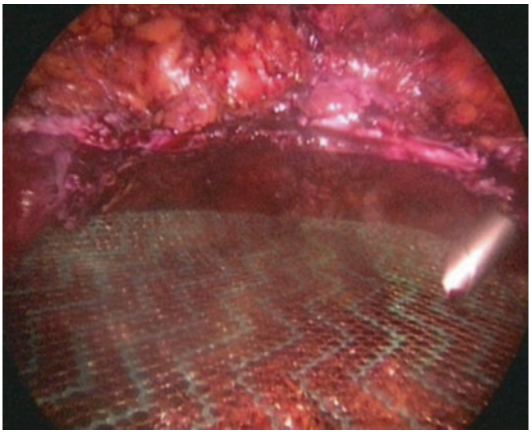


Fig. 34.13 The mesh (20 × 30 cm) is placed

34.3 Preliminary Results

Between June 2015 and September 2016, a total of 33 patients were operated by EMILOS technique. The indication for operation was in 19 patients with an umbilical/epigastric hernia in combination with a rectus diastasis and in 14 patients with an incisional hernia. In 31 patients the size of the implanted mesh was 20 × 30 cm, in 2 patients it was 16 × 30 cm. The results are shown in Table 34.1. No intraoperative complications were observed. The average hospital stay was 3.1 days (range 2–4 days). Postoperatively two complications were observed. One patient developed a small superficial wound necrosis, which was excised; the further course was uncomplicated. The second patient suffered from a severely infected seroma; therefore the mesh was removed 3 weeks after the operation.

The postoperative pain score between the fifth and seventh postoperative day was in rest below VAS 3 and under physical stress 3.9 (range VAS 0–6).

The late cosmetic results are excellent (Fig. 34.14).

Table 34.1 Biologic and treatment data

Operation	Age (years)	BMI	Defect size (cm^2)	Length of incision (cm)	Operation time (min)
EMILOS *n* = 33	57 (31–76)	30,1 (24,3–37,5)	30,1 (3–150)	5,25 (3–8)	157 (90–255)

34

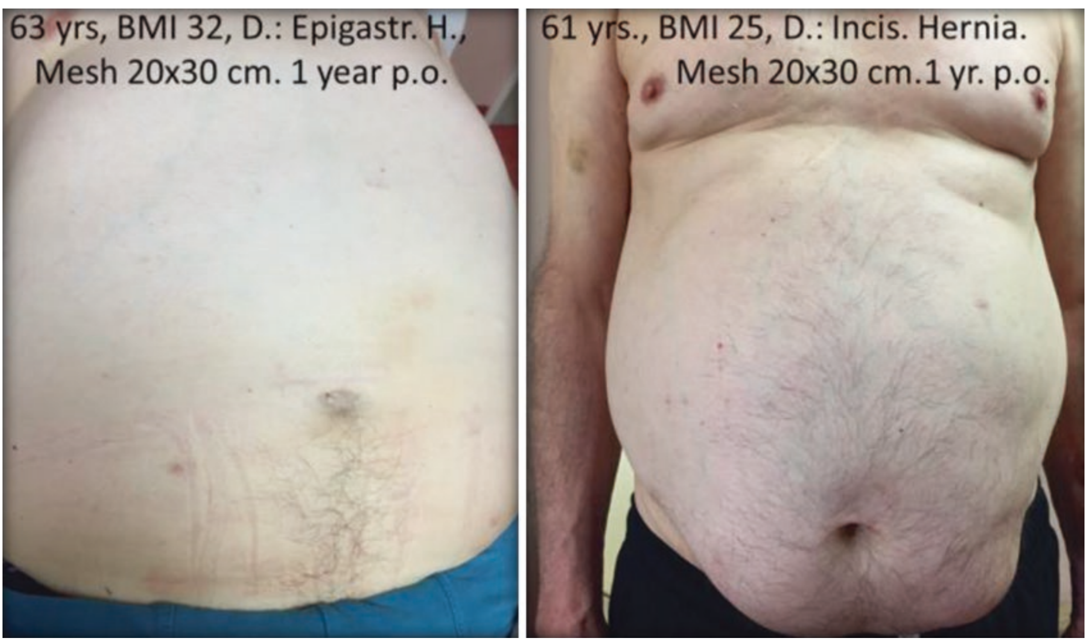


Fig. 34.14 Cosmetic result 1 year after the operation

34.4 Discussion

The ideal indications for this new operation technique are primary or secondary ventral hernias in patients presenting an additional significant rectus diastasis (◘ Fig. 34.1a). In these patients, midline prosthetic augmentation of the whole abdominal wall is recommended as the rate of recurrence is high in this group [9]. Early results of the EMILOS technique in the therapy of primary and secondary ventral hernias are promising [6]. The impetus to develop novel minimally invasive operative techniques which enables the surgeon to get the mesh out of the abdominal cavity has been a new and exciting trend in hernia surgery. The combination of the benefits of the open extraperitoneal and retromuscular repair with the smaller incision and lower wound morbidity of laparo-endoscopic surgery provides the primary benefits of each of these repairs while avoiding their limitations.

In 2004, Conze et al. [10] pointed out that the incision of the posterior rectus sheath and the opening of the "fatty triangle" is an important step of open retromuscular mesh repair, which enables the surgeon to position the mesh behind the xiphoid and the costal margin for prevention of recurrences. Therefore the posterior lamina of the rectus sheath in its upper part must be left open in this technique. However, Reinpold et al. (▶ Chap. 33) did not close the posterior rectus sheath at all in the vast majority of their MILOS cases. According to his experience, the complete closure of the posterior rectus sheath seems to be not necessary for the success of the operation. But, both authors claimed the reconstruction of the linea alba in open sublay repair respectively and the preservation of the anterior sheath in MILOS technique as indispensable steps of the repair. In most of our EMILOS patients, we also didn't suture the posterior sheath accordingly, but in some of these cases, we observed an unpleasant bulging in the midline of the upper abdominal wall. Therefore, to prevent any bulging, in the last seven cases, we sutured the middle and lower part of the rectus sheath. Indeed, in the follow-up regarding the shape of the abdominal wall, these patients showed a better cosmetic result compared with the early cases.

The recent literature reports several techniques for reconstruction of the midline in patients with rectus diastasis by suture plication and mesh augmentation without performing a large skin incision [11, 12]. The disadvantage of one of these two studies is that the mesh is placed in an unfavorable subcutaneous position [11]; the second study recommends that the mesh should be pushed through the hernia defect into the preperitoneal plane [12]; therefore, only meshes with a limited size may be implanted. Moreover, these procedures are complicated by a high frequency of seroma formation [12]. Other authors propagate the transabdominal route in order to bring the mesh into the preperitoneal retromuscular position [13, 14]. The disadvantages of these transabdominal techniques are as follows: (1) enhanced risk for bowel lesion [13, 14], (2) technical difficulties [13, 14], (3) use of several linear cutters [14] which increases the costs dramatically, (4) use of countless tacks [14] which increases the risk for pain, and (5) limited size of mesh [13, 14] which increases the risk for recurrences. According to our experiences utilizing the EMILOS repair, these disadvantages are avoided (6). The best current indications for EMILOS are patients presenting with a primary or secondary hernia in the midline and concurrent rectus diastasis. Each step of the EMILOS operation is well standardized and improved for routine clinical use.

34.5 Conclusion

In conclusion, both new techniques, MILOS and EMILOS, are patient friendly, produce remarkable less acute and chronic pain, minimize the amount of abdominal trauma, avoid traumatic mesh fixation or expensive mesh, and get the mesh out of the abdominal cavity. Both techniques are standardized, reliable, and reproducible. Mini-open and videoendoscopic steps are complementary and indispensable parts of the MILOS concept. Future studies are necessary to clarify which technique will be the best for the specific hernia and individual patient.

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Lumbar and Other Unusual Hernias

Karl A. LeBlanc

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35.1 Introduction

The practicing general surgeon has an opportunity to these types of hernias very infrequently. While most surgeons will have an opportunity to repair a Spigelian hernia occasionally, many will never see or treat the unusual ones such as the lumbar or sciatic hernias. The lumbar hernia has recently become more frequent due to the increasing use of the lumbar approach to anterior fusion of the lumbar spine. However, in many instances these "hernias" actually represent pseudohernias because these lateral bulges are the result of intercostal nerve injury (T11 and T12) and subsequent paralysis of the flat muscles of the abdominal wall. These are especially difficult to treat.

Barbette first suggested the existence of a lumbar hernia in 1672, but the first publication regarding this entity was in 1731 by Garangeot. It is believed that the first surgical repair of a strangulated lumbar hernia occurred in 1750 by Ravaton. The first anatomic description of the inferior lumbar space was by Petit in 1783. Grynfeltt described the superior lumbar space in 1866. Because of their descriptions, Petit and Grynfeltt's names are associated with these hernias rather than that of the other individuals. The anatomic boundaries of the superior lumbar hernia are the 12th rib superiorly, the internal oblique muscle anteriorly, and the erector spinae muscle posteriorly (Fig. 35.1). The anatomic boundaries of the inferior lumbar hernia are the latissimus dorsi muscle posteriorly, the external oblique muscle anteriorly, and the iliac crest inferiorly.

Selby described traumatic acquired lumbar hernia in 1906, and Kelton noted incisional acquired lumbar hernia in 1939. Kretchmer published the first study of 11 of these latter hernias

Fig. 35.1 CT view of a left lumbar hernia

Fig. 35.2 Left Spigelian hernia with incarcerated small intestine

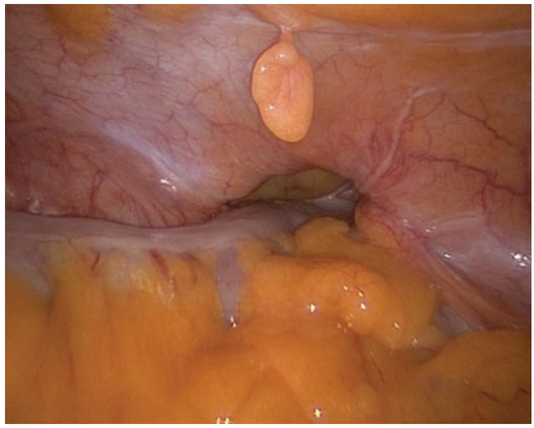
following renal surgery in 1951 [1]. Eighty percent of these hernias are acquired, while the remainder is congenital. This ratio has remained stable over time. The etiology of the acquired defects has changed, however. Infectious etiology has declined from 17% to 2%, whereas incisional hernias have increased from 10% to 31% [2]. The laparoscopic approach to the repair of the lumbar hernia was first described by Burick and Parascandola in 1996 [3]. Both of these techniques are effective.

Similar to the lumbar hernias, the name of the Spigelian hernia is credited to someone who clarified the anatomic description of the entity, van der Spieghel (1578–1625). Similar to the lumbar hernias, his name was associated with this hernia by someone else, Klinkosch in 1764. This hernia occurs at the level of the semicircular line where the fascias of the oblique and transversus muscles begin to split to for the two separate layers of the abdominal musculature. Generally the overlying external oblique fascia remains intact making this herniation interstitial and more difficult to diagnose (Fig. 35.2). These entities are more common than that of the lumbar hernias. They represent 0.12–1% of all abdominal hernias.

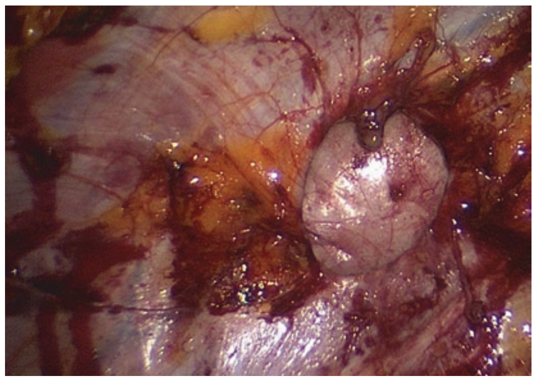
35.2 Laparoscopic Technique

The laparoscopic approach is based upon the intraperitoneal method of other ventral and incisional hernia repairs first described in 1993 [4]. The laparoscopic trocars are introduced by whatever method is familiar and preferred by the surgeon. For the traditional "fascial defect" hernia, the intra-abdominal adhesions must be dissected first. This will expose the hernia and its contents (▫ Fig. 35.3). The fascial edge must be cleared of all of the adjacent adipose tissue with enough margins to allow for a 5 cm overlap of the selected prosthetic material to repair the defect (▫ Fig. 35.4). Once this is completed, an accurate measurement of the defect is necessary. This can be accomplished in a variety of methods. One can insert a ruler of some type and physically measure the defect. Others will either palpate externally or use needles to outline the edges of the hernia. Many surgeons elect to deflate the abdomen somewhat to accomplish this but others do not. Once this has been done, a minimum of 10 cm should be added in all directions to provide for an overlap of the fascial defect of 5 cm in all directions. This will be the chosen size of the mesh.

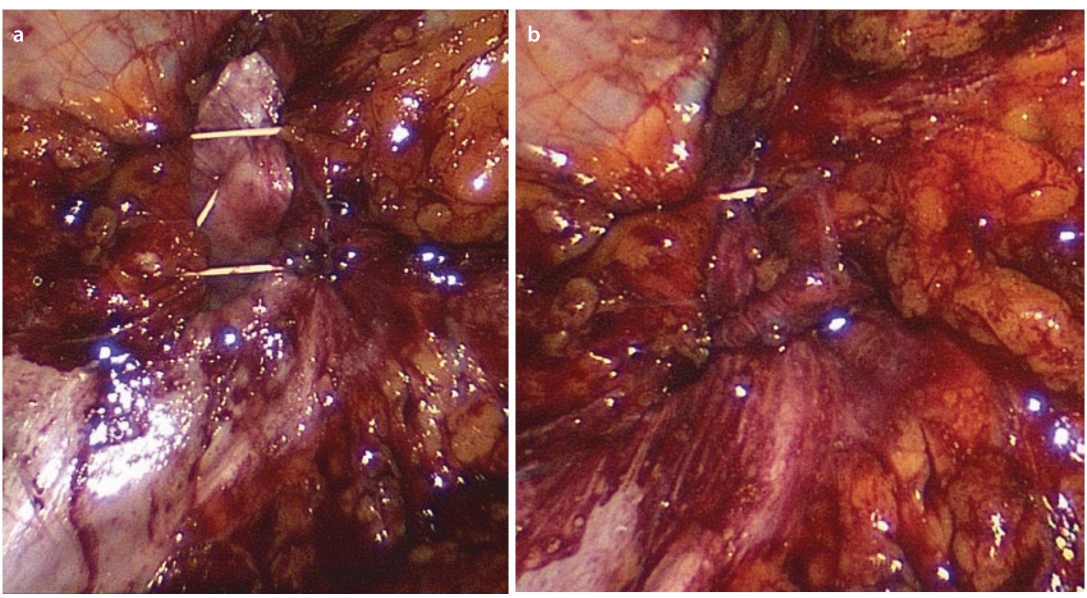
If the defect is not too large, the fascial defect will be closed with transfascial sutures. This will be performed by making one or more small skin incisions over the defect to allow for passage of a permanent suture(s) to close the defect (▫ Fig. 35.5a). Once these are placed, the insufflation pressure will be brought to near zero, whereupon the sutures are tied (▫ Fig. 35.5b). It is important to keep constant tension on these sutures during desufflation so that no intra-abdominal contents will be trapped within the sutures. The abdomen will then be reinflated, sometimes to a pressure at some level less than prior to the closure of the fascia.



▫ **Fig. 35.3** Primary left lumbar hernia containing the colon



▫ **Fig. 35.4** Fully dissected hernia with a large margin of tissue



▫ **Fig. 35.5** **a** Transfascial suture placement. **b** Tied transfascial sutures to close the defect

A variety of mesh products are available to repair the place as an onlay over the fascial defect, whether closed or not. It is critical to note that the size of the mesh is selected prior to closure of the fascial defect. In only this manner, will one assure that if the closure becomes dehisced, the coverage will still be adequate. Once the mesh introduced it will be fixed with an absorbable "tack" device. In general, a double-crown technique will be utilized. This will be followed with the application of transfascial sutures. Generally two to four are placed depending upon the size of the original defect. These are usually placed close to the closed defect to act as an additional buttress to the closure (Fig. 35.6).

Recently, the surgical robot has been utilized in the repair of these hernias. Its advantages are the ease of closure of the defect and the avoidance of transfascial sutures and the tacks (Fig. 35.7a, b). Although there is anecdotal evidence that this is advantageous in terms of diminution of postoperative as well as the incidence of chronic pain, there are no long-term studies on these apparent benefits.

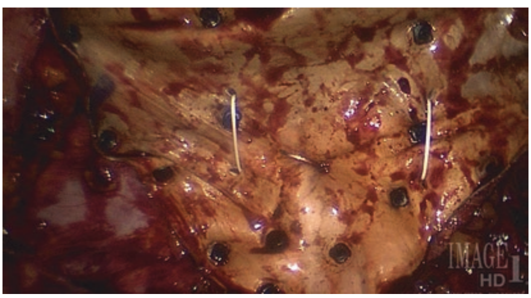


Fig. 35.6 Completed repair with an ePTFE mesh, double-crown "tacks", and transfascial sutures

The other type of lumbar hernia is much more challenging to repair. As noted above, the pseudohernia is the result of muscle paralysis and lacks a true fascial defect (Fig. 35.8a, b). In the past, the use of an onlay mesh with or without the use of plication of these muscles resulted in a very high rate of failure. To mitigate against such an outcome, a sandwich repair has been devised. In this method, a "sandwich" repair involving two meshes and the hybrid technique of both the open and laparoscopic repairs are utilized. In this manner, the benefits of both of these options are realized. Initially the abdomen is approached through the lumbar incision, and any adhesions are lysed.

Initially, the intraperitoneal mesh is sized by requiring a size that extends at least 8 cm above the costal margin superiorly, below the iliac crest inferiorly, medially beyond the semilunar line, and posteriorly to near the paraspinous muscles. Prior to placement in the abdomen, two to four sutures are affixed to become transfascial sutures inferiorly. This is required to assure coverage of the entire paralyzed flat muscles of the abdomen. It is then placed into the abdominal cavity and sewn to the diaphragm. The transfascial sutures are not pulled through at this time. If they were done so at that time, the mesh will be too lax following the closure and plication of the muscles. The lateral and superior portions of the mesh are sutures to the abdominal wall and diaphragm. Three trocars are place laterally to the opposite side of the midline (Fig. 35.9).

The muscles are then closed in a vest over pants closure so as to plicate them (Fig. 35.10). An overlay of macroporous lightweight polypropylene is placed over this closure. It is important that the skin and subcutaneous tissue layers have been dissected far enough away from the closure

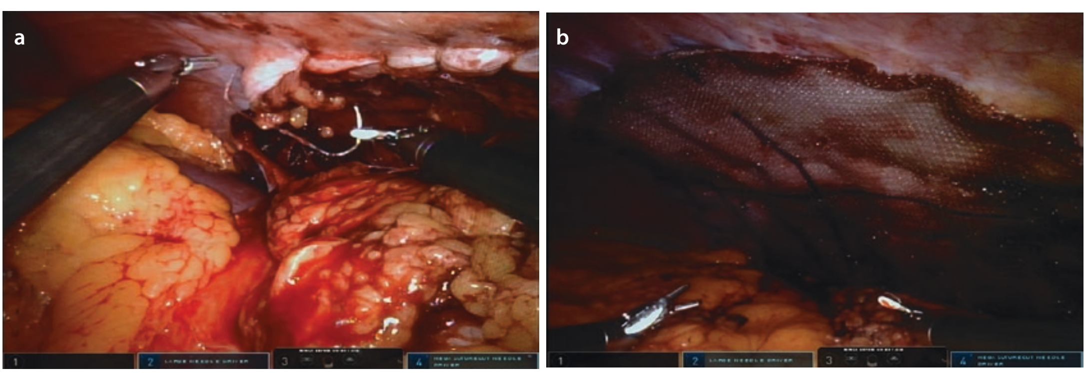


Fig. 35.7 **a** Robotically closed fascial defect; **b** Mesh sutured over the closed defect

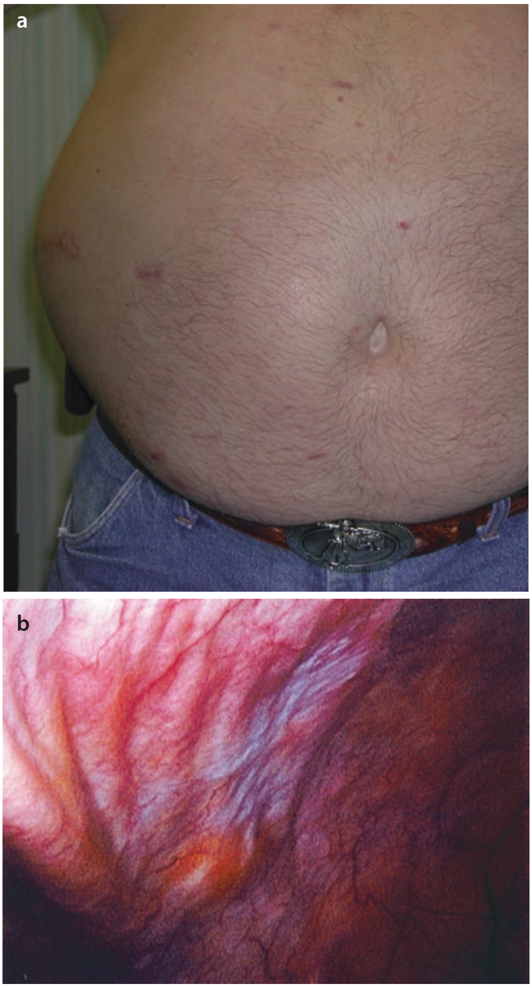


Fig. 35.8 a Preoperative view of the patient. b Laparoscopic view of the "bulge"

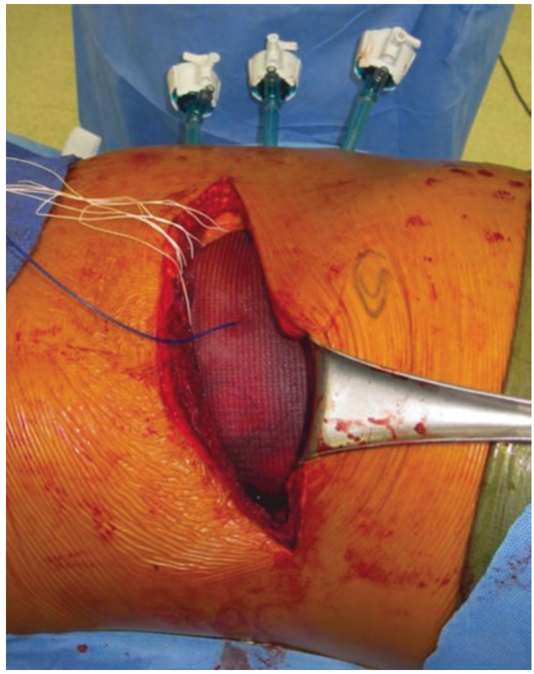


Fig. 35.9 The transfascial sutures are seen inferiorly; the costal margin is to the *right* of the figure

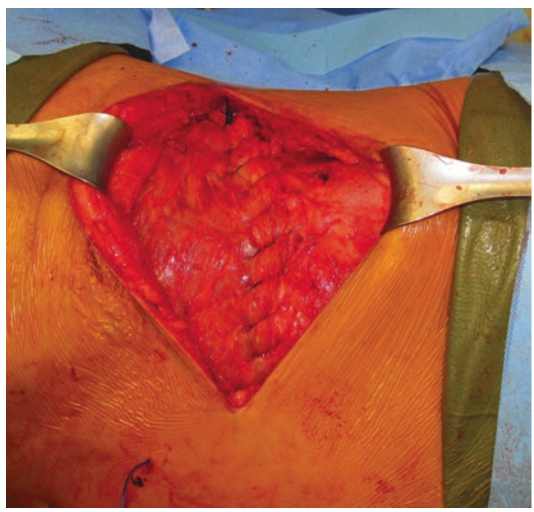


Fig. 35.10 Plicated musculature

so that this mesh will cover above the costal margin superiorly, below the iliac crest inferiorly, over the rectus sheath, and posteriorly to the paraspinous muscles. This will assure that this mesh will buttress the paralyzed muscles anteriorly (Fig. 35.11). A drain is placed followed by closure of the subcutaneous layer and skin.

The abdomen is then insufflated and the laparoscopic portion of the procedure commences. The mesh is then fixated with the transfascial sutures such that the mesh is taut. Final fixation with absorbable tacks in a double-crown method is the final portion of the procedure (Fig. 35.12). The benefit of laparoscopy is that the mesh will not have any laxity against the abdominal wall so that the support of the musculature is complete.

A very rare unusual hernia is located in the sciatic notch. This can occur above or below the piriformis muscle or below the sacrospinous ligament (Fig. 35.13). While an open repair can be done, a laparoscopic approach is preferred. An onlay of mesh may or may not be placed following closure of the defect.

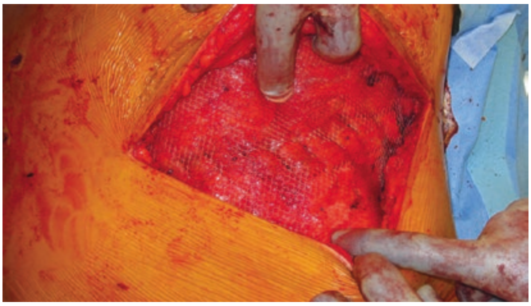


Fig. 35.11 Onlay of polypropylene mesh covering the plicated musculature

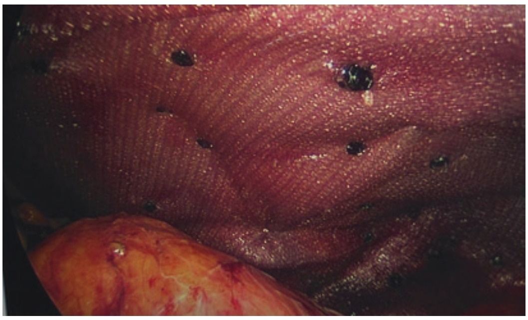


Fig. 35.12 Laparoscopic view of the completed mesh fixation

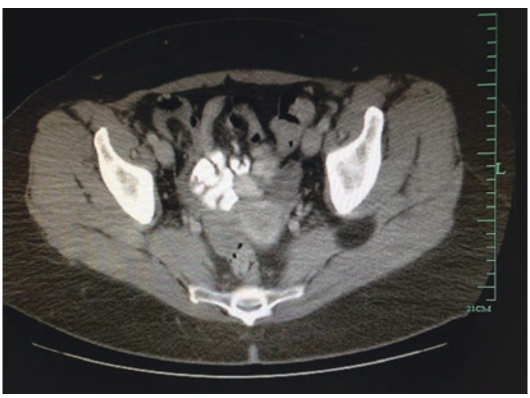


Fig. 35.13 Suprapiriformis left sciatic notch hernia

35.3 Evidence

There is very little published literature on the sciatic notch hernia due to the rarity of the problem. There are many papers, however, discussing the lumbar and Spigelian hernias. A recent publication has provided evidence and recommendations regarding these and many other hernias [5]. In that report, one paper was identified that was the sole prospective (nonrandomized) study of 16 patients [2]. Moreno-Egea et al. showed that the open repair was associated with a longer operative time, longer length of stay, higher morbidity, and three of seven patients recurred. There were no recurrences in the laparoscopic group. This paper represents a level of 2B evidence in support of the laparoscopic repair.

Twelve additional articles were found that provided level 4 evidence of repair with either technique and with or without the use of mesh [5]. However, the length of follow-up of these patients varied from only 1 month to as long as 40 months. Given these varied periods of time and the evidence of the former paper, it would seem that the laparoscopic repair with mesh is preferred.

There has only been a single publication of a prospective randomized trial of open vs laparoscopic repair of Spigelian hernias [6]. There were 11 patients in each arm of the study. Mesh was used in all cases with placement in the extraperitoneal plane except for three patients in the laparoscopic group. There were no recurrences in either group, but there was less morbidity ($p < 0.05$) and shorter length of stay ($p < 0.001$) in the laparoscopic group. The authors felt that the laparoscopic extraperitoneal mesh repair should be preferred. This level of evidence is at 2B.

The prior paper of Bittner et al. also researched Spigelian hernias [5]. Fifteen articles were found with level 4 evidence. A total of 318 patients were identified. The recurrence rate for the open tissue repair was 4.6%, but the recurrence rate when mesh was placed was zero in both the open and laparoscopic groups. Therefore the use of mesh should be included in these repairs.

There is Grade B recommendation for the laparoscopic repair of both Spigelian hernia and lumbar hernia due to the improvement in morbidity. The use of mesh is also recommended with any repair method.

35.4 Conclusion

The different operative choices for lumbar and unusual hernias favor the use of mesh to prevent recurrences. The laparoscopic repair is favored due to reduction in morbidity and length of stay. The very rare hernia types are infrequently or not at all discussed in the literature. This fact does not allow evidence-based approaches to these hernias, but given the results of the lumbar and Spigelian hernia, one might infer that the laparoscopic mesh repair is a better option.

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Single-Port Technique and Robotics in Ventral Hernia Repair

Davide Lomanto and Sujith Wijerathne

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36.1 Principles and Concept

Ventral hernia can be broadly divided into primary and secondary. Secondary hernias are mainly incisional hernias, and the complexity of these hernias still poses a challenge to the surgeons. Open approach for these complex hernias can be associated with a prolonged hospital stay and poor pain control. The laparoscopic approach has given hope for this particular group of patients by minimizing the surgical trauma and minimizing the postoperative pain and complications.

Throughout the past decade the laparoscopic approach has accomplished many milestones in the area of minimally invasive surgery. These accomplishments have been incorporated into many specialty fields including ventral hernia repair. But together with the development of minimally invasive laparoscopic techniques, the ventral hernias have also become more complex and challenging. With the discovery of new biomaterials and techniques, hernia repair has become a continuously changing and upgrading field in surgical practice.

Only the presence of a ventral/incisional hernia does not represent an indication to surgery. The goals of "elective" repair are relief of symptoms (pain and discomfort) and prevention of complications (strangulation/incarceration) [1]. Laparoscopic approach has shown superior capabilities in achieving these targets compared to open technique. A recent meta-analysis of ten randomized controlled trials comparing laparoscopic versus open ventral/incisional hernia repair, involving 880 patients, demonstrated the superiority of the laparoscopic approach in terms of shorter hospital stay and reduced wound infection rate [2]. Thanks to the enhanced visualization, laparoscopic technique provides a complete high resolution view of the entire defect, including smaller defects that have not always been appreciated clinically, and allows tacking of the mesh to healthy tissue [3].

Laparoscopic repair of ventral/incisional hernias is currently accepted when the defect size is at least of 2 cm or larger, because smaller defects can be safely treated with suture repair under local anesthesia [1, 4–6].

In view of the weak integrity of the abdominal wall, the use of a prosthetic mesh to reinforce the abdominal wall is essential in laparoscopic ventral hernia repair. The same principle applies to reduced port ventral hernia repair as well. The preferred method of mesh placement is intraperitoneal onlay mesh (IPOM) technique with securing the mesh in a double-crown manner with an overlap of 3–4 cm from the defect when using trans-fascial sutures [6].

Standard laparoscopic approach for these patients has its own downside as well. The risk of incisional hernia at access port sites after laparoscopic surgeries remains a concern and seems non-negligible according to the literature (1–22%). Factors negatively affecting the rate of port-site incisional hernias are port size, fascial closure method, and port mobilization [7]. It has been demonstrated that patients presenting with primary or incisional hernia are prone to develop further hernia due to extracellular matrix and wound healing deficiencies [8]. More surgical trauma may further damage the abdominal wall architecture and may lead to further weakness and hernia defects. Minimally invasive surgery may play a key role in instances like this, but it may be challenging to the surgeons due to complexity of these cases. One of the disadvantages of single-port surgery, compared to multiport, surgery is the relative loss of triangulation, but this may be overcome with increased experience, modification of dissection techniques, smaller and longer laparoscopes, and angulated or roticulated instruments.

Single-port access ventral hernia repair may be advantageous, as it may reduce the number of incisions in these patients who are at high risk for incisional hernia, as long as the single-access incision is not too large [7]. The other principal advantage of single-port ventral hernia repair over multiport laparoscopic approach is the decreased number of ports, thus reducing parietal trauma and scarring [9]. But one of the challenges in using this technique could be the learning curve to perform surgery for complex ventral hernia with minimal access at the fascial level and skin. This could be the reason that only a handful of literature is available on this technique [3, 7, 9–13]. With this approach, surgery can be performed in patients with primary hernia with only a small scar, and also in patients who are prone to develop incisional hernia because, the number of fascial incisions can be reduced [3]. According to the guidelines for laparoscopic treatment for ventral and incisional abdominal wall hernias by the International Endo Hernia Society, the literature reviewed demonstrates that the single-port ventral hernia repair procedure is feasible, safe and reproducible. No intraoperative complications were observed in the published studies. Standard instruments were used, and patients were discharged on the first day after surgery [14].

The use of the da Vinci robot has expanded in the recent past to a number of general surgery procedures including ventral hernia repair, likely due to its magnified, three-dimensional high-definition view, computer-aided elimination of tremor, and seven degrees of freedom at the distal ends of the instruments with superior maneuverability [15]. During ventral hernia repair the robot permits relatively easy access to the anterior abdominal wall, allowing the surgeon to perform the ideal repair for the individual patient by allowing primary defect closure, retro-rectus mesh placement, intracorporeal suturing, and concomitant posterior component release.

In 2007, Tayar et al. [16] published their initial experience of using the da Vinci robot for robot-assisted laparoscopic incisional hernia repair with exclusive intracorporeal suturing for mesh fixation in 11 patients. Their median operative time was 180 minutes and the overall morbidity rate was 27%. The findings show that the technique is feasible and may not be associated with chronic postoperative pain. No recurrence was reported with a median follow-up of 25 months. In 2012, in another retrospective review of 13 patients, the da Vinci robot was used for closure of the fascial defects and circumferential suturing of the mesh [17]. Their mean operative time was 131 minutes and the overall morbidity rate was 13%. None of the patients experienced chronic suture site pain or discomfort, and only one recurrence was reported with a median follow-up of 23 months.

The ease of robotics may decrease the learning curve for surgeons, making a good laparoscopic surgeon even better by allowing them to replicate the tenets of open repair [15]. However more structured and randomized studies are needed with long-term results to delineate the future of robotics in ventral hernia repair.

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General Issues of Hiatal Hernias

Burkhard H. A. von Rahden, Sumeet K. Mittal, and Ellen Morrow

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37.1 Anatomy of the Esophagus Hiatus: What Is Important for Hiatal Hernia Surgery?

The esophagogastric junction and the esophageal hiatus represent an anatomic unit which functionally resembles the lower esophageal sphincter (LES) [1, 2]. Furthermore, the LES must also be regarded as one functional unit together with the tubular esophagus and the upper esophageal sphincter (UES). Acknowledgment of these functional units seems of crucial importance for hiatal hernia surgery, due to the important effects on esophageal function, i.e., esophageal emptying and antireflux mechanisms.

Note: Hiatal hernia surgery is always also functional esophageal surgery!

The UES is located at the level of the cricoid and is resembled by the cricopharyngeal muscle. Aboral from this muscle, the tubular esophagus originates. The esophageal wall consists of an inner circular muscle layer and an outer longitudinal muscle layer and the esophageal mucosa. The architecture of the musculature at the esophagogastric junction is more complex, with the semicircular clasps and the gastric sling fibers being of major importance for constitution of the LES [1] (see figure "Abb. 24.3 Architektur des tubulären Ösophagus" from Siewert, Praxis der Viszeralchirurgie, Bd. 2). The surrounding muscular structures of the diaphragm, i.e., left and right diaphragmatic crus, also contribute to this complex sphincter apparatus and the lower esophageal sphincter pressure.

The esophageal hiatus is an anatomic gap within the posterior part of the diaphragm. It consists of the right diaphragmatic crus, an anterior commissure of the diaphragmatic crura, and the left diaphragmatic crus. Through this gap, the esophagus enters the abdominal cavity and the thoracic esophagus becomes the abdominal esophagus. For surgery of the esophagogastric junction, it is of utmost importance to note that 2–3 cm of the esophagus belongs to the abdomen, and the major aim of any hiatal hernia operation is to restore this situation. Under the circumstances of type III hiatal hernias, the esophagus is usually retracted into the mediastinum, due to the displaced esophagogastric junction (see ◘ 37.3 Classification).

Note: The major aim of any hiatal hernia operation is to restore an adequate length of the abdominal esophagus!

Immediately behind the esophageal hiatus, the aortic hiatus is localized, where the aorta enters the retroperitoneum. Under the pathophysiologic conditions of large hiatal hernias, both openings – esophageal and aortic hiatus – are sometimes "unified" and form a common hiatus.

Preservation of both – anterior and posterior – vagal nerves during hiatal hernia surgery is crucial for gastrointestinal function. The vagal nerves accompany the esophagus closely at the anterior and posterior esophageal wall. It may not always be necessary to visualize the vagal nerves during hiatal hernia surgery, which can be difficult in obese patients with large hernias, but the surgeon must be aware of their localization and leave them intact.

More controversial than preservation of the trunks of the vagal nerves is whether its hepatic branches must be preserved (see ► Chap. 4). The hepatic branches originate from the anterior vagal nerve at the level of the esophagogastric junction and run toward the liver through the condense part of the lesser omentum. At the level of the liver, the pyloric branches originate from these hepatic branches and go through the hepatoduodenal ligament to reach the pylorus. These branches are deemed involved in relaxation of the pylorus and thereby gastric emptying.

Prominent diaphragmatic veins close to the hiatus must be avoided during dissection and crural repair. Injury of one of these veins can result in significant bleeding, due to their communication/drainage to the left liver vein and the inferior caval vein.

Aberrant/accessory left hepatic arteries, originating from the left gastric artery, occur in about 12% of patients [3]. These arteries accompany the aforementioned hepatic branches of the vagal nerve within the condense part of the lesser omentum. It is advisable to preserve these structures during hiatal hernia surgery.

The posterior parts of the gastric fundus are attached to the left diaphragmatic crus. The short gastric vessels, located within the gastrosplenic ligament, enter the stomach at the greater curve. Creation of a tension-free fundoplication often makes partial division of the short gastric vessels necessary. This is usually possible without negative side effects for the stomach as well as the spleen: the stomach has a very good blood supply through left and right gastroepiploic arteries and left and (to a lesser degree) right gastric arteries. The spleen may show (functionally irrelevant) small defects of blood supply after division of the short gastric vessels.

The anatomy of the left hepatic lobe and its tendinous attachments to the diaphragm is also important for hiatal hernia surgery, because its retraction (using a special liver retractor) is always necessary to expose the hiatus region. Furthermore, in some cases – especially when mesh augmentation is intended – mobilization of the left liver lobe may be necessary.

Further important structures to know are location of the pleura and lungs. Especially in large hiatal hernias, the pleura is often closely co-localized or even attached to the hernia sac. One should always try to lateralize the pleura by gentle blunt dissection, to avoid pleural opening, which is associated with the risk for tension pneumothorax.

37.2 Pathophysiology of Herniation and Diagnostics

In hiatal hernias, the widened esophageal hiatus is the hernia orifice through which the esophagogastric junction/stomach herniates into the mediastinum. In large hernias, this hernia orifice has a clearly visible ring shape through which a clearly visible hernia sac protrudes into the lower mediastinum. Little is known about the exact mechanism how hiatal hernias originate. Hiatal hernia formation is presumably a multifactorial process, which is incompletely understood.

Three major pathogenetic "pathways" can be derived from the relatively scarce literature, which force the esophagogastric junction/stomach upward into the thorax [4]:

1. Increased intra-abdominal pressure
2. Widening of the diaphragmatic hiatus due to congenital or acquired changes in the crural muscles or the connective tissue of the diaphragm
3. Esophageal shortening

The latter point "esophageal shortening" is a matter of strong controversial debate. Proponents of the view supporting the existence of "short esophagus" suggest that an esophageal lengthening procedure is required (Collis gastroplasty) under these circumstances. Opponents who don't believe in "short esophagus" think that an adequate length of the abdominal esophagus can always be achieved with adequate mediastinal type II dissection (see chapter "surgical technique")

37.3 Classification

A very simple and commonly used classification system for hiatal hernias – based on morphologic and pathophysiologic criteria – distinguishes type I, II, III, and sometimes IV hernias: *Type I hernias* are *axial hernias*, in which the anatomic cardia/esophagogastric junction "slides" along the esophagogastric axis through the enlarged hiatal gap toward the mediastinum. Therefore these hernias are also addressed as "sliding hernias", meaning that they are usually not fixed. *Type II hernias* are *paraesophageal hernias*, in which the anatomic cardia remains in the infradiaphragmatic position, but the gastric fundus herniates into the mediastinum and stays in a paraesophageal position. This type of hiatal hernia is very rare, because paraesophageal herniation usually goes ahead with some degree of axial herniation as well, which represents (mixed-type) *type III hernias*. The maximum variant of type II/III hernias is the upside-down stomach. More complex hernias, including other organs (colon, spleen, liver, pancreas), are sometimes addressed as *type IV hernia*.

Although this classification appears almost generally accepted, distinction of these hernia types bears some difficulties in clinical practice as all diagnostic tools (esophagogastroscopy, barium swallow, cross-sectional imaging) and even intraoperative assessment may be imprecise to some degree (e.g., Linke et al. [5]). However, this is not important, because surgical management is on principle the same for all hernia types. Laparoscopic repair is almost always feasible and superior to open surgery in almost all situations. This is even the case for complex (type IV) hernias. A laparoscopic approach is almost always adequate.

37.4 Diagnostic Work-Up

The basic tool for diagnostic work-up of hiatal hernias is *endoscopy*. Usually, the first suspicion for hiatal hernia is raised based on this investigation, which always includes inspection of the esophagogastric junction in forward as well as retroflexed view. Endoscopic grading of hiatal hernias should be performed according to the Hill classification [6].

The major aim of endoscopic examination is exclusion of other pathologies (especially malignancies) and characterization of hernia size and type. For classification of endoscopic appearance of hiatal hernias, the Hill classification is established [6, 7]. Other important information obtained from endoscopic examination are prevalence of esophagitis (erosive GERD) – which should be graded with one of the available classifications (e.g., L.A. grades) – and the columnar-lined esophagus with orally transposed Z-line and intestinal metaplasia (Barrett's esophagus; here grading with the Prague C & M classification is recommendable [8] and manageable according to current guidelines [9, 10]). Although Barrett's esophagus is no longer a contraindication against hiatal hernia surgery/fundoplication anymore, it is important to note that the indication for surgery should aim at symptom control and not prevention of Barrett progression/malignant progression in general.

Cross-sectional imaging with *computed tomography (CT)* or *magnetic resonance imaging (MRI)* is also advisable in advance of performing hiatal hernia repair. The obtained morphologic information can be helpful for the procedure, with respect to anatomic and pathoanatomic structures (see ► Sect. 37.1).

Esophagography (barium swallow) is another imaging tool which can be used in imaging of hiatal hernias. Although esophagography can nicely depict especially large hiatal hernias, which are fixed to the mediastinum, the value of this investigation has been called into question [5]. Esophagography does rarely deliver important additional information and can be omitted from diagnostic work-up prior to hiatal hernia surgery, although most guidelines do still recommend its use.

Gastroesophageal function testing with *manometry* and *reflux testing* is required whenever functional esophageal surgery is recommended prior to operations for GERD with hiatal type I hernias. In contrast, catheters for function testing are difficult or impossible in large hiatal (type II/III) hernias. Therefore, hiatal hernia operations are usually performed without prior function testing in these patients.

Manometry should be performed prior to antireflux surgery/type I hiatal hernias whenever possible. The major goal is exclusion of achalasia. This is important, because failure to diagnose achalasia prior to fundoplication is a catastrophe for the patient. Manometry is crucial in this respect, because sensitivity of symptoms and esophagogastroscopy appears too low to safely exclude achalasia. One other reason to use manometry is proper positioning of the pH-metry/impedance catheter by identification of the lower esophageal sphincter.

Reflux testing is necessary whenever the indication for surgery is gastroesophageal reflux, because symptoms, PPI test, and endoscopic findings are usually not sensitive enough as proof. Which kind of function testing is performed may be irrelevant, but multichannel impedance-pH testing (off PPI) may have the best diagnostic yield and allows identification of patients with acidic as well as weakly acidic reflux.

37.5 Limitations and Indications for Laparoscopic Repair: Reflux Disease and Paraesophageal Hernias

All paraesophageal/mixed-type hiatal hernias (types II, III, and IV; see ► Sect. 37.3 Classification) are obligatory indications for surgery! Reasons for this obligatory surgical indication are:

1. The risk for incarceration
2. The tendency of hiatal hernias to increase in size
3. The potentially increasing difficulty of surgical repair with increasing size
4. The high mortality of an emergency operation in case of incarceration

However, some controversial academic debate has challenged this general recommendation for surgery [11–13]. It has been suggested that the aforementioned risks might be lower than previously thought and a more selective approach might be justified, with an observational strategy in asymptomatic or minimally symptomatic patients. However, most patients harboring type II/III hiatal hernias have symptoms, and asymptomatic and minimally symptomatic patients are very rare.

Note: Type II/III hernias are an obligatory indication for surgery!

Type I hiatal hernias are *no indication for surgery*. However, they are addressed surgically during antireflux surgery for gastroesophageal reflux disease, where the indication is independent from prevalence of hernia (and fundoplication works also in patients who have no hiatal hernia). The indications for surgery in this setting requires a:

1. Proven gastroesophageal reflux disease (GERD)
2. High suffer score
3. Failure of conservative treatment (PPI, lifestyle adjustment, dietary measures)

Proof of GERD means that reflux has been demonstrated functionally by means of reflux testing (e.g., pH-metry/impedance). The sensitivity of morphologic criteria, i.e., reflux esophagitis, appears too low, so that function testing must be recommended also in patients with erosive GERD.

37.6 Perioperative Management

Apart from the aforementioned diagnostic workup, no specific perioperative management is required for hiatal hernia surgery.

Patients need to sign informed consent after being informed about general and specific surgical risks. Especially the risk for recurrence must be addressed prior to all hiatal hernia operations. Furthermore some controversial issues regarding the choice of surgical procedure should be discussed with the patient, especially the potentially advisable mesh reinforcement after crural repair – a decision usually drawn intraoperatively based on measurement of the size of the hiatal hernia gap. The otherwise high recurrence rate on the one hand and the potential associated risks (mesh migration, penetration, perforation, etc.) should be highlighted.

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Techniques of Hiatal Hernia Repair

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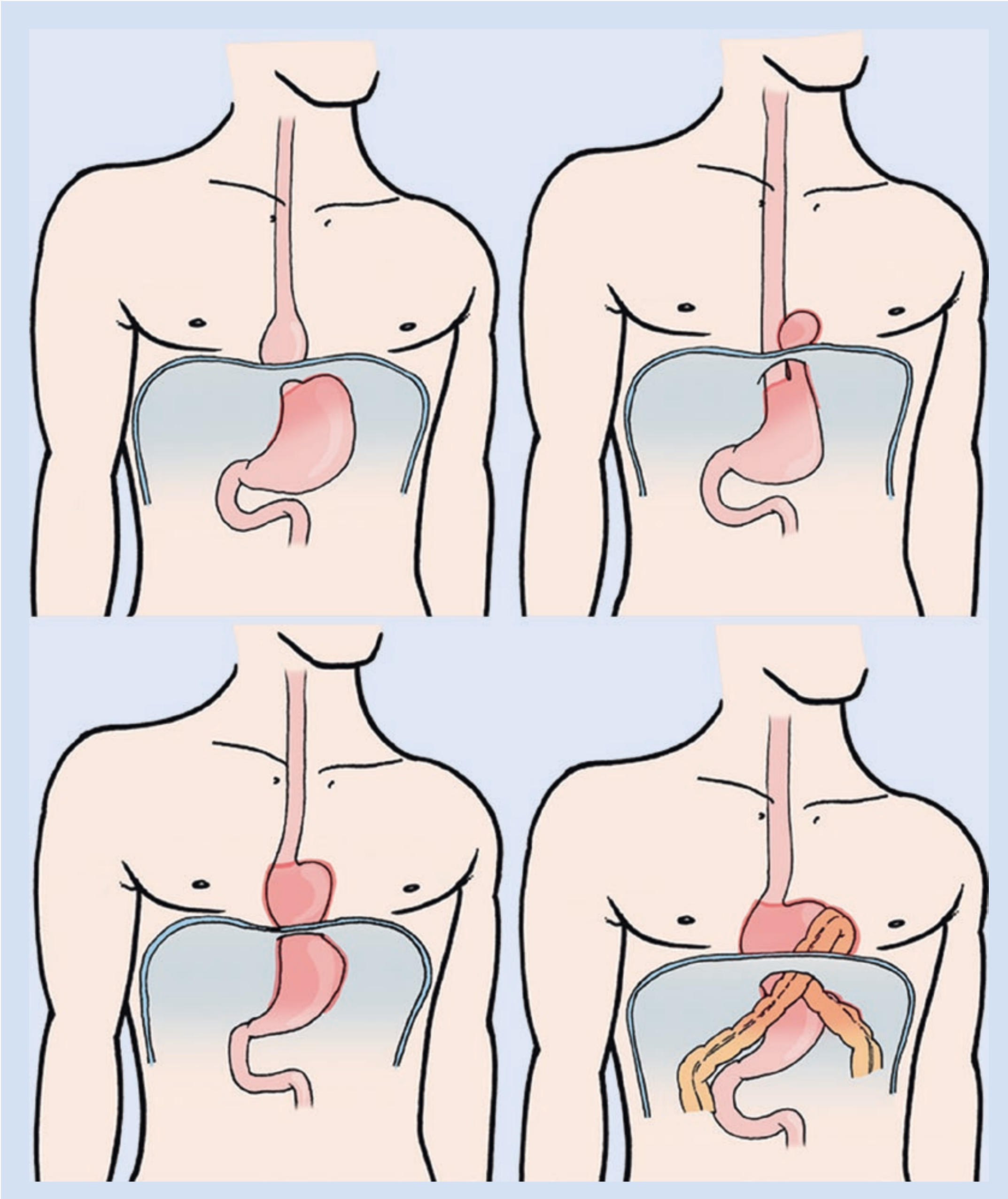

Fig. 38.1 Classification of types of hiatal hernia. Sliding hiatal hernia (type I), pure paraesophageal hernia (type II), and type III as the combination of type I and II hiatal hernias. Type IV hiatal hernias are defined by herniation of other abdominal organ than the stomach

Hiatal hernias are currently classified into type I–IV hernias (Fig. 38.1). In type I hernias, also called sliding hernias, the gastroesophageal junction is situated above the diaphragm. They are the most common type of hiatal hernia with 80–85% of all hiatal hernias. Type II–IV hernias are less common and characterized by a paraesophageal involvement. Especially type II hernias are rare and characterized as pure paraesophageal hernias. Type III hernias are a combination of type I and type II hernias, the gastroesophageal junction, and the fundus herniate through the diaphragm. If an intra-abdominal organ other than the stomach herniates, a type IV hernia is present.

Surgical treatment in type I hiatal hernia is only indicated for concomitant gastroesophageal reflux disease. Hiatal hernias with paraesophageal involvement should be operated if they are symptomatic because of the risk of progression and the risk for complications such as incarceration. The aim of the surgical therapy is the constant reposition of the hernia sac content and the repair of the hiatus. Hiatal hernia repair can either be performed transabdominally or by transthoracic access with an open or minimally invasive approach. The laparoscopic approach is associated with reduced perioperative morbidity and shorter hospital stay while showing equal symptomatic outcome compared to the open abdominal and the transthoracic approach. The minimally invasive abdominal access is thus the preferred approach for most hiatal hernias. Besides the access, the dissection of the hernia sac, the type of cruroplasty, the use of mesh augmentation, and the addition of a fundoplication are factors that have to be considered for an ideal hiatal hernia repair. The chapter gives an evidence-based overview on the mentioned technical considerations, and recommendations are made according to the SAGES Guidelines and the latest literature (◘ Tables 38.1 and 38.2).

◘ **Table 38.1** Levels of evidence and grade of recommendation according to the Oxford Centre for Evidence-Based Medicine (OCEBM Levels of Evidence Working Group. "The Oxford 2011 Levels of Evidence". Oxford Centre for Evidence-Based Medicine) [40]

Level of evidence	Grading criteria	Grade of recommendation
1a	Systematic review of RCTs including meta-analysis	A
1b	Individual RCT with narrow confidence interval	A
2a	Systematic review of cohort studies	B
2b	Individual cohort study and low-quality RCT	B
2c	Outcome research study	C
3a	Systematic review of case-control studies	C
3b	Individual case-control study	C
4	Case series, poor-quality cohort, and case-control studies	C
5	Expert opinion	D

38.1 Dissection of the Hernia Sac

The SAGES Guidelines for the management of hiatal hernias recommend with the grade "strong" that during hiatal hernia repair, the hernia sac should be dissected away from the mediastinal structures and with the recommendation "weak" that the hernia sac should be excised. For both recommendations, the quality of evidence is low (◘ Table 38.2).

In hiatal hernias with paraesophageal involvement (types II–IV), the hernia sac has attachments to the esophagus and stomach. Dissecting the hernia sac away from the mediastinum releases tension that otherwise draws the stomach upward into the former position. When the sack has been completely freed from its mediastinal attachments, this force is eliminated, and the stomach will stay tension-free within the abdomen (◘ Fig. 38.2). Furthermore, a better orientation of the mediastinal structures, i.e., particularly the esophagus, and an effective mobilization of the esophagus are achieved, thus minimizing the risk for a manifest short esophagus. Finally, a non-resection of the hernia sac implies the risk of interposition, e.g., between the fundoplication and the esophagus with consecutive dysphagia. Most surgical publications on hiatal hernia repair reported a complete dissection of the sac and recommended a complete excision [1, 10, 16, 17, 31, 34]. Little data comparing a complete with an incomplete dissection of the hernia sac is available, especially no prospective or randomized controlled trials. In a comparative case series on primary paraesophageal hernia repair by Edye et al., the surgical strategy was changed after 5 recurrences, which occurred in the first 25 patients within the first 6 months after the repair, when they did not completely resect the hernia sac. After performing a complete excision of the hernia sac in the next 30 patients, no early recurrence was observed anymore [10]. In another retrospective case series on large hiatal hernias

Table 38.2 Recommendations on different steps of hiatal hernia repair with the according level of evidence and grade of recommendation

Surgical step	Authors' recommendation (2017)	Level of evidence/grade of recommendation*	SAGES recommendation (2013)	Level of evidence/grade of recommendation*
Complete excision of hernia sac	Yes	3b/C	Yes	3b/C
Division of short gastric vessels	Yes	–	No (if tension-free fundoplication is possible)	1a/A
Extent of division of short gastric vessels	Limited dissection	–	No recommendation	–
Vagal nerve preservation	Yes	3b/C	No recommendation	–
Type of cruroplasty	Anterior or posterior	1b/A	Anterior or posterior	1b/A
Fundoplication	Yes	1b/A	No, in case of no reflux history	–
Type of fundoplication	Partial fundoplication (or short Nissen)	1a/A†	Partial fundoplication (or short Nissen)	1a/A†
Mesh augmentation	Yes‡	1a/A	No recommendation	–
Mesh material	Synthetic§	4/C	No recommendation	–
Mesh fixation	Anteriorly, glue; Posteriorly, glue/tacks/suture	4/C	No recommendation	–

*In case of differing recommendations, only the highest level of evidence available is shown next to the referring recommendation
†Referrers to the preference of a partial fundoplication
‡In large hiatal hernias (>5 cm)
§No PTFE

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(>10 cm) by Watson et al., a 40% conversion rate to an open procedure in the first 40 patients with incomplete hernia sac dissection was reported. The main reason for conversion was an impossible safe mobilization of the esophagus without dissection of the hernia sac. The conversion rate dropped to 9% in the next 46 patients when a complete dissection of the hernia sac was performed ($p < 0.001$). The authors concluded that the change of strategy to a full dissection was the main reason for the improved laparoscopic success rate and recommend it for an improved mobilization of the esophagus and an adequate assessment of the esophageal length [54].

In conclusion a complete dissection and excision of the hernia sac can be recommended from the available literature. The complete dissection and excision allow for a better visualization and mobilization of the esophagus and a tension-free positioning of the stomach within the abdominal cavity (Table 38.2).

38.2 Division of Short Gastric Vessels

The SAGES Guidelines on the treatment of gastroesophageal reflux disease recommend that if the fundus can be wrapped around the esophagus

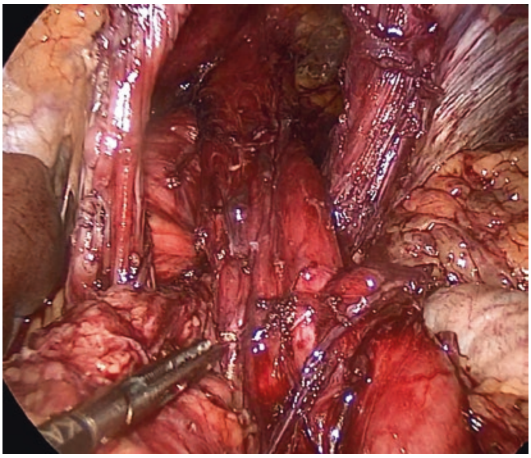

Fig. 38.2 Complete mobilization and excision of the hernia sac allow for optimal orientation at the hiatus, decreasing the risk of injuries to the esophagus

without significant tension, no division of the short gastric vessels is needed. The level of evidence on this topic is high. If a tension-free fundoplication cannot be accomplished, division of the short gastric vessels should be undertaken; this recommendation is made on moderate quality of evidence. However, no recommendation on the extent of the division of the short gastric vessels is made. Furthermore, the guidelines especially note that expert opinion in North America advocates for the routine division of the short gastric vessels to minimize tension (Table 38.2).

Five randomized controlled trials with various follow-up periods investigating the effect of a division of the short gastric vessels in antireflux surgery exist [3, 7, 12, 26, 56]. In a recent meta-analysis by Markar et al. including the five available randomized controlled trials, no difference regarding requirement for reoperations and presence of postoperative dysphagia or reflux was shown. However, division of the short gastric vessels was associated with a longer duration of the operation (mean difference 25.6 min, 95% CI 14.18–37.05; $p < 0.001$) and a reduced postoperative lower esophageal sphincter pressure (mean difference −3.69 mmHg, 95% CI −4.11 to −3.26; $p < 0.001$). No difference in length of hospital stay, postoperative complications, gas bloat syndrome, or DeMeester score was found [29]. The extent of division of the vessels varied greatly from two to four short gastric vessels to the division of all short gastric vessels, and this heterogeneity was not taken into account in the meta-analysis. Clinical studies comparing a limited with an extensive division of the short gastric vessels during fundoplication are not existing. From two of the randomized controlled trials, 10–12-year follow-up data is available on 170 patients [3, 62]. No difference in dysphagia, heartburn, ability to belch or vomit, and use of antisecretory medications was observed. But division of the short gastric vessels was associated with a higher rate of bloating symptoms (72% versus 48%, $p = 0.002$) [11].

Since an extensive division of short gastric vessels seems at most to be associated with impairment of the clinical outcome, it cannot be routinely recommended. However, a limited dissection of the short gastric vessels might be helpful for a tension-free fundoplication (Table 38.2).

38.3 Preservation of the Vagus Nerve

No SAGES Guidelines are available concerning the preservation of the vagus nerve in hiatal hernia repair. The quality of evidence on the topic is low, and data concerning vagotomy in hiatal hernia repair is limited (Table 38.2).

The vagus nerve is responsible for the parasympathetic control of the digestive tract and enhances gastrointestinal motility. The fibers of the nerve run over an anterior and a posterior branch on the left and right side of the esophagus to the stomach. The parasympathetic fibers of the vagus nerve innervate the stomach, kidney, pancreas, liver, gallbladder, and intestine till Cannon's point located in the left third of the colon transversum. The consequences of injury to the nerve or a full denervation are still not fully understood; however post vagotomy syndrome summarizes delayed gastric emptying, diarrhea, recurrent ulceration, and gall stone formation by biliary stasis. It is often stated that the vagus nerve should be carefully preserved, but vagotomy may help in mobilizing the gastroesophageal junction, and an elongation of the esophagus of 3–4 cm has been reported after vagotomy [10, 16, 21, 28, 59]. Follow-up data on this topic is limited to three retrospective case series.

In the study by Vansant et al. on 311 patients with a hiatal hernia, a vagotomy was performed in 159 patients and combined with an antireflux procedure and compared to 152 patients without vagotomy. The incidence of diarrhea was twice as high in the vagotomized group (34% vs. 17%; $p < 0.005$); dumping and nausea and vomiting occurred more often in vagotomized patients (7% vs. 0%; $p < 0.005$ and 13% vs. 1%; $p < 0.005$, respectively). Furthermore the incidence of long-term symptoms (>3 months) was higher in the vagotomy group (26% vs. 1%; $p < 0.005$) [52].

In contrast Oelschlager et al. described their experience in patients with large or recurrent hiatal hernias in whom after extensive esophageal mobilization the gastroesophageal junction could not be made to reach the abdomen without tension. They first added a posterior vagotomy, and if the mobilization was still insufficient, an anterior vagotomy was additionally added. A comparison of 30 vagotomized patients and 72 nonvagotomized patients showed no difference in severity of heartburn, regurgitation, abdominal pain, dysphagia, chest pain, bloating, nausea, and diarrhea. However, vagotomy resulted in a lower acid exposure. The authors concluded that a unilateral vagotomy in contrast to bilateral vagotomy did not increase the incidence of dumping syndrome [45].

In the study by Trus et al., three vagal injuries were reported in 76 patients with a paraesophageal hernia repair. Two of the patients had significant gastric atony. One underwent laparoscopic pyloroplasty the other partial gastrectomy and Billroth II reconstruction. The third patient developed a gastric dilatation that resolved with nasogastric tube drainage [51].

If only a parietal cell vagotomy (PCV) was added during a fundoplication, Jordan et al. reported three advantages: First, PCV provided permanent reduction in gastric acid secretion, which is a cornerstone for the reflux treatment. Second, an excellent exposure of the gastroesophageal junction was provided after PCV. Third, when wrapping the esophagogastric junction, it seemed more appropriate to penetrate the hepatogastric omentum medial to the vagal nerve trunks, thereby interrupting branches of the vagus nerves to the parietal cell mass rather than penetrating the gastrohepatic omentum lateral to the nerve trunks and invariably destroying the hepatic nerves. They performed a PCV in 188 patients without any gastric complaints in the follow-up [24]. Those findings are further confirmed in a study of 49 patients with gastric bandings where an anterior and posterior vagotomy was performed. At average follow-up of 5.7 years, none of the patients had complications of gastric outlet obstruction or diarrhea. The authors concluded that the problem of gastric outlet reported in other studies may be due to chronic inflammation and scarring in the region of the pylorus due to existing ulcers or gastroesophageal reflux disease and may not be caused by vagotomy alone [30].

From the available data, it seems reasonable that special care should be taken to keep the vagus nerve intact during the dissection of the hiatal hernia. If the mobilization of the esophagus seems insufficient, a posterior vagotomy may be added. However, most commonly the esophagus can be mobilized up to the tracheal bifurcation and thereby lengthened into the abdomen without vagotomy when the hernia sac is completely dissected (Table 38.2).

38.4 Cruroplasty

Cruroplasty is the crucial step during hiatal hernia repair and can either be performed anteriorly or posteriorly. The SAGES Guidelines on the treatment of gastroesophageal reflux disease recommend with the grade "strong" and based on a moderate level of evidence the closure of the crura when the hiatal opening is large during antireflux surgery. Based on the findings of one randomized controlled trial in antireflux surgery comparing the efficacy of anterior versus posterior crural repair, anterior crural closure may be associated with less postoperative dysphagia (Table 38.2).

The study by Watson et al. on 102 patients with gastroesophageal reflux disease undergoing laparoscopic Nissen fundoplication with anterior and posterior cruroplasty found no difference between the groups in terms of postoperative dysphagia, heartburn, and overall satisfaction at 6 months follow-up. However, to achieve the similar dysphagia rate, more patients in the posterior closure group had to undergo a second surgical procedure (15% vs. 0%; $p = 0.03$) [58]. In many reports on hiatal hernia repair, the type of cruroplasty was not specified. Some authors [1, 9, 16, 18, 20, 51] described a posterior closure, others used either an anterior or posterior closure [10], and others added an anterior suture selectively to the posterior [41, 44, 55, 63].

In conclusion cruroplasty is the crucial step of hiatal hernia repair. The type of cruroplasty (anterior or posterior) seems to be of minor

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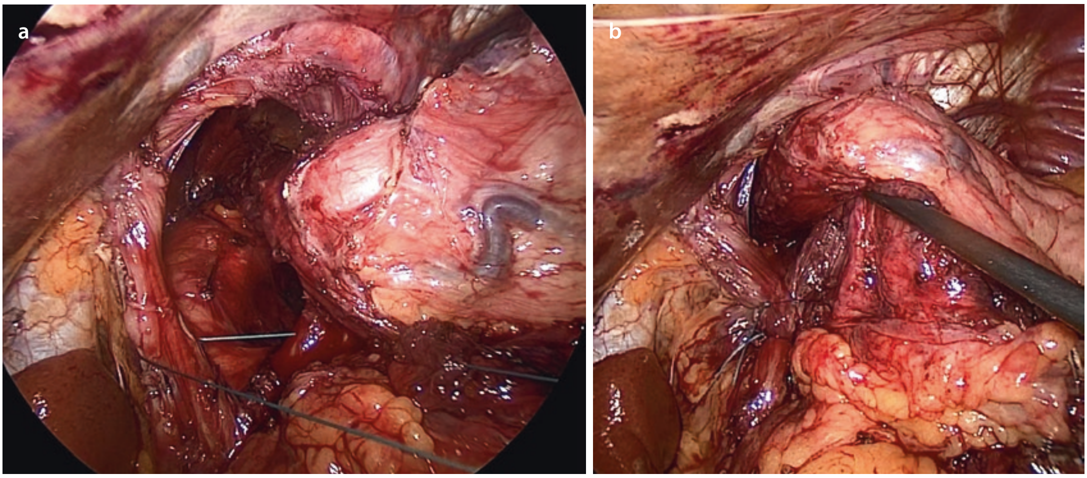

Fig. 38.3 a Symmetrically placed sutures for a posterior cruroplasty. b Completed cruroplasty without narrowing of the esophagus

importance (Table 38.2). A tension-free repair without deviation or narrowing of the esophagus is essential. Furthermore care should be taken in case of posterior cruroplasty that the crura are approximated symmetrically (Fig. 38.3).

38.5 Fundoplication

The SAGES Guidelines recommend that a fundoplication must be performed during the repair of a sliding hiatal hernia to address reflux. For hiatal hernias with paraesophageal involvement, a fundoplication is stated to be important as well, but based on the data available at that time, a routine fundoplication is not recommended. Based on low-quality evidence and with the grade "weak," the guidelines recommend that in the absence of achalasia, tailoring of the fundoplication to preoperative manometric data may not be necessary. Regarding the type of fundoplication to be performed, there is a recommendation that the partial fundoplication should be preferred due to less postoperative dysphagia, fewer reoperations, a similar patient satisfaction, and symptom control of reflux symptoms. The statement is based on a high level of evidence. Due to limited long-term follow-up data on the surgical effectiveness, no strong recommendation is given because partial fundoplication may be less effective in the long term than a total fundoplication. It is strongly recommended to perform a partial fundoplication or a short total fundoplication of 1–2 cm over a large 56 French bougie (weak recommendation) to minimize postoperative dysphagia. The effectiveness of the procedure is maximized with a total fundoplication or a longer (>3 cm) posterior partial fundoplication (weak recommendation). It is further noted that regional differences in clinical practice and expert opinion exist. Especially in North America, total fundoplication is recommended by experts due to concerns for the long-term effectiveness of other procedures (Table 38.2).

The SAGES Guidelines were published before the study by Müller-Stich et al. was available, which included 40 patients with a hiatal hernia with paraesophageal involvement. The patients were randomized to either mesh-augmented hiatoplasty and cardiophrenicopexy (LMAH-C) or mesh-augmented hiatoplasty with a fundoplication (LMAH-F) (Fig. 38.4). At 3 months follow-up, a higher DeMeester score after LMAH-C versus LMAH-F was observed (40.9 ± 39.9 vs. 9.6 ± 17; $p = 0.048$). In line with these findings, there was a higher reflux syndrome score at 12 months in the LMAH-C group (1.9 ± 1.2 vs. 1.1 ± 0.4; $p = 0.020$) and a postoperative esophagitis rate of 53% versus 17% in favor of the patients with a fundoplication ($p = 0.026$) [34]. This data suggested that a hiatal hernia repair should always be combined with a fundoplication irrespective of the preoperative evidence of GERD. Other authors [50, 60] also supported the routine use of a fundoplication and justified it with different arguments. The preoperative prevalence of gastroesophageal reflux disease is high with up to 80% in patients with hiatal

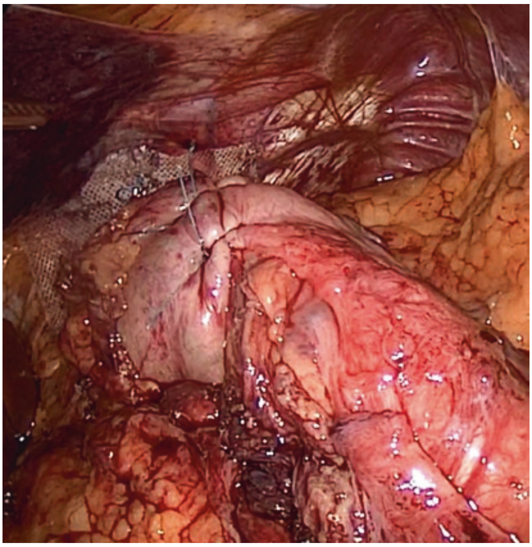

Fig. 38.4 Laparoscopic mesh-augmented hiatoplasty with Nissen fundoplication

hernias. Furthermore, an increased risk for reflux after hiatal hernia repair was found in up to 30% [34]. Second, the ability to reliably objectify reflux preoperatively is limited in case of paraesophageal hernia due to anatomical reasons. If manometry and pH testing is even possible, the results are difficult to be interpreted appropriately. Furthermore an extensive dissection required for the hernia repair predisposes for postoperative reflux even in patients with no previous reflux history. Besides the aforementioned reasons that support the routine use of an antireflux procedure, fundoplication is thought to support the anchoring of the cardia below the diaphragm and might thereby reduce the risk of recurrence. However, this hypothesis could not be confirmed so far by the randomized controlled trial by Müller-Stich et al., which may be due to a limited sample size or a too short follow-up. Looking at the quality of life, Mittal et al. compared patients undergoing hiatal hernia repair with or without fundoplication. In the long term, no difference in quality of life was found [49]. Since a routine fundoplication was shown to reduce severe postoperative esophagitis [34] and quality of life seems not impaired by a fundoplication [34, 49], routine use of fundoplication in hiatal hernia repair should be recommended (Table 38.2).

Historical methods to anchor the cardia below the diaphragm are the posterior gastropexy (Hill repair), the fundophrenicopexy, and the round ligament cardiopexy [22, 27, 39]. Although some of these methods showed promising short-term results, gastropexies are abandoned due to high recurrence rates especially in times of minimally invasive surgery [8]. Therefore, from the current point of view, fundoplication seems to be the only effective method for durable prevention of postoperative reflux.

The different types of fundoplication have been extensively compared in randomized controlled trials and in meta-analyses comparing the different fundoplications for the treatment of gastroesophageal reflux disease. Varin et al. performed a meta-analysis of 11 randomized controlled trials comparing partial fundoplication to total fundoplication [53]. Total fundoplication resulted in a higher incidence of postoperative dysphagia (OR 1.82–3.93; $p < 0.001$), gas bloat (OR 1.07–2.56; $p = 0.02$), and flatulence (OR 1.66–3.96; $p < 0.001$). No difference was found for the incidence of esophagitis, heartburn, or persisting acid reflux. Of note is the significantly higher reoperation rate after total fundoplication compared to partial fundoplication (OR 1.13–3.95; $p = 0.02$). Furthermore, no difference was found in patient satisfaction. The authors concluded that the partial fundoplication was a safe and effective alternative to total fundoplication with potential advantages but called for caution in interpreting the results due to the poor quality of the included trials.

Broeders et al. performed a systematic review and meta-analysis of total posterior fundoplication (Nissen) versus partial posterior fundoplication. Seven randomized controlled trials were included in the analysis [4]. Total fundoplication was associated with a higher postoperative prevalence of dysphagia (RR 1.61 (95% CI 1.06–2.44); $p = 0.02$), a higher reoperation rate (RR 2.19 (1.09–4.40); $p = 0.03$), a higher inability to belch (RR 2.04 (1.19–3.49); $p = 0.009$), and more gas bloating (RR 1.58 (1.21–2.05); $p < 0.001$). No differences were found for recurrent pathological acid exposure, esophagitis, in-hospital complications, or patient satisfaction. However, these results also should be interpreted with caution since the largest study included in the analysis by Strate et al. contradicted to some findings of the other included studies, which favored total fundoplication particularly in terms of acid exposure and esophagitis [48].

Broeders et al. furthermore performed a systematic review and meta-analysis on laparoscopic 180° anterior hemi-fundoplication compared to the Nissen fundoplication including 5

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randomized controlled trials with 458 patients in total [6]. Operation time, in-hospital complication rate, and length of hospital stay were similar in both groups. The prevalence of dysphagia with 15% versus 27% (RR 0.56, 95% CI 0.38–0.81; p = 0.002) and severity of dysphagia measured with the Dakkak dysphagia score (2.8 vs. 4.8; WMD −2.25; 95% CI −2.66 to −1.833; p < 0.001), gas bloating (11% vs. 18%; RR 0.59; 95% CI 0.36–0.97; p = 0.04), and inability to belch (19% vs. 31% RR 0.63; 95% CI 0.40–0.99; p = 0.05) were lower after the anterior hemi-fundoplication. Esophageal acid exposure, esophagitis, heartburn, dilatation rate and reoperation rate, proton pump inhibitor use, lower esophageal sphincter pressure, and patient satisfaction were similar after the two procedures. Even at 5 years follow-up, the Dakkak dysphagia score and the inability to belch remained lowered after laparoscopic anterior hemi-fundoplication. The study supports the use of an anterior hemi-fundoplication for the treatment of gastroesophageal reflux disease. However, it has to be emphasized the investigated 180° anterior fundoplication is a complex procedure, which has to be differentiated from the much simpler Dor or Thal fundoplication. According to Watson et al., with five to six sutures, the fundus has to be sutured to the right lateral wall of the abdominal esophagus and the right crus as well as to the left lateral wall of the abdominal esophagus and the left crus.

In a third systematic review and meta-analysis, the group by Broeders et al. compared the results of laparoscopic anterior fundoplication versus laparoscopic posterior fundoplication [5]. Five randomized controlled trials of anterior versus posterior total and two randomized controlled trials of anterior versus posterior partial fundoplication were identified. In the short-term follow-up of 6–12 months, esophageal acid exposure time (3.3% vs 0.8%; WMD 2.04; 95% CI 0.84–3.24; p < 0.001), heartburn (21% vs 8% RR 2.71 95% CI 1.72–4.26; p < 0.001), and reoperation rate (8% vs 4% RR 1.94 95% CI 0.97–3.87; p = 0.06) were higher after laparoscopic anterior fundoplication. However, the Dakkak dysphagia score was lower after laparoscopic anterior fundoplication (2.5 vs. 5.7 WMD −2.87 95% CI −3.88 to −1.87 p < 0.001). In the short-term follow-up, no differences were found for the prevalence of esophagitis, regurgitation, and the perioperative outcome. During the long-term follow-up of 2–10 years, the higher rate of heartburn after laparoscopic anterior fundoplication persisted and was associated with a higher PPI use rate. The reoperation rate in the long term was twice as high after anterior fundoplication (10% vs. 5% RR 2.12 95% CI 1.07–4.21; P = 0.03) mainly due to recurrent gastroesophageal reflux disease. Dysphagia scores, inability to belch, gas bloating, and patient satisfaction were not different in the long-term follow-up.

In conclusion all forms of gastropexy as single treatment were abandoned due to high reflux recurrence rates. Since objectifying reflux preoperatively is difficult in paraesophageal hiatal hernias, the prevalence of preoperative reflux is high, and hiatal hernia repair furthermore predisposes for postoperative reflux, repair for paraesophageal hernias should be combined with a fundoplication to prevent postoperative reflux. The available data supports laparoscopic posterior fundoplication as the surgical treatment of choice. However, it has to be considered that posterior partial fundoplication and an appropriate 180° anterior fundoplication are demanding procedures. They should be reserved to well-trained surgeons with extensive experience with the method. Otherwise a well-done Nissen fundoplication also can lead to good results with high patient satisfaction, maybe better than a badly done partial fundoplication. Thus, surgeons should perform the type of fundoplication that they are familiar with. Furthermore of note, little is known on the long-term effect of partial fundoplication in comparison with total fundoplication (◘ Table 38.2).

38.6 Mesh Augmentation

The SAGES Guidelines state that insufficient long-term data is available, on which a recommendation could be based either for or against the use of mesh at the hiatus (◘ Table 38.2).

However, today, there is evidence that the use of mesh for the reinforced repair of large hiatal hernias (>5 cm) with paraesophageal involvement leads to a reduction of recurrences and consecutive reoperations at least in the midterm.

In a meta-analysis of four randomized controlled trials, Memon et al. compared primary sutures (n = 186) with a prosthesis repair (n = 220). Mesh implantation led to a significantly decreased reoperation rate (OR 3.73 95% CI 1.18−11.82, $P = 0.03$), whereas no difference was found for operating time (SMD −0.46, 95% CI −1.16 to −0.24, $P = 0.19$) and complication rate (OR 1.06, 95% CI 0.45−2.50, $P = 0.90$) [33]. A recently published meta-analysis and risk-benefit analysis using a Markov Monte Carlo decision-analytic model found even more arguments for the routine placement of a mesh during the repair of large hiatal hernias (>5 cm). In 915 patients, a bisection of recurrences from 20.5% to 12.1% after a follow-up of approximately 3 years was found when mesh augmentation was compared to suture repair alone. This corresponded to an absolute risk reduction for recurrences of 8.4% and a number needed to treat of 12 (95% CI, 10.6–13.5)! The reduction of recurrences was even more prominent in a subgroup analysis restricted to studies with follow-up periods longer than 2 years (mesh augmentation 11.5% vs. suture alone 25.4%; $p = 0.007$) and synthetic meshes (mesh augmentation 9.9% vs. suture alone 19.0%; $p = 0.005$) [35]. Such a reduced risk of recurrence leads to fewer reoperations as shown in a meta-analysis of only randomized controlled trials by Memon et al. In the risk-benefit analysis by Müller-Stich et al., an absolute risk reduction of 5.6% and a number needed to treat of 18 (95% CI, 13.3–27.3) were shown regarding the reduction of reoperations by mesh augmentation. This is an important finding since reoperations at the hiatus are risky and mortality is tenfold increased compared to primary surgery [61]. Furthermore, the mesh-associated complication rate was surprisingly low with 1.9%. Consequently, mesh-associated complications did not lead to a significantly higher procedure-related complication rate (mesh augmentation 15.3% vs. suture alone 14.2%). In contrast, lifelong procedure-related mortality was even reduced by mesh augmentation even with the assumption that reoperations came along with the same operative risk as primary operations (mesh augmentation 1.6% vs. suture alone 1.8%). This corresponded to an absolute risk reduction of 0.3% and a number needed to treat of 344 regarding prevention of procedure-related mortality! (It has to be taken into account that this calculation has been done assuming the same mortality rate for reoperation as for primary surgery, which in fact is tenfold increased [61].

For mesh augmentation, different materials can be used such as polypropylene, polyester, polytetrafluoroethylene, or biomaterial. Furthermore, meshes are categorized by their structural specification such as weight, thickness, and pore size. Both material and structural characteristics have an influence on the biological behavior of meshes, which should be safe and stable. The ideal mesh integrates quickly without the tendency to migrate as shown for large porous polypropylene in the study by Senft et al. [47].

In the meta-analysis by Müller-Stich et al., polypropylene has most commonly been used (39.6% of all included patients) and was associated with a low complication rate of 0.8%. The other widely used meshes were polytetrafluorethylene (31.9% of all included patients) and biomeshes (13.5% of all included patients) with reasonable higher mesh-associated complication rates of 2.5% and 1.3%, respectively (Fig. 38.5) [2].

Polypropylene has thus been characterized by strong tissue incorporation and strong adhesion formation. Polytetrafluorethylene has been associated with less adhesion formation and was often involved in clinical studies when erosions of the esophagus were reported. A reason could be the worse tissue integration that led to a more mobile mesh. In the largest published series on 306 patients with a circular polypropylene mesh of Müller-Stich et al., mesh-related complications were found in 1% of patients (Fig. 38.6). Of note no mesh migration or erosion of the esophagus was observed [36]. The finding is further supported by large animal studies where mesh shrinkage of polypropylene meshes was correlated with an enlargement of the mesh aperture for the esophagus. Taking these findings into account, the fear of stenosis after application of a circular polypropylene mesh at the hiatus may thus be overestimated. Biomeshes from porcine small intestine submucosa was introduced by Oelschlager et al. because of the fear of possible complications by synthetic meshes [42]. The mesh should temporarily reinforce the hiatal hernia repair during the tissue remodeling process. Afterward the mesh was shown to be absorbed between 6 and 12 months after implantation, and thus the risk of mesh-associated complications was estimated to be reduced hypothetically. In their randomized controlled trial, Oelschlager et al. compared a primary repair ($n = 57$) to a primary repair with the biologic U-shaped mesh ($n = 51$). The reason why they used the U-shape was that they feared the amount of fibrosis and traction that could lead to dysphagia

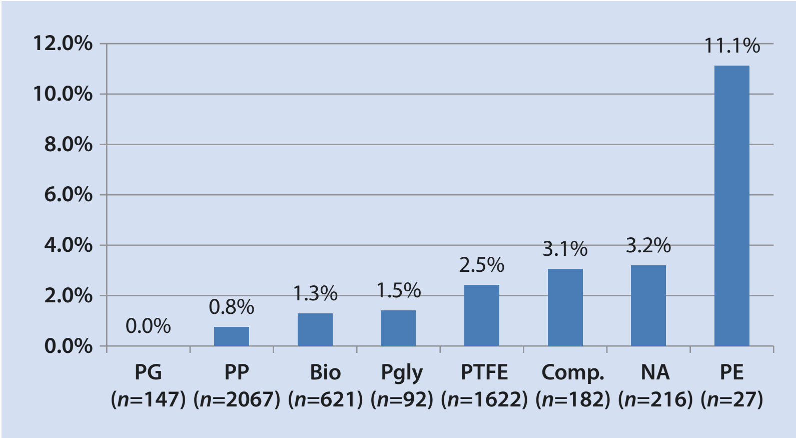

Fig. 38.5 Risk of mesh-associated complications according to mesh material (Müller-Stich BP, Kenngott HG, Gondan M, Stock C, Linke GR, Fritz F, et al. Use of mesh in laparoscopic paraesophageal hernia repair: a meta-analysis and risk-benefit analysis. PloS One. 2015;10(10):e0139547). *Comp.* composite, *DM* dermal matrix, *PE* polyethylene, *PG* polyglactine, *PGly* polyglycan, *PP* polypropylene, *PTFE* polytetrafluorethylene, *SIS* small intestinal submucosa, *NA* not answered

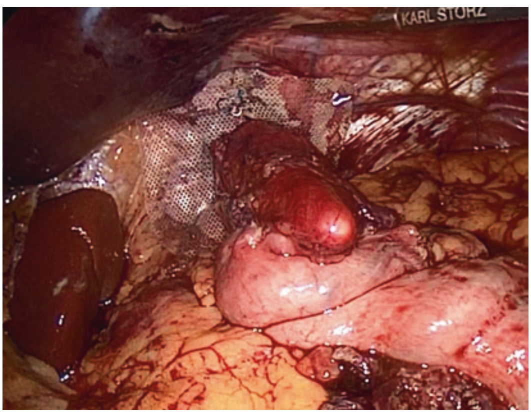

Fig. 38.6 Circular polypropylene mesh placed around the esophagus with a 56 French calibration tube in place

postoperatively when using a circular mesh. At 6 months postoperatively, 12 patients (24%) in the primary repair group and 4 patients (9%) in the prosthesis group developed recurrent herniation ($p = 0.04$) [44]. However, at 5 years follow-up, 59% in the primary repair group and 54% in the biologic mesh group had a recurrent hiatal hernia demonstrating that biomeshes are of no use in the long-term prevention of recurrences ($p = 0.7$) [43]. This finding was confirmed in a meta-analysis by Antoniou SA et al., which focused on biomeshes [2]. The use of biomeshes seems therefore to be ineffective for the repair of large hiatal hernias with paraesophageal involvement.

If a mesh is used, different shapes of meshes have been proposed: strips and U-, A-, V-, and circular-shaped. The different shapes have not been compared in randomized controlled trials so far. The mesh strips used by Ganderath et al. were placed after approximation of the crura with nonabsorbable sutures. The 1 × 3 cm mesh was placed posteriorly as an onlay mesh and secured with a stich on each side. Different data is published. First, in a nonrandomized trial, patients that underwent antireflux surgery for gastroesophageal reflux disease received either mesh ($n = 170$) or primary suture ($n = 361$) without mesh for their hiatal closure. One year after the procedure, wrap migration was seen in 6.1% of patients in the non-mesh group compared to 0.6% in the mesh group. However, dysphagia was significantly increased after 3 months in the mesh group (35.3% vs. 19.8%), although after 1 year the dysphagia rate of the two groups was equal (4.9% vs. 4.4%) [20]. The second study was a randomized controlled trial including 100 patients with gastroesophageal reflux disease treated with a 360° Nissen fundoplication and either primary suture repair or mesh-augmented repair. Three months after surgery, 10% of the patients in the primary suture group compared to 2% of patients in the mesh augmentation group were found to have wrap migration. This number even increased at 1-year follow-up to 26% of the patients with a primary suture versus 8% of patients with mesh augmentation. As in the first case series at 3 months, the patients with a mesh augmentation had a higher dysphagia rate (16% vs. 4%) that decreased after 12 months to 4% in both groups [19]. A similar mesh strip was applied in a randomized controlled trial by Watson et al., even though they used a larger mesh measuring 2–3 cm in height and 4–5 cm in width. The study compared three methods: suture repair ($n = 43$) vs. absorbable mesh ($n = 41$) vs. nonabsorbable mesh ($n = 42$). A 92% follow-up rate at 12 months was achieved. A recurrent hernia was found in 23.1% after suture repair, in 30.8% after absorbable mesh, and in 12.8% after nonabsorbable mesh [57]. The clinical outcomes were similar. Müller-Stich et al., Frantzides et al., and Szold et al. used a circular mesh [13, 25, 36, 38]. Müller-Stich et al. used a polypropylene mesh with an outer diameter of 80 mm and an eccentric hole of 18 mm. As mentioned before, the circular polypropylene mesh was associated with a low mesh-related complication rate of 1% in 306 patients. From clinical data and animal experiments, the circular mesh was found to remain in a stable position around the esophagus, which was explained by a statistically centered repositioning in case of every accidental mesh displacement. Because of the circular form, every movement in one direction could be followed by a countermovement until the final integration into the adjacent soft tissue was completed. Another explication for the stable position of circular meshes by the authors was that the circular mesh provided a large overlapping in the area around the repaired hiatus. In theory the large overlapping of the mesh guaranteed the best possible distribution of all involved forces. Frantzides et al. used an oval polytetrafluorethylene onlay patch with a 3.5 cm keyhole in the center of the mesh. Seventy-two patients with large (>8 cm) hiatal hernia were randomized to Nissen fundoplication with cruroplasty and to Nissen fundoplication, cruroplasty, and onlay mesh. At a median follow-up of 2.5 years, the primary closure group had a recurrence rate of 22% compared to 0% in mesh group ($p < 0.006$) [14].

Since the esophageal hiatus is a very dynamic area, different methods for mesh fixation have been proposed. A sufficient fixation is essential since mesh displacement can contribute to recurrences or displaced meshes may erode into adjacent structures like the esophagus, aorta, stomach, or pericardium. Tack fixation and suture fixation should be used with caution as they have resulted in lethal cardiac and vascular injuries (Fig. 38.7) [15, 37]. Special caution should be taken in the central tendon part of the diaphragm where the thickness of the diaphragm averages only 3 mm. Most of the injuries are caused by helical tacks. Fixation with sutures may therefore be favored. However, sutures also can lead to injuries of the pericardium [37]. Furthermore intracorporal suturing at the hiatus remains a difficult task contributing to a longer operative time, so that mesh fixation with fibrin glue has been proposed recently. This way of fixation may especially be sufficient when a large porous circular polypropylene mesh with fast tissue integration is chosen. The glue seeps easily through the porous mesh to adhere to the underlying tissue. This type of fixation reduces the technical complexity of laparoscopic mesh fixation. The risk for cardiac or vascular injuries associated with fixation by sutures or tacks is eliminated. In the available randomized controlled trials comparing placement of mesh with primary suture, different strategies for mesh fixation were used: Ganderath and Oelschlager secured the meshes with sutures. Frantzides used straight tacks and Watson used either sutures or tacks. No fixation-related complications were reported in 220 patients from those randomized controlled trials. No prospective trials comparing the different fixation strategies at the hiatus are available in humans. Müller-Stich et al. reported two cases with a cardiac tamponade after mesh fixation, one with

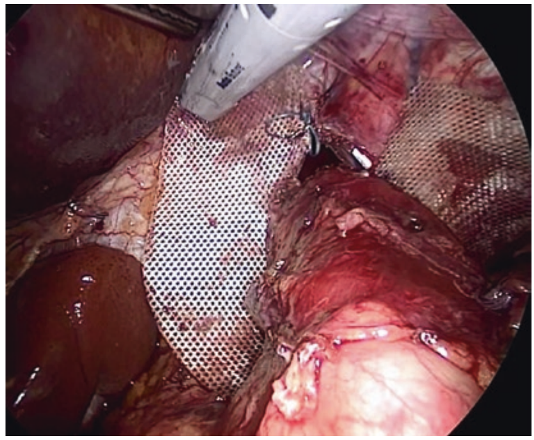

Fig. 38.7 Fixation of a circular mesh at the hiatus with a straight endostapler

helical tacks and one with sutures. The study furthermore summarized different foreign cases (*n* = 7) with cardiac tamponade caused by hiatal hernia surgery. Powell et al. used fibrin glue in 70 patients with paraesophageal or large sliding hernias. The mesh was placed and fixed in an average of 5 min. No complications were encountered. Animal survival experiments were performed to compare suture repair with fibrin sealant fixation for hiatal hernia repair. Despite the significantly reduced operative time (74.7 versus 127.0 min; $p < 0.01$), no mesh migration, nor a difference in cellular repopularization, or inflammatory changes around the mesh were found after 30 days [46]. The authors concluded that fibrin sealants resulted in integration strength similar to standard suturing. Different data was found on ventral hernia repair, where meshes were fixed to the abdominal wall in a porcine and rabbit model. In the experiment by Melman et al., the acute fixation strength was significantly greater for suture compared to tacking devices and to fibrin sealants. Tacking devices were stronger than fibrin sealants [32]. Jenkins as well found an inadequate fixation strength of fibrin sealants. The fixation strengths of suture plus fibrin sealants were equivalent or superior to the fixation strength of tacks alone [23].

In conclusion a mesh should always be placed in large hiatal hernias (>5 cm) with paraesophageal involvement since a positive effect on the prevention of recurrences is proven and, as a consequence, the need for complex reoperations is reduced. Risk-benefit considerations seem to benefit mesh application since mesh complications are rare and complex reoperations imply a higher lifelong mortality. When a mesh is used, a quick integrating material such as polypropylene should be considered. Polytetrafluorethylene should not be used due to bad tissue integration characteristics, and biomeshes should be avoided due to missing long-term effectivity. Different forms of meshes can be used. U-shaped and circular meshes seem to have advantages due to their stability around the esophagus. Mesh fixation in the anterior tendinous half of the hiatus should be done with fibrin glue, and in the posterior muscular half of the hiatus fibrin glue, straight staplers or suture fixation can be applied. No staplers or sutures should be placed in the anterior central tendon part of the diaphragm (▣ Table 38.2).

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Mesh Technology in Hiatal Hernia

Ferdinand Köckerling, Beat Müller-Stich, and Bruce Ramshaw

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39.1 Suture Versus Mesh Repair

Laparoscopic repair of large hiatal hernias is associated with high recurrence rates [1]. In the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) Guidelines for the management of hiatal hernia [2, 3] is stated on the basis of a moderate level of evidence that the use of mesh for reinforcement of large hiatal hernia repairs leads to decreased short-term recurrence rates. There is inadequate long-term data on which to base a recommendation either for or against the use of mesh at the hiatus [3].

In the meta-analysis of Antoniou et al. [4], three randomized controlled trials reporting the outcome of 267 patients were identified. The follow-up period ranged between 6 and 12 months. The weighted mean recurrence rates after primary and mesh-reinforced hiatoplasty were 24.3% and 5.8%, respectively.

In the meta-analysis of Memon et al. [5], 4 RCTs were analyzed, totaling 406 patients (suture = 186, prosthesis = 220). For only one of the four outcomes, i.e., reoperation rate (OR 3.73; 95% CI 1.18; 11.82; $p = 0.03$) did the pooled effect size favor prosthetic hiatal herniorrhaphy over suture cruroplasty. For other outcomes, comparable effect sizes were noted for both groups which included recurrence of hiatal hernia or wrap migration, operating time, and complication rates.

In a systematic review by Furnée et al. [6], 26 studies were included. Laparoscopic hiatal hernia repair was performed with mesh in 924 patients and without mesh in 340 patients. The type of mesh used was very different: polypropylene in six, biomesh in nine, polytetrafluoroethylene (PTFE) in two, expanded PTFE (ePTFE) in two, and composite polypropylene-PTFE in another two. Radiological and/or endoscopic follow-up was performed after a mean period of 25.2 ± 4.0 months. There was no, or only a small, recurrence <2 cm in 385 of the 451 available patients (85.4%) in the mesh group and in 182 of 247 (73.7%) in the non-mesh group.

In a meta-analysis of Müller-Stich et al. [7], 3 RCTs and 9 observational clinical studies (mesh types: PTFE, biological, polypropylene, composite) including 915 patients with paraesophageal hernia repair revealed a significantly lower recurrence rate for laparoscopic mesh-augmented hiatoplasty (pooled proportions, 12.1% vs 20.5%; odds ratio 0.55 [0.34–0.89]; $p = 0.04$). The authors concluded that mesh application should be considered for laparoscopic paraesophageal hernia repair.

In a further systematic review and meta-analysis, Tam et al. [8] identified 13 studies with 1194 patients, 521 with suture and 673 with mesh repair. Odds of recurrence (OR 0.51; 95% CI 0.30–0.87; overall $p = 0.014$) but no need for reoperation (OR 0.42; 95% CI 0.13–1.37; overall $p = 0.149$) were less after mesh cruroplasty. The authors concluded that the quality of evidence supporting routine use of mesh cruroplasty was low.

39.2 Complications of Mesh Implantation

Erosion and mesh migration are rare but devastating complications of synthetic mesh repair [1]. Stadlhuber et al. [9] reported about 17 cases of intraluminal mesh erosion, esophageal stenosis in 6 cases, and 5 patients with dense fibrosis. The authors concluded that complications related to synthetic mesh placement at the esophageal hiatus were more common than previously reported. Likewise, several case reports have drawn attention to severe complications following the use of synthetic meshes for hiatal hernia repair [10, 11]. Additionally, hiatal mesh is associated with major resection at revisional operation [12]. In the meta-analysis of Müller-Stich et al. [7], the complication rates of laparoscopic mesh-augmented hiatoplasty and laparoscopic mesh-free hiatoplasty for paraesophageal hernias were comparable (pooled proportions, 15.3% vs 14.2%, OR = 1.02 [0.63–1.65]; $p = 0.94$). The systematic review of laparoscopic mesh-augmented hiatoplasty data yielded a mesh-associated complication rate of 1.9% for those series reporting at least one mesh-associated complication [7]. No erosions, strictures, or dysphagia were identified on follow-up after 6, 45, and 58 months of using biological meshes [13, 14, 15], nor did a systematic review find evidence of any material-specific side effects of biological meshes on using such biological meshes for mesh-augmented hiatoplasty [16].

39.3 Biologic Versus Synthetic Meshes Versus Suture

A prospective randomized trial did not find any significant difference in the recurrence rate between the groups with suture repair vs absorbable mesh vs nonabsorbable mesh repair [17]. However, the sample size of around 40 patients per group was relatively small.

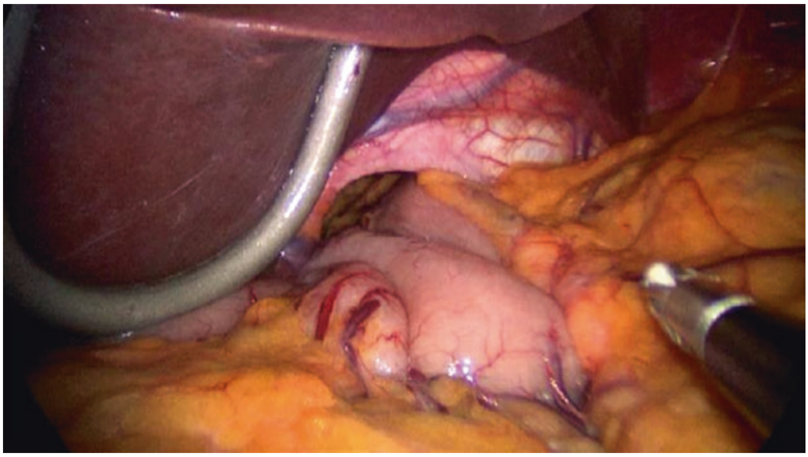

Fig. 39.1 Typical clinical finding of a large paraesophageal hernia

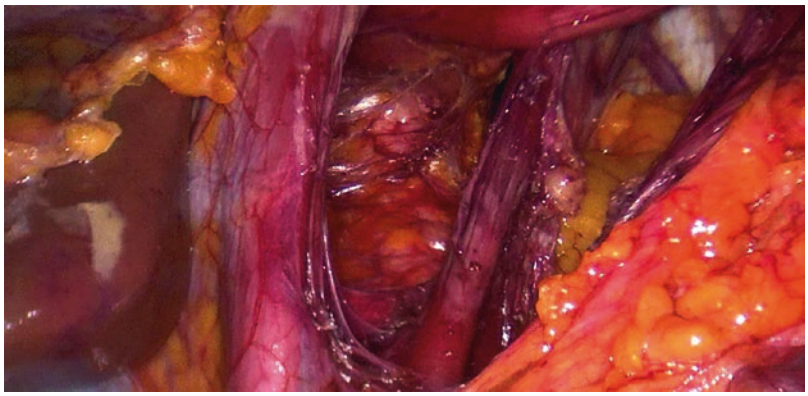

Fig. 39.2 Wide open hiatus after reposition of the stomach into the abdominal cavity

One systematic review, which included meta-analysis [1], identified 5 relevant studies with 295 patients where short-term follow-up revealed a suture repair recurrence rate of 16.6% vs 3.5% for biologic mesh repair ($p = 0.003$). The limited available information does not permit any conclusions about the long-term efficacy of biologic meshes in this setting [1].

39.4 Risk-Benefit Analysis for Mesh Augmentation

When performing hiatal herniorrhaphy, the increased risk of recurrence without mesh must be weighed against the potential risk of subsequent major resection when using mesh because of erosion and mesh migration [9–12]. Müller-Stich et al. [7] found that recurrences can be bisected by mesh application from 20.5% to 12.1% after a follow-up period of approximately 3 years. Mesh-associated complications are rare at a rate of 1.9% and do not markedly contribute to overall procedure-related complications. The reduction from 20.5% to 12.1% after use of mesh corresponds to an absolute risk reduction of 8.4% and a number needed to treat 12 (95% CI, 10.6–13.5). Reoperation rates after "mesh use" and "no mesh use" are 2.4% and 8.0%, respectively, and correspond with an absolute risk reduction of 5.6% and a number needed to treat 18 (95% CI, 13.3–27.3). The risk-benefit analysis revealed an 11% higher lifelong operation-related mortality rate of 1.6% for laparoscopic mesh-augmented hiatoplasty vs 1.8% for laparoscopic hiatoplasty (thinking of operation-associated mortality of very risky reoperations), corresponding to an absolute risk reduction of 0.3% and a number needed to treat 344 (95% CI, 297.6–406.5). Even more interesting was that the rate of polypropylene-associated complications (0.8%) was lower than that of biological-associated complications (1.3%) [7]. Other authors concluded [1, 16] that the severe complications related to mesh erosion and migration do not appear to occur on using biological meshes (Figs. 39.1, 39.2, and 39.3). On

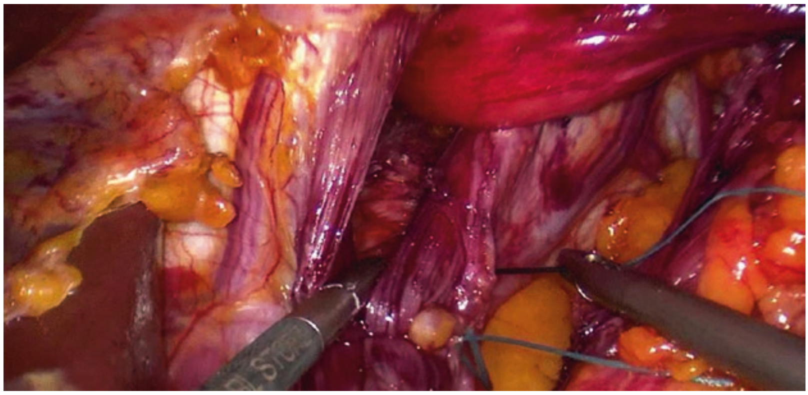

Fig. 39.3 Closing of the hiatus with nonabsorbable sutures

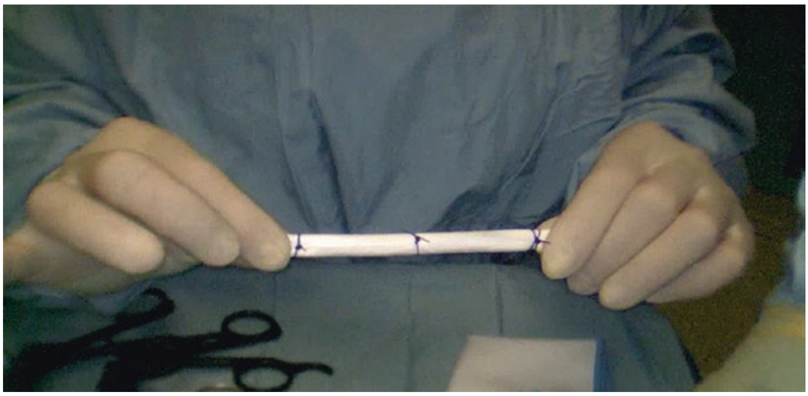

Fig. 39.4 A 12 × 8 cm Tutomesh is formed to a roll

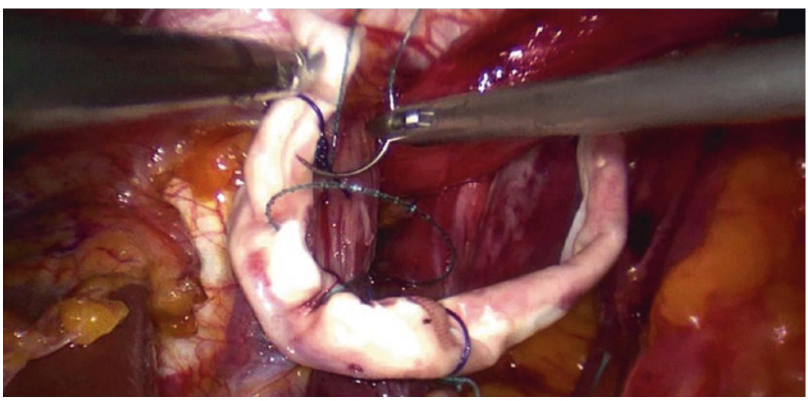

Fig. 39.5 The Tutomesh roll is sutured in a u-form to the hiatal crus for augmentation of the hiatoplasty

39

short-term follow-up, biological meshes were found to also reduce the recurrence rate [1]. To date, there is no sufficient data available on the longer-term follow-up outcome. On weighing up the risks against the benefits, the short-term data available would seem to support the use of biological meshes for mesh-augmented hiatoplasty in the case of large hiatal hernias. Further RCTs should be carried out in the future with greater sample sizes to conclusively determine which meshes are more suitable for hiatal hernia repair (Figs. 39.4, 39.5, and 39.6).

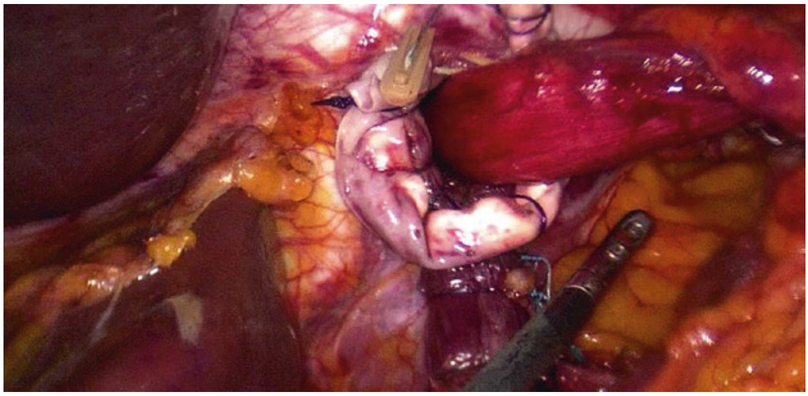

Fig. 39.6 Final view to the Tutomesh augmentation of the hiatoplasty

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Check for updates

Complications of Hiatal Hernia Repair and Prevention

Jelmer E. Oor, Ferdinand Köckerling, Rajesh Khullar, and Eric J. Hazebroek

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40.1 Praxis in Detail, "How I Do It", Daily Routine Tips and Tricks

40.1.1 Introduction

Surgical correction of hiatal hernias (HH) is a relatively safe procedure, with low reported mortality and morbidity rates [1, 2]. When complications do occur, however, they may significantly influence the patients' outcome and quality of life. In this chapter, we describe the different types of complications that may occur during and/or following HH repair and provide valuable tips and tricks for the prevention and/or management of these complications.

40.1.2 Intraoperative Complications

The most frequently reported complications during hiatal hernia repair include bleeding, capsular tears of the liver or spleen, perforation of the esophagus and/or stomach, and opening of the pleura [1]. Intraoperative complications are frequently caused by dense adhesions causing confusing anatomy and difficulties during the dissection and resection of the hernia sac. Especially large-type IV HHs, characterized by the intrathoracic migration of abdominal contents, including the omentum, small intestine, and colon, are associated with extensive intrathoracic adhesions near the mediastinum and pleura, with the risk of damaging these and other structures during dissection.

Intraoperative bleeding can originate from the hernia sac and hiatal pillars during resection of the hernia sac or from iatrogenic lesions of the liver and spleen. Iatrogenic esophageal perforation is a rare but potentially life-threatening complication, with severe consequences for patient outcome. Placement of a bougie for adequate sizing of the hiatus and fundoplication wrap carries the risk of iatrogenic esophageal perforation during the passage of the bougie, since this is performed without esophageal visualization by others than the operating surgeon [3]. However, this complication is extremely rare. Postoperative upper gastrointestinal contrast series can be used following difficult surgical procedures or bougie placement in order to detect esophageal perforation at an early stage, followed by endoscopic stenting of the esophagus.

40.1.3 Early Postoperative Complications

Morbidity following HH repair is most commonly caused by general postoperative complications, including pneumonia, thromboembolic complications, and congestive heart failure. Procedure-specific complications, such as esophageal leakage or early hernia recurrence, occur much less frequently [1].

Dysphagia may occur at an early stage or develop as a late complication following HH repair. In case of early dysphagia, a wait-and-see policy seems justified in order to rule out dysphagia caused by early postoperative edema. In case early dysphagia does not reside within several weeks to months, with persistent obstructive symptoms and/or dysphagia-like symptoms, dysphagia caused by a wrap or cruraplasty that has been constructed too tight seems more likely. Postoperative follow-up in patients with persistent dysphagia should at least include upper gastrointestinal contrast series in order to rule out esophageal stenosis, and upper gastrointestinal endoscopy and/or esophageal manometry to rule out esophageal aperistalsis. In patients suffering from dysphagia, special attention must be paid to the caloric intake, since dysphagia may easily cause nutritional deficiencies [4]. In case of esophageal stenosis, endoscopic pneumodilatation is a relatively safe and feasible technique for improving dysphagia and obstruction [5, 6]. Recurrent surgery is an option that should be reserved for those patients in which an objectified cause has been found and who do not or insufficiently respond to conservative or endoscopic treatment, including pneumodilatation. In these patients, the risk of insufficient improvement of symptoms and the increased risk of serious intraoperative morbidity should be well balanced against the impact of recurrent symptoms for the patient.

40.1.4 Late Postoperative Complications

Late postoperative complications include complications that are more specifically associated with HH repair. As stated before, dysphagia is a serious and frequently reported problem, and recurrent surgery should be reserved for a selected group of patients in whom it seems likely that they will benefit from recurrent HH repair.

A rare type of complication is caused by intestinal erosion of nonabsorbable mesh into the stomach or esophagus [6, 7]. This is an unusual complication; however, the consequences can be devastating. ► Chapter 39 specifically focuses on this and other complications associated with the use of mesh during HH repair. One of the most important preventative measures for this specific type of complication is mesh placement in a non-circumferential u-shape while carefully avoiding direct contact between the mesh and the stomach and esophagus.

Recurrence of HH is another important complication. Since it has been demonstrated that most recurrent HHs are relatively small and (partly) asymptomatic, performing redo surgery should be well reserved for those patients that suffer from a symptomatic and objectified HH and in whom it is likely that functional outcome will improve following recurrent repair [8]. The management of recurrent HH will be discussed in more detail in ► Sect. 41.2.

In the following section, we will provide several additional tips and tricks based upon our own experiences in order to help prevent the occurrence of both intra- and postoperative complications.

40.1.5 Avoidance of Urgent Surgery

Acute or nonelective surgery should be avoided whenever possible. Several studies have demonstrated increased mortality and morbidity rates and longer hospitalization following acute surgical repair compared to elective surgery [9, 10]. In case a patient presents with symptoms of acute obstruction and there is a high suspicion of strangulation, urgent decompression using nasogastric tube placement or endoscopic aspiration is usually sufficient and provides time for scheduling elective or semi-elective surgery under optimal conditions [10]. Only when decompression is unsuccessful, the patient is unstable, or there is evidence for gastric ischemia and/or perforation of the esophagus or stomach, urgent surgery should be performed [11].

Patients with a history of HH and progressive obstruction frequently suffer from a suboptimal nutritional status because of reduced dietary intake. Decompression with subsequent preoperative nasogastric or parenteral feeding provides the opportunity to optimize the patients' nutritional status, which could decrease the risk of perioperative complications. This also accounts for patients suffering from chronic obstructive pulmonary disease (COPD), who could significantly benefit from preoperative pulmonary rehabilitation. Especially in elderly patients, who frequently suffer from cardiac or pulmonary comorbidities, surgery should be planned after the patient has visited the anesthesiologist, cardiologist, or pulmonologist, in order to optimize the conditions under which the patient is operated.

40.1.6 Laparoscopic Approach

The introduction of laparoscopic abdominal surgery has significantly improved patient outcome in terms of reduced morbidity, postoperative pain, and length of stay compared to conventional, open surgery. These advantages have also been demonstrated to account for laparoscopic HH repair and antireflux surgery [12]. Since the introduction of laparoscopic paraesophageal hernia repair in 1992 by Concreve et al. and Cuschieri et al., the laparoscopic approach has replaced the conventional open approach, with lower reported morbidity rates and shorter hospitalization following laparoscopy, benefits that are particularly important in the treatment of elderly patients [12–14]. Symptom resolution and reoperation rates seem to be similar for laparoscopic HH repair and open surgery, a fact that used to be a matter of debate [8, 15]. Furthermore, the laparoscopic approach provides enhanced access to the mediastinum, thereby facilitating adequate dissection and excision of the hernia sac compared to conventional surgery and reducing the risk of intraoperative complications and early recurrence due to inadequate dissection.

Consequently, laparoscopy has now been accepted as the standard approach for HH repair. Despite a history of previous abdominal surgery, laparoscopy should be the primary approach in all patients. The conversion rate of laparoscopically HH repair appears to be less than 2%, most frequently caused by bleeding, perforation, adhesions, or inability to laparoscopically reduce the hernia into the abdominal cavity [1]. The benefits of laparoscopic surgery, especially the lower morbidity rate, outweigh the risk of conversion.

40.1.7 Leakage Following Esophageal Lengthening Procedures

Postoperative leakage is a rare but serious complication that most frequently occurs following esophageal lengthening procedures for treating "short esophagus", such as Collis gastroplasty [1]. The phenomenon of "short esophagus" will be discussed in more detail in ► Chap. 41. Due to the serious consequences of esophageal leakage, esophageal lengthening procedures should be avoided as much as possible. Circumferential esophageal mobilization and especially extended mediastinal mobilization are of vital importance in reducing axial tension exerted on the hiatus, not only to prevent recurrent HH by providing a tension-free position of the gastroesophageal junction in the abdominal cavity, but also to provide adequate length of the esophagus in order to prevent a "short esophagus". Esophageal lengthening procedures should be reserved for patients with a history of Barrett's esophagus with associated esophageal shortening due to chronic esophageal damage, and the decision to perform this procedure should be based upon intraoperative findings and adequate experience in performing these procedures [1].

40.1.8 Postoperative Care

As accounts for most types of surgery, early mobilization should be stimulated in order to prevent postoperative morbidity, such as pneumonia and thromboembolic complications. In patients with known respiratory comorbidities, early postoperative vaporizing and chest physiotherapy help prevent respiratory complications.

In order to prevent a sudden increase in intra-abdominal pressure and subsequent disruption of the HH repair, early postoperative gagging, belching, coughing, and vomiting should be treated aggressively [4, 16, 17]. Nasogastric tube placement may be necessary to treat early gastric distension [4].

As stated before, postoperative upper gastrointestinal contrast series (UGIS) may be used for early detection of iatrogenic esophageal perforation following difficult procedures or in patients experiencing severe postoperative dysphagia. However, there is insufficient evidence to support the routine use of postoperative UGIS [7].

40

40.2 Is What I Am Doing Every Day Evidence Based?

The following recommendations, including available evidence, are adopted and modified from the outcome of SAGES Guidelines Committee concerning the management of hiatal hernia [18].

Recommendations

- **Grade C**: It is recommended that postoperative nausea and vomiting should be treated aggressively to minimize poor outcomes

A sudden increase in intra-abdominal pressure is thought to predispose to early anatomical failure of the hiatal hernia repair [19]. It is suggested that early postoperative gagging, belching, and vomiting are predisposing factors for anatomical failure and the need for subsequent revision and therefore should mandate early and aggressive therapy if they occur [19]. Gastric distension should be recognized early, since it can be dangerous in the immediate postoperative phase and can be treated successfully by the placement of a nasogastric tube or, in cases where an intraoperative gastrostomy tube was placed, by venting the stomach through this tube [20, 21].

Recommendations

- **Grade D**: Because early postoperative dysphagia is common, attention should be paid to adequate caloric and nutritional intake

40.2.1 Comments

With early postoperative dysphagia rates of up to 50%, the general recommendation is for slow advancement of diet from liquids to solids. Attention should be paid to adequate caloric and nutritional intake in the postoperative period. Expert opinion suggests that most patients will lose 10–15 pounds (4.5–7 kg) with laparoscopic fundoplication and hernia repair followed by a graduated diet from liquids to soft solids. If dysphagia persists or weight loss occurs of more than 20 pounds (9 kg), evaluation and intervention for the dysphagia should be considered.

Recommendations

- **Grade B**: Routine postoperative contrast studies are not necessary in asymptomatic patients

40.2.2 Comments

There are no studies supporting routine contrast imaging after hiatal hernia repair. If patients demonstrate symptoms of severe dysphagia or there is a suspicion of a perforation, a contrast study is indicated. Routine radiographic follow-up shows a higher incidence of recurrence than symptomatic follow-up alone, but because most recurrences are small and asymptomatic, many suggest that routine radiographic follow-up is not indicated [22, 23].

Recommendations

- **Grade B**: Laparoscopic hiatal hernia repair is as effective as open transabdominal repair, with a reduced rate of perioperative morbidity and with a shorter hospital stay. It is the preferred approach for the majority of hiatal
- hernias

40.2.3 Comments

Laparoscopic hiatal hernia repair results in less postoperative pain compared to the open approach. The smaller incisions of minimally invasive surgery are less likely to be complicated by incisional hernias and wound infection. Postoperative respiratory complications are reduced [24]. Results from multiple studies are similar, with shorter hospital stay and less morbidity resulting from the minimally invasive approach [25–36]. Recurrence rates are similar. Conversion to open surgery is occasionally necessary for reasons such as bleeding, splenic injury, or dense adhesions, and it is important that surgeons taking these on as laparoscopic procedures are comfortable with an open repair should conversion become necessary.

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Complex Hiatal Hernias

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41.1 Upside-Down Stomach

Dirk Weyhe

41.1.1 Hiatial Hernia Classification

Hiatial hernia often develops due to a combination of insufficient hiatial fixation of the cardia region and concurrent intra-abdominal pressure, which mainly arise due to age and/or obesity [1]. The amount of dislocated tissue is used to classify hiatial hernia:

- Type I: axial hernia
- Type II: paraesophageal hernia
- Type III: combination of I and II
- Type IV: large hiatial hernia with additional abdominal organs dislocated into the thorax

> Classification of hiatial hernia: Type I, axial hernia; Type II, paraesophageal hernia; Type III, combination of I and II; and Type IV, large hiatial hernia with abdominal organs (besides the stomach) dislocated into the thorax

For the most common, reversible axial hernia (Type I), the cardia region is dislocated in longitudinal direction above the hiatus esophagi. Most Type I hernias (80–90%) are incidental findings in the context of gastroscopies. The paraesophageal hernia (Type II) is characterized by the dislocation of parts of the stomach following larger hiatal defects and a subphrenic cardia (i.e., in loco typico). The subphrenic cardia is by definition the main distinguishing feature of a Type II hiatial hernia and results in a more or less completely thorarcal antrum region. The upside-down stomach may occur as a maximal variation even in a Type II hiatial hernia. A Type III hernia is characterized by a mix between axial and paraesophageal hernia in addition to an intrathoracic, dislocated cardia. Type IV hiatial hernias are very rare, and they are defined by the dislocation of abdominal organs like the small intestine, colon, pancreas, and spleen, in addition to the stomach.

Patients with dislocated abdominal organs may be asymptomatic for a long time, until they present with exertional dyspnea or pulmonary fibrosis with chronic recurrent silent aspiration, and differential diagnosis then reveals well-progressed clinical findings. Dysphagia, regurgitation, postprandial cardiovascular disorders, arrhythmia, and anemia are typical symptoms for large hiatial hernia, whereas reflux is an infrequently reported symptom.

The actual prevalence of so-called "complex" or "large" hiatial hernia is unknown. Also, there are no clearly defined criteria for "medium-" or "large-"sized hernia, and therefore differentiation according to size is inconsistent. Disregarding the Type I–IV classification, comparison between studies or research questions is therefore nearly impossible. In addition, there are ongoing discussions concerning details of surgical procedure. For example, it still remains unclear whether resection of the hernial sac or simple gastropexy is a valid alternative for simultaneously performed antireflux procedure (360°/270° Fundoplication), which is a common standard nowadays. Another central, currently unanswered question concerns the practice of mesh augmentation for "large" hiatal hernia.

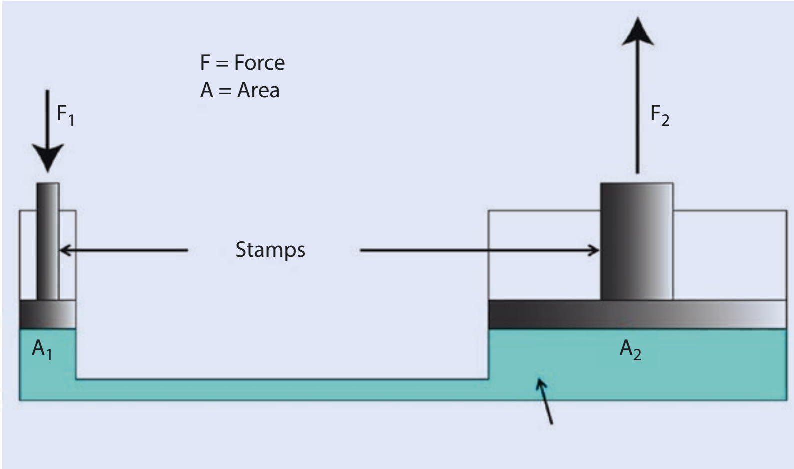
41.1.2 Mesh Augmentation

Indication for Mesh Augmentation

For abdominal wall or inguinal hernia, mesh augmentation is a standard surgical procedure and an integral part of international guidelines with high-level evidence, both for conventional and for laparoendoscopic techniques [2, 3]. By contrast, guidelines are very cautious concerning recommendations for mesh implants at the hiatus esophagi [4]. According to SAGES, missing long-term evidence, as well as the potential risk of local chronic foreign body reaction, and heterogeneous study results with regard to the implant materials do not allow for a conclusive recommendation.

> Guidelines are very cautious concerning recommendations for mesh implants at the hiatus esophagi due to missing long-term evidence and potential risks.

However, according to Rathore et al. [5], recurrence rates of 25% and above may be expected after using mere suture technique, not taking individual surgical learning curves into account. By contrast, after initial surgery with hiatal augmentation using alloplastic or biological



■ Fig. 41.1 Pascal's principle; hydrostatic pressure evenly spreads in all directions at each point of a fluid. Therefore, with a small force F_1 a large force F_2 might be exerted

materials, revisions needed due to recurrence are often associated with high morbidity, including the potential need for an esophagectomy [6]. Individual surgeons might reach different decisions with regard to the risk-benefit analysis resulting from careful consideration of these arguments. This may explain the questionnaire result of Pfluke et al. [7], according to which more than 50% of all interrogated surgeons state that they rarely or never use mesh augmentation in the surgical treatment of hiatial hernia.

Biomechanical Principles of Mesh Augmentation

In comparison to solely using suture techniques, mesh augmentation at the hiatus esophagi reduces the risk of recurrence [8, 9]. Since the first hiatal mesh augmentation published by Kuster and Gilroy [10], a plethora of modified techniques for mesh augmentation after hiatial hernia were described. Some surgeons only implement a partial augmentation of the dorsal crura, whereas other surgeons perform a circular augmentation of the hiatus esophagi. However, partial, strip-shaped, or U-shaped augmentation of the defect strongly disagrees with main principles of inguinal or incisional hernia surgery implemented in recent years [3, 11] and with the laws of physics in general. Because of Pascal's principle of uniform pressure distribution (■ Fig. 41.1), a mesh overlap at the defect location of at least 3–5 cm is needed for a complete and sustainable coverage of the defect (■ Fig. 41.2; [12, 13]). Therefore, all techniques, which use noncircular augmentation, and/or augmentation, which does not completely cover the defect with sufficient overlap, should not be implemented.

> Because of Pascal's principle of uniform pressure distribution, a mesh overlap at the defect location of at least 3–5 cm using circular augmentation is needed for a complete and sustainable coverage of the defect.

In keeping with the principle of an abdomen with abdominal compartmentalization and considering uniform pressure distribution throughout the whole abdomen (container principle), the hiatial hernia may be regarded as an abdominal wall hernia in a broader sense. Consistently, all theoretical considerations concerning biomechanical rules and principles should be taken into account as well, even if the practical realization (e.g., overlap) of those fundamental biomechanical principles at the region of the hiatus esophagi is somewhat limited. However, they should be adhered to as closely as possible.

Since recurrence rates increase with increasing size of the hernia orifice [14], and in accordance with the aforementioned needed overlap, it seems appropriate to determine the size of the hernia and to tailor the surgical technique accordingly. Based on the studies by Granderath and Pointner (e.g., Granderath [15]; Granderath et al. [16]), the hiatial surface area (HSA) can be determined by measuring the diaphragmatic side and crural commissure of the hernia orifice intraoperatively (■ Fig. 41.3) and by then plotting the measurements in an appropriate coordinate system (■ Fig. 41.4). A hiatial hernia with a HSA > 5 cm^2 may be classified as "large," and mesh augmentation is recommended. As mentioned above, the

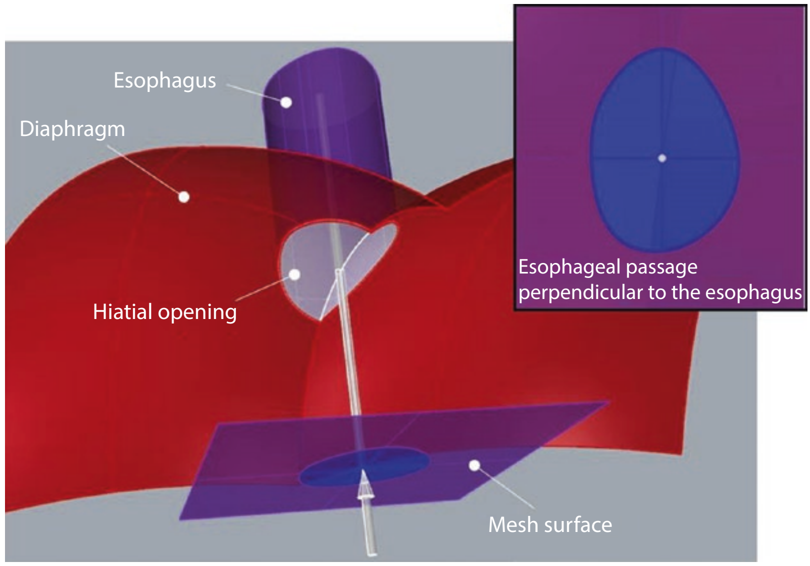


Fig. 41.2 Schematic mesh augmentation. Considering Pascal's principle, overlap of the mesh at the hiatus esophagi should be 3–5 cm

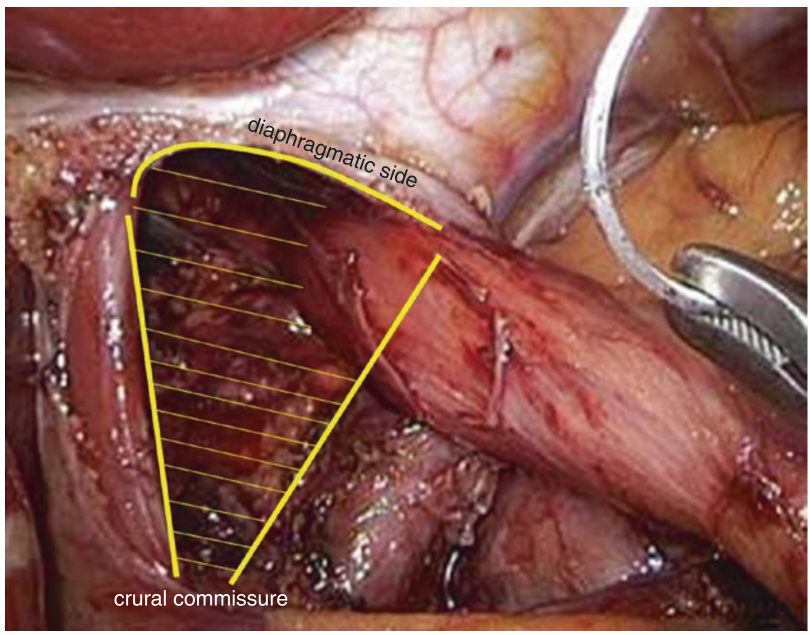


Fig. 41.3 Measuring the size of the hernial orifice

coverage of the defect with the mesh should be circular (Fig. 41.5). In addition with a large enough overlap, the intra-abdominal pressure may then be distributed across a larger area of tissue [17].

> Hiatal hernia with a HSA > 5 cm^2 may be classified as "large," and circular mesh augmentation with at least 3–5 cm overlap is recommended.

Choices of Mesh

With regard to biocompatibility of synthetic implants, the same minimum requirements apply at the hiatus esophagi as for all implants used intra-abdominally. Lately, the pore size of synthetic meshes, and not implant weight, was identified to be the best predictor for optimal mesh integration. Current guidelines therefore recommend monofilament polymers with a pore size of at least 1.0–1.5 mm. The tensile strength (including tearing

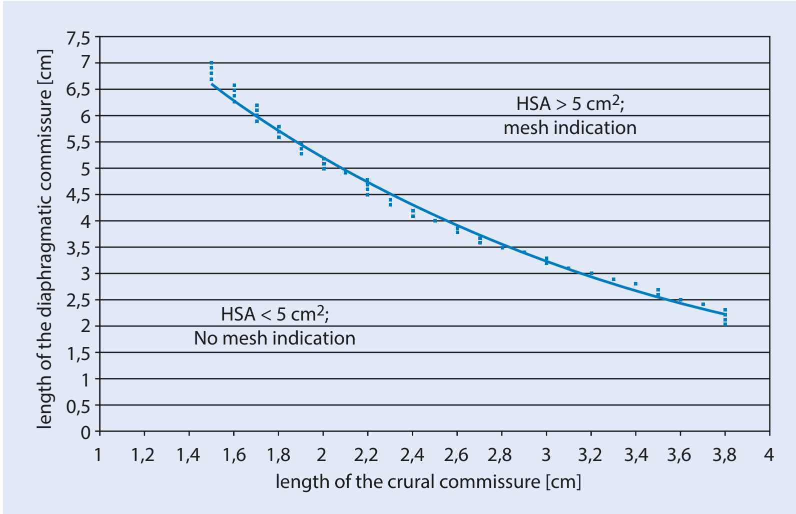


Fig. 41.4 Determining the size of the HSA: the length of the crural commissure is entered on the horizontal axis and the length of the diaphragmatic commissure is entered on the vertical line. If the resulting data point is above the *blue line*, HSA is >5 cm^2, and indication for mesh augmentation is met

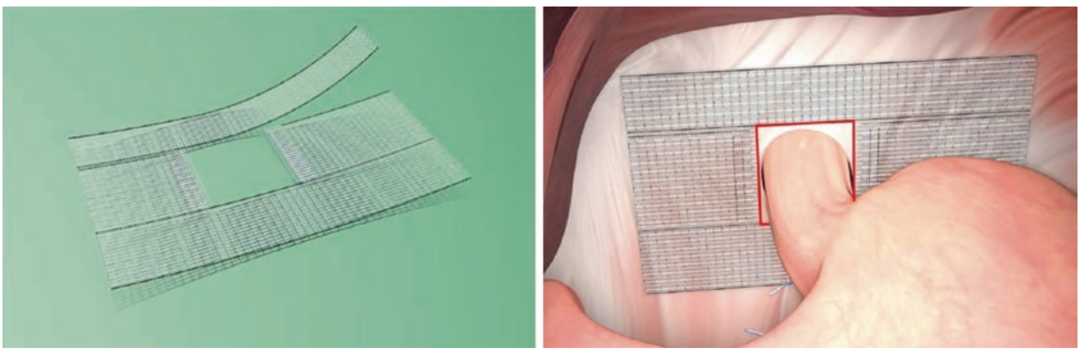


Fig. 41.5 das MRI-visible mesh (*left*) and its placement centrally around the hiatus esophagi

force) should be >16 N/cm^2 [18]. In addition, in the last decade, there has been a paradigm shift with regard to the definition of biocompatibility. The initially favored approach of focusing on bionic material changed into one of maximal implant integration, which adapts to the desired function without local or systemic adverse effects [19]. Adhering to the latter definition, currently, no safe recommendation can be made regarding potential complications of synthetic meshes or biological membranes.

> Currently, no safe recommendation can be made regarding the use of synthetic meshes versus biological membranes.

Short-term results show no difference between biological and synthetic implants [20, 21], whereas in the long term, recurrence rates seem to be markedly higher for biological implants [4, 22–24]. The heterogeneity of studies, especially with regard to missing definition of recurrence (e.g., asymptomatic vs. symptomatic), differences in follow-up duration, and a plethora of technical modifications, limits the validity of meta-analyses, such that surgeons still can choose the mesh at their own discretion [25].

Potential Complications of Mesh Augmentation

As described in small case series, uncoated polymers built from polypropylene or polyester are associated with higher chronic foreign body reactions and with a higher risk of hollow organ erosion or intestinal fistula [26–28]. Coated polymers seem to reduce these risks (e.g., Köckerling and Schug-Pass [29]). Meshes built from combinations of PTFE and polypropylene may not be integrated fully in the surrounding tissue, thus increasing the

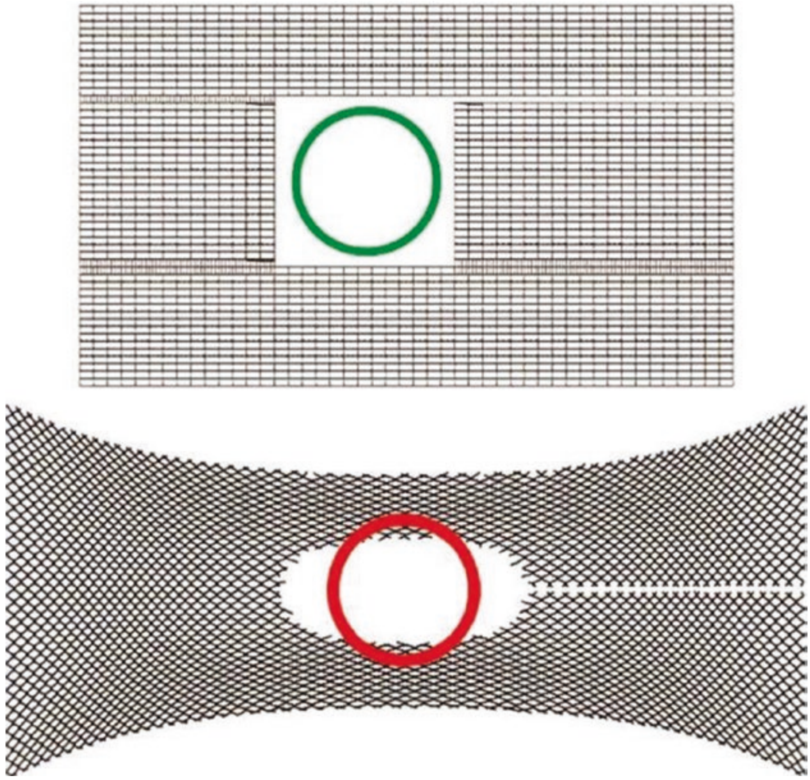


Fig. 41.6 Mesh deformation for an applied force of 50 Nm is a predictor for mesh shrinkage

risk of mesh shrinkage [30, 31]. Use of biological membranes may result in higher recurrence rates and dysphagia due to fibrosis.

Overall, the material-related potential for complications seems to be overestimated for polypropylene meshes, if the number of published complications is related to the amount of polypropylene implants used in hiatial surgery (18/2181 ≈ 0.8%). Indeed, complication rates seem to be the lowest for meshes made from polypropylene and for completely absorbable polyglactin meshes [32].

41.1.3 How I Do It

Choice of Mesh

Especially in circular augmentation of a hiatial defect, mesh shrinkage may have enormous consequences, since shrinkage is likely associated with postoperative dysphagia. Therefore, structural stability is of main importance, since high structural stability may reduce the potential for shrinkage in synthetic meshes. For instance, in vivo animal studies showed that the amount of elongation and deformation (Fig. 41.6) occurring for forces of 50 Nm is predictive of shrinkage [33].

> To avoid shrinkage with subsequent dysphagia, meshes with high structural stability should be used.

Therefore, in our clinic, we use an MRI-visible, synthetic mesh with high structural stability [34]. Thus we are able to observe both, shrinkage due to strain and/or incomplete healing processes and development of recurring hernia in the long term (Fig. 41.7). The rational behind the usage of the MRI-visible mesh is the consistent implementation of the circular overlap principle described above. The hernia orifice (in terms of HSA) is measured and is covered by the mesh by at least 2–3 cm in all directions. To prevent dysphagia due to stenosis, shrinkage is taken into account as well. Only absorbable tackers are used. Efficiency of the fixation is validated by directly postoperative and long-term MRI.

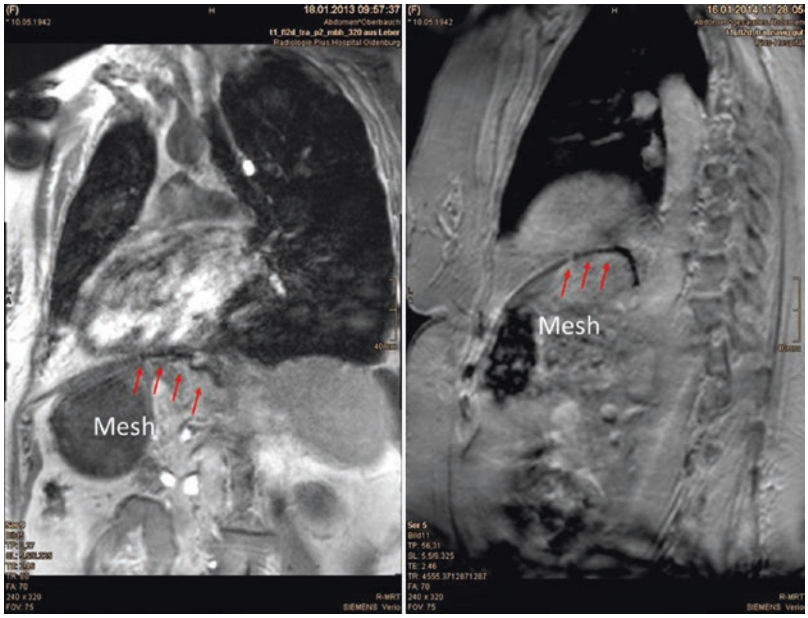


Fig. 41.7 Perioperative MRI and 1-year follow-up to visually control the healing process and potential mesh shrinkage

MRI-visible implants allow for visual control of the mesh position, even in the long term.

Surgical Steps in Detail

Positioning and Preparations

Surgery is performed in beach chair position. After application of the trocars, the left part of the liver is retracted with a fan. The hiatial orifice is prepared, and all dislocated tissue is repositioned into the abdomen. The pars flaccida is severed, and the diaphragmatic commissure of the hiatial orifice is prepared clockwise, followed by the preparation of the intrathoracic hernia sac.

Hernial sac preparation is best done mostly blunt with a compact sponge.

The intrathoracic part of the esophagus is mobilized over at least 5 cm. Depending on the amount of tissue, the hernial sac is resected and removed to allow for easy suture of the fundic wrap.

After preparation, the cardia should be positioned intra-abdominally without traction. Otherwise further intrathoracic mobilization of the esophagus might occur (cave circulatory disorder).

Hiatal Surface Area (HSA)

To assess the need for mesh augmentation, the diaphragmatic side and crural commissure of the hernia orifice are measured intraoperatively. A surgical nurse copies the values into the aforementioned graph. A HSA > 5 cm^2 is indicative of mesh augmentation.

For easy measurement, take a 6–8 cm suture and measure both the diaphragmatic side and crural commissure. The first forceps spans the suture, and the second marks the length of the commissure. The length of the marked part of the suture is measured extracorporeal.

Hiatus Reconstruction

Dorsal hiatoplasty is performed by three intracorporeal simple interrupted stiches using polyester sutures. Depending on the anatomy and the size of the hernial orifice, an additional ventral suture might be necessary. For HSA > 5 cm^2, the indication for mesh augmentation is met. We use a MRI-visible PVDF polymer (DynaMesh® visible; size: 15 × 12 cm). The slit mesh is pulled underneath the esophagus from left to right and is placed such that the slit comes to rest at the upper left quadrant. In its resting position, the central mesh opening should not touch the esophagus or confine it in any way. The mesh is fixated with absorbable tackers (AbsorbaTack – Covidien®) at the muscular diaphragm. If necessary, an additional, absorbable suture might be used for fixation at the centrum tendineum. Typically, further fixation is not necessary, since intra-abdominal pressure evenly fixates the mesh in situ.

Note: Cardiac tamponade might occur by using too long or misplaced tacker.

Fundoplication

For larger hiatial hernia, we perform a 360° Fundoplication in every case. Rational behind this procedure is the even spread of pressure on the hiatus esophagi. The gastric fundus is mobilized along a length of at least 14 cm to ensure a tension-free fundic wrap.

> Open Babcock forceps and move it along the cardia two times the length of the forceps opening. In this area, remove the omentum majus with an ultrasound dissection device (e.g., Olympus-Thunderbeat®).

Three simple interrupted stiches using polyester sutures are used to fixate the fundic wrap. The middle stich gathers the cardia region to prevent pouch slipping. Intraoperatively, a stomach expiration probe is applied.

Follow-Up

Normal diet is initiated during the first postoperative day, if there is no evidence of gastroparesis. In the early postoperative days, MRI is used to study the mesh placement (Fig. 41.7).

Note: Directly following surgery no postprandial vomiting may occur, to prevent early recurrence.

41.1.4 Summary

- A hiatial hernia with a HSA > 5 cm² is called a "large" hernia.
- Recurrence rates for hiatoplastic using only suture technique may be up to 50%.
- By using circular, non-constricting mesh augmentation, recurrence rates decrease to <5%.
- Biological membranes are associated with higher recurrence rates than synthetic meshes.
- To avoid shrinkage and subsequent dysphagia, implants with high structural stability should be used.
- MRI-visible implants allow for long-term visual control of the mesh.

41.2 Short Esophagus

Pradeep Chowbey

Gastroesophageal reflux disease (GERD) is associated with chronic inflammation which may result in intrinsic shortening of the esophagus and can lead to short esophagus and associated hiatus hernia. Short esophagus is difficult to diagnose preoperatively and is one of the important causes of recurrence of hiatus hernia if left unnoticed during surgery. Many surgical options with many approaches are available to handle this situation. Laparoscopic Collis-Nissen procedure is one of the favored surgical treatment options.

41.2.1 Introduction

The term short esophagus was coined in the era when Barrett concluded that any portion in the swallowing passage that is lined by columnar epithelium is the stomach [35]. Now short esophagus can be applied appropriately to any patient who has an unacceptable degree of stretch of the distal esophagus once the esophagogastric junction is reduced below the diaphragm [36]. Approximately 10–15% of patients undergoing antireflux surgery actually have short esophagus [37], of which approximately 7–10% can be appropriately managed with extensive mediastinal mobilization of the esophagus to achieve the required esophageal length and the remaining 3–5% require an aggressive surgical approach [38], which may include gastroplasty procedures or procedures to create an adequate length of intra-abdominal esophagus to perform a wrap.

Gastroesophageal reflux disease (GERD) is the most common etiology, and associated *chronic inflammation* may result in intrinsic shortening of the esophagus [39]. Other conditions associated include Type III paraesophageal hernias, sarcoidosis, Barrett's metaplasia, caustic ingestion, scleroderma, and Crohn's disease [38].

41

41.2.2 Classification

Types [38]

No proper classification has been described in literature, but short esophagus can be classified in:

I. A true, nonreducible short esophagus
II. A true but reducible short esophagus
III. Apparent short esophagus

Perioperative endoscopic or radiologic studies document that all the three groups have a GEJ located at or above the hiatus and the only way to differentiate between these types is surgical mobilization of the mediastinal esophagus.

Diagnosis

Preoperative assessment of the presence of short esophagus is very difficult, and investigations are not reliable predictors but can increase the clinician's index of suspicion. The actual diagnosis of a short esophagus can be made only in the operating room [36].

Management

Routine division of the short gastric vessels with crural closure and repairs performed without tension around a 2.5–3 cm length of intra-abdominal esophagus [40–44] is the key for proper hiatus hernia surgery.

Unrecognized short esophagus during surgery is responsible for about 20–33% of the surgical failures after open or laparoscopic fundoplication [38], due to increased risk of a "slipped" fundoplication or a crural disruption with subsequent herniation of the wrap into the mediastinum and which further warrants requirement of second surgery with less favorable long-term functional result [45, 46].

41.2.3 Treatment Options Include

Open

Transthoracic Collis-Belsey procedure

- Collis-Nissen procedure
  - Transthoracic
  - Thoracoabdominal
  - Transabdominal
- Esophagectomy

Laparoscopic

- Collis-Nissen procedure
- Esophagectomy

Intrathoracic Fundoplication

Effective control of reflux can be achieved with this approach [47–49], but epigastric or chest pain, dysphagia, and major complications like strangulation, perforation, ulceration, or bleeding [47–52] are associated with this iatrogenically created paraesophageal hiatal hernia. Because of these complications, intrathoracic fundoplication is seldom if ever recommended [50–52].

Esophagectomy

Patients with extremely long nondilatable strictures, strictures associated with Barrett's mucosa with high-grade dysplasia, and strictures after multiple failed antireflux operations [36] may occasionally require total esophagectomy and reconstruction.

41.2.4 Esophageal Lengthening Procedures

Collis Procedure

This procedure involves the creation of neoesophagus (a gastric tube) by dividing the stomach near angle of HIS. Unfortunately, the Collis gastroplasty alone, without a wrap, did not control reflux [53].

Using the combined Collis-Belsey [54, 55] and Collis-Nissen procedure [56, 57], the results reported are excellent. Complications like leaks from the gastroplasty line, fistulas, and acid secretion from the ectopic gastric mucosa of the neoesophagus [58] are reported and occurred in 10% or less of cases [51]. It has also been noted that a Collis neoesophagus typically lacks normal motility and is at risk of eventual dilatation or may be a factor related to postoperative dysphagia.

41.2.5 Conclusion

Though rare but a notorious entity for recurrent hiatus hernia, "short esophagus" is difficult to diagnose yet can be diagnosed intraoperatively with a vigilant approach. Once diagnosed, it can be and should be managed appropriately.

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Upside-Down Stomach

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Hiatal Hernia Repair in Difficult Pathologic-Anatomic Situations at the Hiatus

Pradeep Chowbey, Alice Chung, and Ellen Morrow

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42.1 Recurrent Hiatus Hernia

Pradeep Chowbey

Laparoscopic fundoplication is safe and effective and currently is considered as the “gold standard” surgical treatment for GERD with a success rate of about 80–95%. Due to lack of proper definition, different criteria like relief of GERD symptoms, improvement in quality of life, avoidance of postoperative complications, and patient satisfaction were considered. Patients sometime report symptoms strongly suggesting that of recurrence but with no objective evidence of reflux by pH study. There are various mechanisms described for recurrence, transdiaphragmatic herniation of wrap being the most common mechanism after laparoscopic repair. If symptoms are not effectively managed by PPIs or affecting quality of life, redo surgery is advisable and can be completed laparoscopically with results comparable to primary surgery with little increase in risk of recurrence.

42.1.1 Introduction

Proper exposure of hiatus, correct orientation of gastric anatomy, and formation of an optimally positioned floppy wrap with gastroesophageal junction at least 2–3 cm into the abdomen without tension [1] are the keys to success. However the extent of optimal dissection is difficult to define but can slowly be understood and achieved with experience [2].

About 80% to 95% of patients reported resolution of short- and long-term reflux [3, 4]. However, the absence of objective documentation of reflux by measures such as ambulatory pH monitoring does not guarantee a successful outcome because patients sometimes develop the sets of new postoperative, recurrent, or persistent symptoms. So using the objective method solely to determine the success of the operation can therefore be inadequate and often inconsistent with patient reported symptoms and satisfaction [5].

Due to lack of proper definition and criteria for a successful or failed fundoplication, there are the range of treatment end points used which include relief of GERD symptoms, improvement in quality of life, avoidance of postoperative complications, and patient satisfaction. Patient satisfaction is considered as an important criteria of effective treatment, with many studies reporting 90% satisfaction rates or higher after laparoscopic fundoplication as well as improvements in symptoms and quality of life [3, 6, 7].

About 0–13% of patients experience recurrence of reflux symptoms on long-term basis [3, 7–9], and the majority of them have an intact fundoplication [10, 11] which can effectively be managed by PPIs, and if reflux hinders their quality of life, reoperation is the option.

High-Risk Factors

Features which have been considered predictors of poor outcomes include [9, 11–14]:

- Signs of advanced disease such as low or absent lower esophageal sphincter pressure
- Very high DeMeester scores
- The presence of Barrett’s metaplasia, stricture, and esophagitis
- Poor response to antacids preoperatively
- The presence of atypical primary symptoms such as sore throat, hoarse voice, and cough
- Psychiatric comorbidities
- Associated morbid obesity
- Short esophagus
- Technical deviations

42.1.2 Clinical Presentation

Patients may present with new symptoms. Bloating/dysphagia is the most prominent postoperative complaint (59%), followed by symptom recurrence (23%) and symptom persistence (4%) [15].

Mechanism

Main mechanisms involved in recurrent hiatus hernia [16]

- Slipped or misplaced fundoplication
- Disrupted fundoplication
- Herniated fundoplication
- Fundoplication that is too tight or too long

Other Mechanisms Involved

- Wrap breakdown
- Short (<1 cm) wrap
- Stricture at the gastroesophageal junction
- The fundus of the stomach may be folded due to adhesions, causing obstructive symptoms

42.1.3 Management

Repair of recurrent hiatal hernia is indicated when the symptoms match anatomical findings and are not effectively managed by PPIs or affecting quality of life [17]. In experienced hands the revisional surgery can often be completed laparoscopically [17–19]. Take down previous fundoplication if any, and then the right and left crura are exposed and the hernia sac excised. Adequate intra-abdominal esophageal length ensured [18] and fundoplication done. The success rate of laparoscopic revisional hiatal hernia surgery is as high as of the primary repair [20], although there remains an increase in recurrence rates.

Anterior gastropexy is also one of the additional procedures described to reduce the recurrence rate after laparoscopic hiatal hernia repair. Reduction of the hernia, sac excision, crural repair, antireflux procedure, and routine anterior gastropexy are done, especially in patients with large hiatal hernias [21], long-standing hernia, and in patients in whom gastroparesis is expected for long.

42.2 Hiatal Hernia Repair in Obese Patients

Alice Chung and Ellen Morrow

Obesity is a growing problem worldwide, particularly in the United States. Obesity is defined as a body mass index (BMI) over 30 and morbid obesity as a BMI over 35. In a recent study looking at the United States population between 2011 and 2012, 34.9% of adults and 16.9% of all children and adolescents were found to be obese [22]. European countries have not been immune to the obesity epidemic, with 15.5% of the adult population in France defined as being obese [23]. Obesity is associated with higher intra-abdominal pressures that predispose to both GERD and hiatal hernia. In fact, obese individuals are 4.2 times more likely to have a hiatal hernia than normal-weight individuals with an overall prevalence of hiatal hernia of 40%, versus 12.6% for the general population [24]. The obese hiatal hernia patient is, therefore, a problem that surgeons are facing frequently.

Outcomes for laparoscopic antireflux surgery (LARS) in obese patients have been examined, including recurrence of reflux symptoms, recurrent hernia, and need for reoperation. Studies have suggested that outcomes are worse in such patients, [25–27] and this is the prevailing expert opinion [28]. Some more recent studies suggest that although the surgery may be more difficult (i.e., extra port sites required, longer operative time), medium-term outcomes are similar when compared to normal-weight patients [29]. Many studies are limited by their exclusion of morbidly obese patients (BMI >35) or mean BMI <35. Indeed, a few of these groups reported that patients with BMI >35 were referred for weight-reduction surgery instead of proceeding to LARS [27, 30].

So what is the best treatment for the obese patient with a hiatal hernia? How do we select procedures appropriately? LARS may give acceptable outcomes for obese patients with BMI 30–34. In morbidly obese patients, a better option is weight-reducing surgery, specifically laparoscopic Roux-en-Y gastric bypass (LRYGB). Bariatric surgery will reduce intra-abdominal pressures contributing to GERD and symptomatic hiatal hernia. More importantly, it treats the life-threatening condition of morbid obesity and its associated comorbidities. Weight-reduction surgery is not without additional risks, but it is a better option for patients with BMI greater than or equal to 35. Guidelines for the treatment of GERD in the obese patient recommend consideration of bariatric surgery, specifically gastric bypass surgery, although no guidelines are offered specifically addressing hiatal hernia [31].

The main bariatric procedures currently favored in the United States are LRYGB and laparoscopic sleeve gastrectomy (LSG). LRYGB has been described as an optimal surgery to reduce GERD through weight reduction, limiting the size of the gastric reservoir, eliminating bile reflux, and nearly eliminating all acid-producing cells from the gastric pouch. LRYGB has been combined with hiatal hernia repair with good relief of GERD symptoms and weight loss without an increase in postoperative morbidity or mortality [32–34].

The treatment of hiatal hernia with laparoscopic gastric banding (LGB) or sleeve gastrectomy is a more controversial subject. When there are no contraindications to gastric bypass, obese patients with preoperatively diagnosed hiatal hernia or severe reflux should be treated with LRYGB over LSG or LGB. The effects of LGB and especially LSG on reflux are active areas of investigation. The mechanics of the postoperative gastric anatomy with these procedures are not favorable for reflux. Some surgeons have gone so far as to say that performing LSG in a patient with Barrett's esophagus should be considered negligence. Intractable reflux has been a common indication for band removal [35]. Some studies suggest that laparoscopic gastric band (LGB) can reduce symptoms of GERD as long as hiatal hernia is repaired during the initial procedure, but there continues to be conflicting evidence on this [35–37]. With regard to sleeve gastrectomy, Mahawar et al. performed a large systematic review, which demonstrates the safety of sleeve gastrectomy with hiatal hernia repair. They reported symptomatic postoperative GERD in 12.6% of patients. Their group still recommends LRYGB preferentially, however, for eligible patients in this population [38]. Another recent study showed a change in operative plan to LRYGB for 30% of bariatric patients undergoing thorough esophageal workup [39].

Ultimately, there have been no controlled or randomized studies comparing each type of weight-loss surgery combined with hiatal hernia repair, and each operation comes with its own risks and benefits. The decision for the best type of surgery in the obese patient with a hiatal hernia should be performed after a careful risk-benefit analysis with the patient, with preference given to LRYGB.

In the case of patients where hiatal hernia is incidentally identified at the time of bariatric surgery, with the priority in treatment being weight reduction rather than symptomatic hiatal hernia, the evidence points toward the standard of care being operative repair at the time of surgery [28]. The International Sleeve Gastrectomy Expert Panel Consensus Statement recommends aggressive identification of hiatal hernia at the time of surgery, along with repair if a hiatal hernia is found [40].

In summary, hiatal hernia in the obese patient is a challenging and increasingly common problem. We believe that appropriate procedure choice is the crux of caring for these patients. While this is an active area of investigation, LRYGB should be considered the gold standard for patients with hiatal hernia and GERD with BMI greater than or equal to 35. Obese patients with BMI 30–34 can achieve good outcomes with LARS.

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Comparisons of Methods at Hiatal Hernia Repair

Sumeet K. Mittal

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In this chapter we will review various controversies in regard to technical aspects of hiatus hernia repair. While the debate is in no matter totally settled, we have attempted to present a succinct review of literature followed by a brief commentary to reflect our opinion.

43.1 Open Versus Laparoscopic Hiatus Hernia Repair

Hiatus repair with reduction of viscera at the time of fundoplication is accepted as standard practice. Elective repair is indicated for symptomatic type 1 and almost all type 2, 3, and 4 hiatus hernia. Rudolf Nissen first described Nissen fundoplication as an open transthoracic procedure; however it can also be performed via laparotomy and remains the quintessential standard fundoplication. Other open transthoracic (Belsy repair) and transabdominal (Toupet) fundoplications have subsequently been described. Advent of laparoscopic cholecystectomy in the late 1980s laid way for induction of laparoscopic hiatal surgery. Laparoscopic fundoplication was first described by Delmangae in Belgium and soon gained popularity worldwide. Initial technical hurdles such as optics, short gastric division, suturing, and knot tying were sequentially overcome with technological advancements. This allowed for laparoscopic surgery even for large hiatus hernias. First laparoscopic paraesophageal hernia was described by Cuschieri et al. in 1992 [1]. Significant increase in volume of anti-reflux surgery was reported in the late 1990s.

The euphoria was soon subdued by poor surgical outcomes. Laparoscopic fundoplication and especially large hiatus hernia repair are technically challenging procedures and require advanced skills but have a steep learning curve. An unacceptably high recurrence rate (42%) reported by Hashemi et al. for laparoscopic paraesophageal hernia repair questioned its role and advocated persistence with open procedure [2].

A meta-analysis of 12 prospective trials found a risk reduction of 65% for complications in laparoscopic anti-reflux surgery as compared to open cases. Additional advantages stressed upon were shorter hospital stay (by 2.68 days) and time to return to activity (by 7.75 days) in laparoscopic surgeries with comparable rates of treatment failure when compared with open group [3]. Others have also stressed upon the advantage of shorter hospital stay and rapid recovery [4]. In one of the earliest studies published in 1998, comparing open vs laparoscopic approach for paraesophageal hernia repair, laparoscopic surgery patients showed significantly lesser requirement for ICU care and pain medication and had earlier start of oral intake and discharge [4]. However authors report significantly longer operative time with laparoscopic approach [3, 4]. Karmali et al. reported similar findings with longer operative time for laparoscopic repairs though associated with shorter hospital stay and fewer operative complications (22% vs 53%, $P < 0.01$) [5]. A large multicenter study of more than 2700 patients reported similar results along with significantly lower 30-day readmission rates and overall costs for laparoscopic surgery [6]. They reported a significantly lower in-hospital mortality even in obstructed/strangulated paraesophageal hernia cases for laparoscopic cases compared with open cases (1.5% vs 6%; $p < 0.01$). Several other authors have shown favorable short-term outcome following laparoscopic HH repair [4, 7–9].

Complication rates as high as 37% have been reported for laparoscopic repairs [10] in literature, but recent major trials report that with improved laparoscopy techniques and experience, overall complication rates have decreased to as low as 2.7–3.8% for laparoscopy compared to 8.4% in open cases [5, 6, 11]. Overall 30-day mortality for laparoscopic anti-reflux procedures, in a review of 7531 patients, was reported to be as low as 0.19% [11]. Thirty-day mortality for patients younger than 70 years of age was almost negligible (0.05%), while it was acceptably low for those above 70 years of age too (0.8%, $p < 0.0001$). Nguyen et al. compared the two groups after adjusting for severity of illness and still found laparoscopic repairs to have significantly lower hospital stay (3.1 vs 6.6 days) and requirement for ICU (10.4% vs 29.3%) as well as lower 30-day readmission rates (1.3% vs 3.1%) compared with open repair [6]. Despite these reports, the main focus against laparoscopic repair comes from the significantly higher recurrence rates in long-term follow-up and requirements for redo surgery of up to 80% [3]. Experienced surgeons have reported recurrence rates of 23–42% after laparoscopic surgeries [7, 12, 13].

The risk of failure (anatomic, symptomatic, or radiographic recurrence) of hiatus hernia repair is one of the major factors against laparoscopic approach. The steep learning curve could be considered one of the major reasons. The reported recurrence rates widely vary from 7% to as high as 44% after laparoscopic repairs [7, 12, 14, 15], while in comparative studies by same group of surgeons, open repairs are found to be associated with 9–23% recurrence rates [7, 12, 15]. A meta-analysis on recurrence after laparoscopic repair of paraesophageal hernia, published in 2007, compared 13 studies and reported an overall clinical recurrence rate of 14% in long-term follow-up for any type of laparoscopic procedure [16]. Recurrence, based on follow-up esophagograms, was reported to be 25.5%. While no laparoscopic study has come close to radiographic 4% recurrence rate reported by Maziak et al., several reports with less than 10% radiographic recurrence have been published [17].

Authors' opinion: Laparoscopic hiatus hernia surgery has come a long way since 1990s, thanks to improved skill set, training process, technical advances, and perioperative control of risk factors (i.e., retching). The symptomatic recurrence is significantly lower. While the purist may use radiological recurrence rate to argue against laparoscopy realist would counter with significant patient specific advantages of laparoscopic surgery and irrelevance of small asymptomatic recurrence. Indeed, the authors concur with recently published SAGES guidelines that laparoscopic hiatus hernia repair in experienced hands is as good as open procedure and is associated with lower perioperative morbidity. In our opinion laparoscopic repair should be the first choice for all hiatus hernia repairs when expertise is available.

43.2 Partial Versus Complete Fundoplication

DeMeester et al. popularized the short and floppy 360° Nissen fundoplication as the ideal fundoplication with good symptom relief without excessive dysphagia [18]. Side effects such as gas bloat and dysphagia have led some to recommend partial fundoplication (anterior or posterior) as alternate options.

There has been an ongoing debate on the comparison of partial posterior 270° (Toupet) fundoplication vs complete 360° Nissen fundoplication. While many authors support partial wrap in view of proposed fewer side effects like dysphagia [19, 20], there have been concerns regarding purported higher risks for recurrent disease [21–23]. While most trials have presented a short-term follow-up [21–24], two recent randomized controlled trials comparing laparoscopic Nissen 360° wrap with Toupet partial 270° wrap, authors found no significant difference in improvement of symptoms, recurrence, and patient satisfaction in a long-term follow-up [25, 26]. Higher postoperative wrap pressures in Nissen group did not translate into higher dysphagia. Fernando et al., in their study on 206 patients, reported similar early outcomes after partial vs complete wrap. They found significantly higher requirements for PPIs, worse longer satisfaction among patients, and higher dysphagia in partial wrap (Toupet) group as compared to complete wrap (Nissen) group [27].

In a more recent randomized controlled trial by Mardani et al. [28], studying 137 patients and a mean follow-up of 18 years, complete and partial wraps did not differ significantly in control of heartburn (80% vs 87%) and acid regurgitation (82% vs 90%), respectively. Both groups showed similar rates of long-term side effects including dysphagia scores, bloating, and flatulence. The higher rate of flatulence seen in the early postoperative period after complete fundoplication decreased over time.

Kamolz et al. studied the subjective and objective quality of life (QoL) between two groups. They found significant improvement in QoL of patients with GERD after either surgery and found no significant differences in QoL between Nissen and Toupet fundoplication groups. Only reported difference was frequency of mild transient dysphagia seen in Nissen group [29].

Some authors have proposed an anterior fundoplication wrap (90–80°) to replace the 360° wrap or 270° partial posterior wrap. Although they were proposed in view of reducing the post-procedure dysphagia, they have been found to be associated with a higher postoperative recurrence of reflux [30–35]. A recent meta-analysis comparing short- and long-term outcomes following a complete Nissen fundoplication vs anterior 180° fundoplication included five RCTs [36]. At short term (1 year post surgery), dysphagia scores, bloating, flatulence, and inability to belch were significantly lower for anterior wrap and continued to remain lower at long term (5 years post surgery). Heartburn, regurgitation, endoscopic dilatation, need for redo surgery, need of PPIs, and patient satisfaction did not differ significantly between the two groups at short and long term. However, a meta-analysis of seven RCTs, done by the same research group, comparing anterior vs posterior partial wraps favored posterior wraps with lesser esophageal reflux symptoms (8% vs 21%), esophageal acid exposure time (0.8% vs 3.3%), and reoperation (4% vs 8%) as compared with anterior wraps [35]. While the two groups did not differ significantly in short-term outcomes, long-term outcomes in posterior fundoplication group had significantly lower rates of persistent heartburn (14% vs 31%) and reoperation rates in long-term follow-up (5% vs 10%). There were no difference in dysphagia and gas bloating symptoms.

Recently, Svetanoff et al. reported no difference in use of medication, symptoms, and quality of life in a cohort of patients with and without fundoplication with intrathoracic stomach repair [37].

Author's opinion: Excellent patient centered outcome with both partial and total fundoplications have been reported by several centers. We rarely use anterior partial anti-reflux procedure except ones with myotomy. Posterior partial or complete fundoplication should be performed based on surgeon's preferences.

43.3 Mesh Versus Non-mesh Crus Closure

Recurrent hiatus hernia is the proverbial Achilles heel of benign foregut procedures. Recurrent hiatus hernia is noted on up to 40% of patients after PEH repair if routine contrast radiography is undertaken. However majority of these patients are asymptomatic. But recurrent hiatus hernia is noted in up to 70–80% of patients undergoing reoperative foregut surgery after previous anti-reflux procedures.

Given the success of mesh repairs for inguinal and ventral hernia, the use of mesh in hiatoplasty was pursued enthusiastically. Unfortunately, several complications including the need for esophagogastric resection were reported, and the role of mesh reinforcement is being closely relooked.

Ever since the use of prosthetic material for hiatal closure, first described by Kuster and Gilroy in 1993 [38], there have been controversies revolving around selective or liberal use, shape and material of the prosthetic meshes being used, as well as the technique of placement. Major worry by most authors in using a prosthetic reinforcement in hiatal closure is the risk of visceral adhesions, erosion, and mesh migration along with the wrap to intrathoracic cavity [39]. Granderath et al. reported that mesh hiatoplasty was associated with significantly lesser rates of postoperative wrap migration (0.6% vs 6.1%) compared with non-mesh reinforced cases, while early dysphagia was significantly higher with mesh group (35.3% vs 19.8%) [39]. However, there was no significant difference in dysphagia between two groups at 1-year follow-up and later.

Oelschlager et al. in their prospective randomized trial reported a radiologic recurrence rate of 9% at 6-month follow-up in the biological mesh group vs 24% in the non-mesh group [40]. However, with follow-up at 5 years, there was no difference in rate of recurrence [40]. What was surprising in the study was greater than 50% recurrence in both with mesh and without mesh groups, even though most recurrences were asymptomatic. Another RCT of 72 patients reported the use of PTFE mesh to be associated with higher costs and longer operative time but no difference in hospital stay or complications compared with posterior suture cruroplasty [41]. They reported all recurrences of hernia in the non-mesh group while none in mesh group. Though the authors favored the use of PTFE mesh, use of polypropylene mesh was discouraged in view of high propensity of polypropylene material to cause erosions and strictures around the esophagus (in both open and laparoscopic settings) [10, 42, 43] along with erosion of other viscera, mesh extrusion, and fistulization.

Among comparison of various mesh materials used for hiatal hernia repair, a survey conducted by SAGES reported that the highest rates of failure of surgical repair were seen with biomaterial, while composite meshes had the least rates of failures [44]. Most common mechanism of failure was a loose hiatoplasty or technical failure of mesh anchorage. Complications were reported higher with PTFE meshes compared with polypropylene and bioprosthetics.

Another survey conducted by SAGES in 2012 about the types of hiatal hernia repairs done by surgeons and use of mesh vs non-mesh repairs, 9% surgeons reported to use mesh in all cases [45]. Another 15% reported to use mesh in more than 50% of their cases. Among surgeons doing

>20 HH repairs per year, 23% used mesh in majority of their cases. However, 23% never used mesh reinforcement, while 29% used mesh in less than 10% of their cases. Among the surgeons using mesh, one third preferred nonabsorbable meshes over absorbable mesh.

However, there is significant paucity of comparative studies and randomized controlled trials to compare primary suture cruroplasty with absorbable and nonabsorbable mesh reinforcement for hiatal hernia repair.

According to the current SAGES guidelines, there is strong evidence that the use of mesh for reinforcement of large hiatal hernia repairs leads to decreased short-term recurrence rates [46]. However, there is inadequate long-term data on which to base a recommendation either for or against the use of mesh at the hiatus. Complications are reported with all types of meshes, and the common and most dreaded complications are mesh erosion, esophageal stenosis, pericardial tamponade, and effusion. SAGES guidelines recommend avoiding bridging synthetic meshes as they are found to have higher chances of mesh erosions [46].

Author's opinion: While recurrent hiatus hernia continues to vex the surgeons, most are asymptomatic. Routine mesh hiatoplasty is definitely not the answer. Complications associated with mesh closure are frequently associated with the need for esophagogastric resection. Mesh use should be very limited if at all and used only by surgeons with expertise in hiatus hernia surgery.

43.4 Anterior Versus Posterior Crurorraphy

The role of hiatoplasty (also called cruroplasty or crurorraphy) is indispensable as unacceptably high rates of recurrent paraesophageal hernias are seen in patients not undergoing closure of hiatus [47–49]. Posterior crurorraphy has been the cornerstone of crus closure from both thoracic and abdominal approach whether done laparoscopic or open. However, there is paucity of literature comparing the outcomes following anterior vs posterior cruroplasty (hiatoplasty) for hiatus hernia.

The posterior hiatoplasty is the most common approach by most surgeons and is considered standard for hiatal hernia surgeries with acceptable outcome and good clinical control of symptoms [18, 50, 51]. However, Watson et al. emphasized that a posterior wrap nonphysiologically displaces the esophagus too anteriorly and significantly contributes to dysphagia [52]. The same group published a double-blinded RCT in 2002 showing no need of redo surgical interventions in patients who underwent anterior cruroplasty compared with almost 10% posterior cruroplasty patients requiring second surgical procedure [53]. They reported no difference in postoperative dysphagia, relief of heartburn, overall satisfaction at 6-month follow-up, and likelihood of early postoperative paraesophageal herniation. They also reported hiatus being too tight a more common cause requiring reoperation than fundoplication problems (2% vs <1%). However, they attributed the difference in anterior and posterior cruroplasty to the possible type II error considering the earlier reports by the same group reported an incidence of reoperation being 1% in posterior cruroplasty group [54, 55]. The same research group published the long-term (5 years) follow-up on the previous RCT in 2008 [56]. Anterior hiatal group showed better control of symptoms, while the overall satisfaction and postoperative dysphagia were similar in two groups. Posterior hiatal repair group showed higher need for "dysphagia-related" redo surgical intervention than anterior hiatal repair group (14.5% vs 4.3%, $P = \text{NS}$). Difference was significant among two groups with respect to the need for redo intervention "for any cause" (4.3% vs 20%, $P = 0.011$). In yet another recent RCT with a long-term follow-up (10 years or more for 93% patients), anterior hiatal repair group reported significantly less dysphagia to lumpy solid foods (14% vs 39.5%, $P = 0.01$) as compared with posterior hiatal repair [57]. They did not report any significant differences in reflux symptoms, need for anti-reflux medications, and overall satisfaction to surgery in long term.

Thus, although there is a paucity of data for the comparison of these two groups, anterior cruroplasty seems more promising in reducing current rates of postoperative dysphagia as seen after posterior cruroplasty.

Author's opinion: While posterior cruroplasty is the standard repair option for hiatus repair, there is a concern to displace the esophagus anteriorly resulting in dysphagia. Additionally, the posterior crus closure can sometimes not be achieved without tearing of the crus. In these situations, anterior cruroplasty is needed. We have approached these situations by closing the crus more in an anterolateral direction rather than a true 12 o'clock anterior location. This results in the final crus closure to look like an inverted L with the esophageal opening at the angle.

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New Technologies in Hiatal Hernia Repair: Robotics, Single Port

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44.1 Introduction

Hiatus hernia (HH) involves herniation of contents of the abdominal cavity through the diaphragm into the mediastinum. The first description of hiatus hernias dates back to 1853 by a physician, Henry Ingersoll Bowditch [1]. Then in 1926, Ake Akerlund, a Swedish radiologist, coined the term hiatus hernia. He further classified HH into three types, which is still in use [2]. HH occurs due to enlargement of the diaphragmatic aperture, which then allows herniation of abdominal contents into the mediastinal cavity, most common organ being the stomach but may also contain other viscera like the colon or spleen. Until the 1950s the relationship of HH with gastroesophageal reflux disease (GERD) was not appreciated. While the type I or sliding HH are more commonly associated with GERD, the larger types II–IV or paraesophageal hernias (PEH) are associated with gastric volvulus, leading to mucosal ischemia, strangulation, and gastric obstruction.

The appreciation of the physiological link between HH, GERD, and other problems has changed the approach toward HH surgery from simple repair to restore the anatomy to restoring the physiology. Ever since Nissen and Belsey described their revolutionary techniques, several modifications and innovations have been published in literature. Essential principle for these modifications is physiological restoration.

Since the advent of laparoscopic cholecystectomy in 1980s, the philosophy to be less invasive has led to the exponential growth of minimal access surgery. Laparoscopic hiatal hernia repair is the standard for treating HH today. Compared to laparotomy, laparoscopic hiatal hernia repair offers all the well-established benefits of a minimally invasive surgery, such as reduced postoperative pain, faster recovery, shorter hospital stay, and decreased risk of wound infection which favor its continuing use. Combined together it allows early return to routine life and work. Smaller scars give better cosmesis and hence improve patient satisfaction [3–6].

Today, technological advances in both diagnosis and treatment have revolutionized surgical practice in hiatal hernia. With a view to further reduce the trauma of surgical access and perform more complex surgical tasks, researchers and surgeons have invested in concepts of reduced port laparoscopic surgery (RPLS), single incision laparoscopic surgery (SILS), natural orifice transluminal endoscopic surgery (NOTES), and robotic surgery. HH repair techniques also have attempted to incorporate these novel techniques into practice.

In this chapter, we focus on the role of SILS and robotics in hiatal hernia surgery, indications, instrumentation, surgical steps, and postoperative care.

44.2 Indications

The advent of minimal invasive surgery has led to an increase in the number of operations for hiatal hernia. This coupled with widespread availability of endoscopy, 24-h pH studies, manometry, impedance studies, and radiological studies have helped in diagnosing patients who may benefit from surgery. SAGES guidelines provide a good basis for investigating patients with reflux disease and hiatal hernia [7, 8]. Only those investigations that will help in clinical decision-making or alter the treatment plan can be performed.

Most surgeons consider single incision laparoscopic surgery (SILS) or robotic surgery to be more complex techniques requiring longer learning curve. But with increasing experience, many surgeons have today readily accepted these novel techniques.

The indications for SILS or robotic surgery for HH are similar to laparoscopic hiatal hernia repair.

As per the SAGES guidelines offer surgery to:

1. Type I hiatal hernia with GERD.
2. All symptomatic PEH.
3. Elective repair of completely asymptomatic PEH routinely is not indicated. Decision-making is based on patient's age and comorbidities (strength of evidence weak as per guidelines).
4. Acute gastric volvulus.
5. Asymptomatic PEH with anemia.

In fact on careful history taking, most patients will elicit some symptoms of reflux disease or obstruction. About 14% of asymptomatic PEH patients every year will develop symptoms [9, 10], and less than 2% patients per year will need emergency surgery due to acute symptoms [10–14].

Patients unfit for general anesthesia and intractable coagulopathy are contraindications for any laparoscopic surgery. Robotic surgery may give an advantage in large hiatal hernia and patients with high BMI. Large paraesophageal hernia (types II–IV), long history with esophageal shortening, BMI >30 kg/m^2, and acute presentation are presently not strict exclusion criteria for SILS or robotics but should be done by an experienced surgeon.

A beginner should preferably operate on the following patients:

- Patients undergoing elective hiatal hernia repair
- Patients with type I HH
- Patients with BMI < 30 kg/m^2
- Patients fit for general anesthesia
- Patients who can safely withstand longer operative times

A beginner should preferably not perform SILS on the following patients:

- Patients with acute presentation (HH with bleeding, gastric volvulus, features of strangulation, types II–IV, esophageal shortening)
- Patients with previous upper abdominal surgery
- Patients who are obese (BMI > 30 kg/m^2)
- Patients who are unable to withstand longer operative times

With increasing expertise in SILS, most of these technical difficulties will be overcome.

More recently, development of robotic surgical system, a novel technology, is becoming popular among minimal invasive surgeons. The suggested advantages are three-dimensional vision, abolition of tremors, better motion scaling, and higher degrees of freedom due to intuitive movements. In the end result, it allows surgeon to perform complex maneuvers which are difficult to master in standard laparoscopy. However, actual benefits to patients due to use of this technology are still controversial. While its benefits are clear for complex procedures, its use is still not justified for routine simple surgery. The complexity observed particularly during large and complex varieties of PEH repair and in obese patients with PEH during laparoscopic repair can be considered an indication for use of this novel technology. It may also help a beginner to overcome some technical difficulties to perform complex tasks using a robot, which he may find difficult during standard laparoscopy or SILS.

44.3 Preoperative Preparation

Always counsel patient's so that they understand the exact nature of disease process and its treatment. Explain the patient in detail the various available modalities of treatment with their possible benefits and risks. Long-term results of surgery, recurrence, and failure rates should be explained.

Take a proper consent for SILS or robotic surgery. Counsel the patient about the possibility of conversion to standard laparoscopy/open surgery in case of technical difficulties, for patient's safety and well-being.

Apart from the routine workup and investigations, a coagulation profile must always be performed to rule out intractable coagulopathy, which is an absolute contraindication for laparoscopic surgery.

Preoperative shaving may be done based on individual surgeon preference but should always be performed on the operative table. In cases when the surgery is expected to be of a longer duration and during emergency, the bladder is catheterized. An antibiotic prophylaxis is always administered before anesthesia.

Always perform a team time-out between surgeon, operation nurse, and anesthesiologist before making the first incision. It is mandatory to reconfirm the patient's name, diagnosis, availability of instrumentation/devices, and the planned procedure.

44.3.1 SILS Hiatal Hernia Repair

Operation Theater Layout

The patient is placed in supine position on a split leg table. Both arms are tucked by the side and legs apart. Properly secure the patient to the table. The surgeon stands in between the patient's legs; the camera assistant stands on the patient's right with the monitor placed on left side of the patient's head (◘ Fig. 44.1). If two monitors are available, place one on either side of the head. An additional assistant may stand on the patient's left in selected cases. The scrub nurse stands on the left side. Give a steep reverse Trendelenburg position as this helps exposure of the hiatus.

Instrumentation

Irrespective of approach used, the surgeon should be able to perform the procedure safely. The key factor when using any device or instrument is its

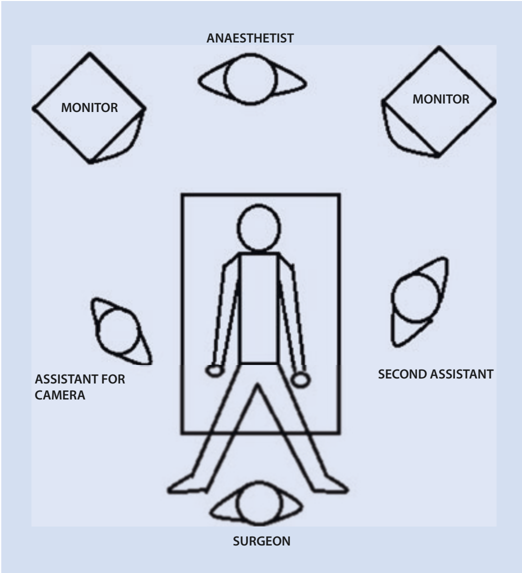

Fig. 44.1 Operation theater layout SILS

safety in patients. Instrumentation in single-port surgery should give the surgeon similar degrees of freedom as in standard multiport laparoscopic surgery. In the last decade, due to research in instrument technology, variety of articulating instruments (pre-bent, reticulating, or articulated/wristed) (Fig. 44.2) and devices have been developed. The devices range from conventional laparoscopic instruments to more sophisticated ones to simple self-made devices, which give access to more instruments inside confined space. Other important factors are simplicity of the device, cost, easy availability, and reusability.

A variety of single-port access devices are available in practice. These vary from simple self-made devices to complex devices with multiple access ports. These include SILS port (Covidien, USA), GelPort (Applied Medical, USA), X-Cone (KARL STORZ, Germany), Uni-X (Pnavel Systems Inc., USA), TriPort (Advanced Surgical Concepts,

Fig. 44.2 Instruments SILS

Fig. 44.3 Multiple channel port devices

Ireland), OCTO port (Dalim, Korea), and the SPIDER Surgical System (TransEnterix, USA) (Fig. 44.3).

The camera system can be 10 or 5 mm depending on the requirement and based on the ports available in the device. Due to absence of triangularization, movements in SILS are often restricted as compared to standard laparoscopy. Train your nondominant hand to perform different maneuvers. Technical modifications such as intentional crossing of instruments (cross-hand technique) and use of reticulating or pre-bent instruments are some of the tricks. When conventional instruments are used, disparity in length of instruments and the camera, use of low-profile trocars and a coaxial light cable are advisable to avoid crowding of instruments.

There are three techniques of abdominal access reported for any SILS.

Single Incision Multiple Fascial Puncture Method

After infiltration of local anesthetic, make a 2 cm vertical transumbilical incision. Dissect to identify the fascia and circumferentially clear the subcutaneous fat for about 2–3 cm. Then a Veress needle is used to achieve pneumoperitoneum through the caudal corner of the cleared fascia. A pneumoperitoneum of 12–14 mm of Hg is maintained. The first port (10 mm or 5 mm) is placed at the caudal corner of the cleared fascia by closed access or an optical viewing trocar. Alternatively, an open entry may be used for the same, but then take a purse-string suture around the trocar. Conduct a preliminary survey of the peritoneal cavity and rule out any access-related injuries. Then insert two low-profile 5 mm trocars (at least 5 mm outside the purse-string suture when used) through the fascia in such a way that these three fascial incisions form a triangle. Ideally, use threaded trocars of different length and low profile to avoid instrument clashing.

Homemade Glove Port Method

After infiltration of local anesthetic, make a 2 cm vertical transumbilical incision. As in open technique, dissect and open the fascia to enter the peritoneal cavity. Fascial incision should be about 2 cm. To prepare the glove port, use an Alexis wound retractor (Applied Medical) and a powder-free surgical glove (size depends upon surgeon preference). The distal ring of the wound retractor is introduced intra-abdominally, and the proximal ring is attached to the wrist portion of the glove. The fingers of the glove are used as multiple ports for the instruments and scope. Use three low-profile 5 mm ports.

Multichannel Port Method

After infiltration of local anesthetic, make a 2 cm vertical transumbilical incision. Dissect down and make a fascial incision of about 2 cm to enter the peritoneal cavity. A variety of multiple channel ports are available which are used based on individual surgeon preference.

Discussion SILS In 1997, Navarra reported the first case of single incision laparoscopic surgery for cholecystectomy [15]. Since then multiple approaches and procedures for various abdominal diseases have been described in literature. The surgical community was initially reluctant to accept the concept of SILS due to technical difficulties and failure to achieve traingularization of instruments which was the basic principle of laparoscopic surgery. But with increasing expertise and development of new access devices and bended instruments (pre-bent, reticulating, or articulated/wristed), more surgeons started accepting SILS. Today we have come a long way ahead. Single incision laparoscopic surgery has been utilized to perform almost each and every abdominal disease, and hiatal hernia is no exception. Though SILS HH repair finds mention in isolated case reports, it offers promise. In 2011, Barbaros U et al. reported use of SILS by performing a floppy Nissen fundoplication for repair of hiatal hernia. They could safely perform the operation offering all the advantages of standard laparoscopy with a cosmetically better scar. They reported maximum difficulty while retracting the left lobe of the liver during hiatal dissection [16]. Fan Y et al. described their series of seven cases (three achalasia cardia and four hiatal hernia) who were offered SILS using conventional laparoscopic instruments. They also used a novel technique of using cyanoacrylate glue to retract the liver by binding the left lobe of the liver to the diaphragm [17]. They concluded that SILS is a safe and efficacious procedure for achalasia cardia and hiatal hernia with excellent cosmesis. Since then we find mention of isolated case reports and few retrospective series on application of SILS for surgeries on the esophageal hiatus. Barry L et al. in their retrospective study of 66 patients showed laparo-endoscopic single-site surgery to offer similar symptom relief and patient satisfaction rates as compared to conventional laparoscopic approach, albeit longer operative times [18]. In their series of 100 patients of achalasia cardia, Ross et al. offered laparo-endoscopic single-site (LESS) Heller myotomy with anterior fundoplication. They suggested that use of SILS in achalasia cardia provides safe, efficacious, and cosmetically superior outcomes relative to conventional laparoscopy [19]. They also concluded that for surgeons well trained in standard laparoscopy, the learning curve in LESS Heller myotomy with fundoplication is reasonably short and safe and quickly attained. Today SILS has been demonstrated to be a safe and efficacious approach for a variety of surgeries on the upper gastrointestinal tract ranging from gastric resections to bariatric surgeries [20–25]. Hence, it would be reasonable to conclude that single incision laparoscopy hiatal hernia repair is a feasible, safe, and reproducible technique.

44.4 Technical Difficulties

- Getting used to in-line vision
  - Reduced depth perception as compared to standard laparoscopy
- Clashing of instruments
  - More with use of 10 mm telescope
  - Due to clashing instruments can "jump" suddenly with potential risk for inadvertent injury particularly during use of energy source
- Stapler technique (only if need to perform Collis gastroplasty)
  - Requires bigger incision
  - Increases clashing of instruments

44.5 Tips and Tricks

- Instrumentation
  - Use of special instruments (reticulating/pre-bent/articulated/wristed instruments)
  - Use of coaxial light cable
  - Cross instrument (cross-hand technique)
  - To avoid clashing use instruments and telescope of different length

44.5.1 Robotic Hiatus Hernia Repair

Operation Theater Layout

The patient is placed in supine position. Both arms are tucked by the side. Properly secure the patient to the table. The robotic cart is docked at the head end of patient (Fig. 44.4). One monitor is placed to the left side of patient for the assistant, who seats on a chair on the right side of the patient. The anesthetist stands at the right side of the patient's head. A 12 mm camera port is inserted 2 cm to the left of the umbilicus and two 8 mm ports in the left and right midclavicular line for robotic arms in such a way that both ports are at least 7–8 cm away from the camera port. An additional 5 mm port is inserted in the right hypochondrium – this is used by assistant to insert a snake endoretractor for liver retraction. An additional 8 mm port can be inserted for the third robotic arm in anterior axillary line based upon the difficulty of case for retraction. Again

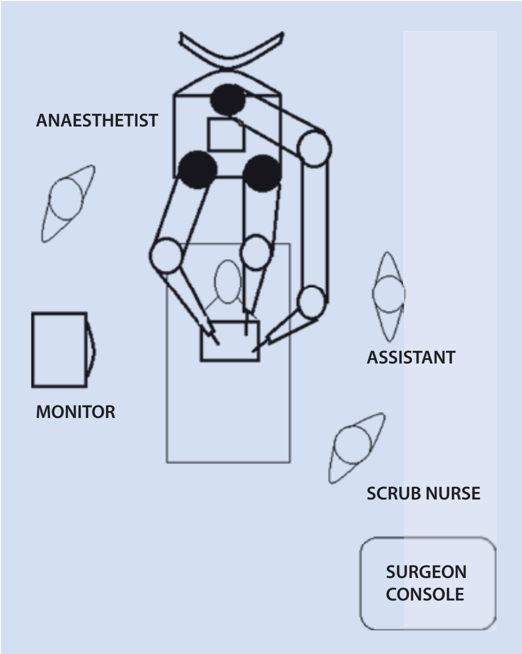

Fig. 44.4 Operation theater layout robotic

take care to be at least 8 cm away from the port in the left midclavicular line. Give a steep reverse Trendelenburg position as this helps exposure of the hiatus.

Instrumentation

Robotic 8 mm endowristed bowel grasper and fenestrated bipolar are used. Some surgeons may use Harmonic Ace Curved Shears [Ethicon, USA]. Robotic needle driver is needed for suturing. Apart from this snake endoretractor and standard laparoscopic 5 mm bowel graspers for assistant use are kept.

Discussion Robotic Laparoscopy today is the preferred approach for repair of hiatus hernia, but many patients of HH are still offered open repair particularly for large PEH, complex cases, and esophageal shortening and for performing Collis gastroplasty, as laparoscopy may be technically difficult in these cases. The use of surgical robot for such cases may be beneficial. Today robotic technology is used for a variety of complex procedures in the abdominal and thoracic cavity. Robot allows a surgeon to perform complex maneuvers in limited space with 3D vision. Major limiting factor for use of robotic system is its cost and availability. Though robotic HH repair finds mention in isolated case reports and few retrospective series, it offers promise. Retrospective studies by Braumann et al. [26], Draaisma et al. [27], and Seetharamaiah et al. [28] have shown robotic repair of hiatal hernia to be safe and efficacious. Gehrig et al. [29] in his series compared robotic PEH repair with laparoscopic and open approach. They found that robotic approach was superior to the open repair but had similar results to laparoscopic repair. They reported no recurrence in robotic group after mean follow-up for more than 15 months and hence suggested that robotic repair may reduce the risk of recurrence. Large randomized trials are needed before any definite conclusions can be derived.

44.5.2 Technique of Hiatal Hernia Repair

Liver Retraction

Various techniques are available. In SILS for simple cases, distal curvature of curved instruments is used to retract the left lobe of the liver. Alternatively make a small stab incision on the skin, and a 2–3 mm grasping forceps are inserted percutaneously just below the xiphoid process. This grasper is used to retract the left lobe. Percutaneously inserted sutures can be used to do the same. While in robotic approach, a snake endoretractor is inserted through the right hypochondrium for retracting liver by the assistant.

Once adequate exposure is achieved, start by making a window in the hepatogastric ligament close to the caudate lobe to identify and free the right crus.

Excision of the Hernial Sac

It is important to achieve complete reduction of the hernial sac when present and to assess for esophageal shortening. Reduce the sac completely and incise the left phrenogastric ligament to expose the left crus. To achieve a successful repair, complete sac reduction and mobilization of hernia contents and circumferential dissection of the distal esophagus are necessary. Dissect the sac from the hiatus and mediastinal structures. Evert and excise the hernial sac completely as this removes tension (sac tends to exert upward traction) on the esophagus and stomach and improves visualization of hiatus and gastroesophageal junction (GEJ). Also when left in situ, it may interfere in crural approximation.

■■ Mobilization of Distal Esophagus

Circumferential dissection of the distal esophagus is important. Once distal esophagus is freed, use a cotton tape or Penrose drain to encircle the lower end. This helps to dissect posterior to the esophagus. Clear the distal esophagus high up in the mediastinum, taking care to preserve the vagus nerve. It is necessary to have at least 3 cm of intra-abdominal esophagus. Failure to adequately mobilize distal esophagus may result in a short esophagus, which is most common cause for recurrence. The exact incidence of short esophagus is unknown. In literature review, the incidence of esophageal shortening varies from the 60% as reported by Pearson and Todd [30] to almost 0% in many studies [31, 32]. Thought to be commonly associated with reflux disease, a study by Swanstrom et al. found the incidence to be 20% in patients with a PEH [33]. Johnson et al. also found similar incidence in their study [34]. A combination of factors in HH such as chronic position of the stomach within the mediastinum, adhesions with the sac, long-standing reflux, and stricture formation may lead to shortening of the esophagus. Hence, it is important that surgeons perform adequate mobilization of the distal esophagus. Keep a high index of suspicion in large PEH (5 cm or more), type III PEH, "upside-down stomach" on radiology, long history of reflux symptoms, Barrett's changes, or esophageal stricture on endoscopy. When found mobilize the esophagus up to the level of the carina. In selected cases, surgeon may divide one or both the vagus nerve, as this can help in lengthening of the esophagus, keeping in mind the theoretical risk of delayed gastric emptying. If all fails, Collis gastroplasty can be done but is seldom needed if adequate esophageal mobilization, complete sac excision, and division of vagus are performed.

■■ Reapproximation of Hiatus

Closure of hiatus is one of the most important steps in hiatal hernia surgery. Primary crural approximation is always under tension due to dynamic nature of the diaphragm and crura. In long-standing cases and large PEH, the crural muscles are stretched widely and attenuated, leading to a wide gap. As a result, a high failure rate is seen with primary suture closure. Multiple techniques such as use of pledgets to reduce cutting effect of suture on crura release incisions over the right crus and use of prosthetic mesh has been advocated, though exact benefit is still debatable. The author uses a figure-of-eight stitch with 2–0 Ethibond Excel Suture (Ethicon, USA) to close the crural defect, preferentially posterior to the esophagus. Placing the sutures posteriorly places the esophagus anteriorly, increasing the intra-abdominal length. Sutures anterior to esophagus are needed rarely in large PEH to avoid excessive angulation.

■■ Fundoplication

Always add an anti-reflux procedure in a hiatal hernia repair. Most studies in literature show a high incidence of reflux disease in patients with hiatal hernia. Secondly, the process of mobilization of the esophagus and reduction of sac from the mediastinum causes disruption of normal anatomy of lower esophageal sphincter, predisposing the patient to postoperative reflux. Divide the gastrosplenic ligament and stop dissection after dividing the first short gastric vessel. Additional dissection of short gastric vessels may be done if needed to achieve further mobilization of stomach. After performing the standard "shoe-shine" maneuver, author routinely performs a floppy Nissen fundoplication with three sutures in order to anchor and maintain the stomach below the diaphragm. Again Ethibond Excel 2–0 Suture (Ethicon, USA) is used. The superior and inferior sutures are gastro-gastric, whereas while taking the middle suture, a bite of the esophageal musculature is also taken. In cases where esophageal motility is impaired based on preoperative evaluation, we perform Toupet or Dor fundoplication in order to avoid postoperative dysphagia in these patients.

■■ Mesh

Use of mesh for hiatal hernia repair is still a debatable topic. Multiple varieties of mesh both synthetic and biological have been used to prevent recurrence. But use of mesh at hiatus itself is associated with risk of dysphagia, stricture, ulceration, and mesh erosion into the esophagus and stomach. As a result, the author advocates use of mesh only if we are unable to approximate the crura or the closure is under severe tension. Author prefers use of synthetic mesh made up of polypropylene (composite). Two randomized trials done by Oelschlager et al. showed that although use of mesh reinforced over the crural closure prevented early recurrence, long-term follow-up of these patients showed recurrence rates similar to patients with primary suture repair [35, 36]. Similar results were also reported by Frantzides et al. [37] The SAGES guidelines on hiatal hernia suggest that mesh reduces early recurrence, but there is inadequate long-term data to conclude efficacy of use of mesh at the hiatus [8].

Redo anti-reflux surgery in GERD and hiatal hernia is known for higher morbidity and mortality. Tolboom et al. [38] have recently published their experience in the evaluation of conventional laparoscopic versus robot-assisted laparoscopic redo hiatal hernia and anti-reflux surgery. In their single-institution cohort of 75 patients, the main indications for redo surgery were dysphagia, pyrosis, or combination of both with a proven anatomic abnormality. 45 patients underwent robotic-assisted surgery while 30 underwent conventional laparoscopic surgery. Their observational study showed technical feasibility for minimal-invasive robot-assisted redo surgery after open primary anti-reflux surgery with a reduced number of conversions and a shorter hospital stay.

44.6 Conclusion

Surgeries at the gastroesophageal junction are challenging. A detailed workup, proper diagnosis, and use of appropriate surgery are paramount for optimal results. Today minimal invasive approach is considered the standard of care for repair of hiatal hernia repair. Though in literature only isolated case reports and retrospective series are found for the application of SILS and robotics in hiatal hernia repair, it may be reasonably safe to conclude that novel techniques of SILS and robotics offer the promise of reduced postoperative pain, faster recovery, and better cosmesis. Proper case selection during learning curve is paramount. Both SILS and robotics can be safely offered to patients with hiatal hernia particularly in experienced hands. The less invasive nature of these operations, with continuous advancing technology and surgical skills, holds promise for the future. Further randomized controlled trials are needed to conclusively determine the benefits of single incision or robotics over convention laparoscopic hiatal hernia repair and guide future surgical strategies.

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Education and Learning in Hiatal Hernia Repair

Davide Lomanto and Hrishikesh P. Salgaonkar

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45.1 Introduction

Hiatal hernia (HH) commonly associated with gastroesophageal reflux disease (GERD) and its incidence is approximately 5 per 1000. About 95% of these are type I hernias of sliding variety that are not commonly associated with serious complications [1]. The remaining 5% can be classified as giant paraesophageal hernias (PEHs) type 3 and 4 and are associated with significant complications [2]. Our understanding of hiatal hernia has evolved over the years. Initially considered an anatomical pathology, our focus has now shifted toward the physiology of the esophagus. The appreciation of the physiological link between HH, GERD, and the related problems has caused a paradigm shift toward management of hiatal hernia. Now, we attempt to restore the physiologic function of the esophagus and lower esophageal sphincter and not just a simple repair aimed at restoring the anatomy of the lower esophageal sphincter (LES). Multiple techniques and there modifications are described in literature for repair of hiatal hernia. In the last two decades, hiatal hernia repair has undergone challenges in terms of newer approaches like tension-free repair, use of prosthetic mesh or new biomaterial, laparoscopic approach and lately NOTES, single-port laparoscopic surgery, or robotic surgery.

On literature review we find several studies which show that the morbidity in any procedure increases with surgery being performed by inexperienced surgeons, thus making the surgeon an important factor for any hernia repair to reproduce optimal results [3]. The same stands true for hiatal hernia repair [4, 5]. It has long been considered that the worth of a surgeon can be ascertained by the way he performs a hernia repair. Hiatal hernia repair is even more challenging than a ventral or an inguinal hernia. With advancements in diagnostic technology, the volume of hiatal hernia operations being performed has increased and so has patient expectation. Today there is a need to establish a well-structured hiatal hernia training program to increase surgical standards of patient care.

The surgical education today has undergone a paradigm shift from a traditional experience-based model to a structural program that requires documentation of proficiency and acceptable levels of surgical skill. An old Chinese proverb *I hear, I forget... I see, I remember...I do, I understand* emphasizes the importance of learning by doing.

The challenges for surgical training in hiatal hernia today are:

1. Acceptance of new techniques and technology (i.e., laparoscopy, single-incision laparoscopy, robotic surgery, use of mesh and biomaterial, etc.)
2. Retraining
3. Time taken for surgery
4. Costs involved – particularly with use of mesh, energy sources, etc.
5. Feasibility, efficacy, and efficiency of new technologies

The importance of hiatal hernia training was first described by Angelo Soresi [6] in 1919 in his teachings entitled "Diaphragmatic Hernia. Its Unsuspected Frequency: Its Diagnosis: Technique for Radical Cure." quoted *"to call the attention of interns and of surgeons to the frequency of diaphragmatic hernias especially small ones, because patients suffering from this condition are not properly treated.... This lack of interest is not easily explained, because diaphragmatic hernias give rise to so many complicated and serious symptoms, which if not properly attended to, will lead the patient to an unfortunate life and premature death."*In his technique, he advised reduction of the hernia followed by closure of hiatal opening. He advised utmost care while closing the hiatal opening taking care to avoid compression of the organs passing through the hiatus, possibly the first described surgical technique of hiatal hernia repair. His technique underwent various modifications over the next few decades. In 1951, Allison described the physiological link between hiatal hernia and reflux disease. He along with Barrett brought about a confluence of two streams of thought, the anatomic focusing on herniation and the physiologic focusing on acid reflux. Their teachings were critical to the development of modern hiatal hernia surgery. Advances in diagnostic modalities such as development of manometry and esophageal pH monitoring helped us in accurate diagnosis of reflux disease and also gave us a tool to evaluate the standard of surgery objectively.

Since the revolutionary teachings of Nissen and Belsey, several modifications and innovations have been published in the literature. The principle behind these modifications is restoration of physiology of esophagus and LES. The few landmarks in the history of hiatal hernia repair are:

1. Belsey description of the Mark IV operation in 1952
2. Nissen description of fundoplication in 1956
3. Esophageal lengthening gastroplasty by Collis in 1957
4. Fundoplication techniques of Dor and Toupet in 1962 and 1963, respectively
5. Laparoscopic Nissen fundoplication in 1991

Nissen fundoplication is considered the gold standard for surgical management of GERD. Hiatus hernia is considered to have various similarities to GERD when we compare the patient factors, epidemiology, symptoms, and anatomic and physiological correlations with reflux disease. Most of the times, its treatment is by a fundoplication technique. But hiatus hernia particularly the larger types II to IV is known to be associated with higher risk of development of gastric volvulus with life-threatening complications or severe symptoms, mandating an early surgical repair. Hence, most repair techniques for hiatal hernia are modifications to Nissen technique.

Laparoscopic anti-reflux surgery was first described by Dallemagne et al. [7] in 1991. The advent of laparoscopy allowed for development of instrumentation, refinement of techniques, shorter operative times, faster recovery, and reduced morbidity. There are problems with longer learning curve, but these have to be recognized and overcome. Laparoscopy today is considered the preferred choice for repair of hiatal hernia. In fact over the last three decades, on literature review, we find multiple studies both prospective and retrospective studies with longer follow-up periods confirming the safety and efficacy of laparoscopic approach using a variety of fundoplication techniques both by laparoscopic and combination with thoracoscopy for correction of hiatal hernia [8–10]. Few of the early studies on minimally invasive approaches for HH repair suggested an increased incidence of recurrence compared to traditional open surgery [9–11]. But modifications such as laparoscopic mesh crural reinforcement and esophageal lengthening technique of Collis gastroplasty in selected cases give us better functional results with reduced recurrence rate [12, 13]. The safety, efficacy of laparoscopy, and long-term results in giant hiatal hernia are also promising [14, 15].

Overall minimal invasive surgery for hiatal hernia repair is considered procedure of choice in most centers worldwide today. Reduced pain, better cosmesis, reduced wound and pulmonary complications, shorter hospital stay, early return of bowel movements, and better effectiveness combined with significantly lower morbidity and mortality are reasons enough to consider it the standard of care today [16, 17].

Minimal invasive techniques for hiatal hernia repair involve laparoscopy, thoracoscopy, reduced port or single-incision laparoscopic techniques, and the use of surgical robot. Though difficult to learn, as compared to open repair, it provides patient all the benefits of minimal invasive surgery [16, 17]. The challenges to laparoscopic/minimal invasive hiatal hernia repair are those that are common to any laparoscopic technique like cost, technology, steep learning curve, and new instruments. In addition, specific problems like different view of anatomy, technical difficulties (in giant or recurrent hernia due to distorted anatomy like adhesions, scar, etc.), narrow space, proximity of vital structures and need for assistants particularly for good optical vision. Since laparoscopic/thoracoscopic surgery requires a high degree of special resolution, dexterity, technical skills, and need to learn the use of new technologies, an initial training period is often required for most surgeons to become proficient and skilled in hiatal hernia repair by repetition of tasks continuously.

Surgical procedures have been shown to have better outcome when performed by high-volume specialist centers, even for teaching purpose.

45.2 Training Center

A training center is required for:

- Training of young surgeons
- To provide state-of-the-art upper gastrointestinal surgery unit for performing and teaching simple as well as complex hiatal hernia surgery (giant paraesophageal hernia/recurrent hiatal hernia/emergency surgeries). Expertise in GERD surgery
- To coordinate patient treatments
- To coordinate studies, protocols, research, and development activities
- To provide trainees with a dedicated library and auditorium for learning
- To access hospital database and auditing

- To promote collaboration with centers around the world
- To establish partnerships with companies to coordinate preclinical studies, to develop new products, etc.

Moreover the training center should have a well-structured program consisting of:

1. Teaching faculty
2. Interactive classroom teaching
3. Practice at surgical technique
4. Animal and cadaveric laboratory for training
5. Proctorship/supervised surgery
6. Morbidity and mortality review
7. Monthly case report/research projects
8. Residents operative logbook
9. Learning curve
10. Attending national and international surgical conferences/workshops

45.2.1 Teaching Faculty

Any hospital-based training program should have teaching faculty, program director or primary tutor who is well trained, and thoroughly experienced surgeon with credentials in upper GI surgery from a recognized international surgical society. He/she should be on a full-time employment. He/she should be qualified and experienced in performing a variety of upper GI surgery, both open and laparoscopic. He/she should have sufficient knowledge and skills in thoracoscopy and endoscopy. He/she should be committed and passionate to training young surgeons. The program director should arrange for qualified faculty from different hospitals to visit the center to interact and teach, so that trainees get exposure to different surgeons.

45.2.2 Interactive Classroom Teaching

A designated room should be allocated for classroom teaching with facilities such as LED screen, projectors, etc. The teaching should focus on technical aspects like:

- Detailed anatomy of upper gastrointestinal tract (both open/laparoscopic/thoracoscopic/endoscopic)
- Clinical presentations of hiatal hernias
- Preoperative assessment and evaluation
- Informed consent customized to hiatal hernia repair
- Instruments and prosthesis requirements
- Knowledge of aseptic technique
- Complications and their management
- Postoperative follow-up and assessment

45.2.3 Practice at Surgical Technique (See also ▶ Chap. 30)

All patients expect themselves to be treated by a surgeon, who is experienced and trained in latest advancements. Trainees should read about the different surgical techniques, with themes including how to do, what to do, and what not to do in hiatal hernia and upper GI surgery before any practice session. Practical sessions should be encouraged on live tissues and/or virtual reality simulators. All sessions should provide the trainees learning in a structured environment using inanimate strategies and modalities. The aim is to mimic learning in a patient without compromising patient safety. Making use of autonomous teaching and assessing workstations, the efficiency of educational will increase. We can train more trainees in a shorter time see ▶ Chap. 30.

In author's own experience at his training center, participants needed about 30% less time to complete the predetermined and selected tasks after sessions of hands-on training [18].

45.2.4 Animal and Cadaveric Laboratory for Training

There is lack of sufficient data to conclusively prove the effectiveness of animal and cadaveric training workshops particularly on how these workshops improve the surgical skill and performance of trainees during subsequent live surgery. However, most trainees and assessors hold these training methods in high regard. The general feeling is that they help to improve the trainee's operative skills [19, 20]. The author believes that animal/cadaveric workshops are useful adjuncts in training and teaching operative skills to young surgeons. By developing facilities that enable the use of animal/cadavers for surgical training, it is not difficult to design studies to confirm the proposed benefit to trainees and whether they can transfer these skills to the operating theater.

45.2.5 Proctorship/Supervised Surgery

Trainees should be allowed to operate on actual patients only after they have demonstrated adequate proficiency and skills. This should always be under direct supervision of consultant/expert surgical specialist. On literature review most trainees have demonstrated comparable results to consultants while operating under adequate supervision for a variety of procedures, e.g., colorectal surgery [21], upper gastrointestinal surgery [22], and pancreatic surgery [23]. There is lack of data describing the learning curve for hiatal hernia repair. But literature review of learning curve for anti-reflux surgeries shows small but statistically significant impact on early patient outcomes when surgery was undertaken by trainees. Longer operative times, higher conversion rate and increased hospital stay, higher reoperative rates, post-op dysphagia needing endoscopic dilatation, and lower satisfaction rate were seen in patients operated by trainees, and these results improve with experience [4, 5]. Some of these outcomes are seen even when supervised by experienced surgeons [5]. So without observation, these outcomes are bound to further deteriorate. Although individual learning curves may vary, the author believes that teacher/proctor is the most important factor which influences the trainee's performance score [24].

The trainee needs to start with simple cases like type I/type II hiatal hernia repair first, gradually progressing to the difficult ones like type III/IV, recurrent cases, emergency cases, etc. The same protocol needs to be followed when performing endoscopy in patients with hiatal hernia. Preoperative and postoperative care is best learnt by regularly accompanying the attending surgeon during bedside rounds on patients in the surgical wards.

45.2.6 Morbidity and Mortality Review

Personalized learning programs like discussion in morbidity and mortality meetings help the trainee assess and evaluate from his mistakes. The trainee should take the inputs from seniors in a constructive manner.

45.2.7 Monthly Case Reports, Research Projects, and Journal Clubs

At every stage of training, a trainee learns more quickly and completely if they discover things themselves. Though inputs from the teachers is necessary, monthly written case reports/research projects and journal clubs help the trainee to find solutions and answers to the problems they encounter during their training themselves. Give them projects like comparison of different types of repair techniques, different types of approaches and different fundoplication techniques, need of prosthetic materials for repair, need for esophageal lengthening, or recovery after laparoscopic versus open hiatal hernia repair. The program director should develop a library equipped with requisite textbooks and journals which the trainee can access whenever needed.

45.2.8 Resident's Operative Logbook

Residents/trainees should also be required to keep a log of all the hiatal hernia operations (both open and laparoscopic) they observe, assist, perform, or teach there juniors. Senior residents can update the program director to keep track of areas that junior needs more attention.

45.2.9 Learning Curve

The learning curve is defined as the number of operations required for the stabilization of operative times, postoperative outcomes, and complications [25]. A study done by Soot et al. to assess the transition from open to laparoscopic fundoplication found that both experienced surgeons and trainees show improvements in operative time, conversion rate, and intraoperative complications with experience, and these improvements continue to occur even after 100 cases. He suggested that most residents can become comfortable with this procedure after about 10–15 procedures performed under supervision [26].

It is difficult to generalize any number, as trainees/residents learn at different speeds. We need to realize that outcome improves with experience.

Table 45.1 Learning curve in laparoscopic hiatal hernia

Study	Learning curve for lap hiatal hernia repair
Okrainec et al. 2011 [28]	20 cases
Neo et al. 2011 [4]	40 cases
Paul et al. 2016 [29]	25–46 cases

Different studies report different number of cases required for a surgeon to reproduce consistent outcomes after open or laparoscopic hiatal hernia repair [4, 27–30] (Table 45.1).

45.2.10 Attending National and International Surgical Conferences/Workshops

Trainees should attend national, regional, and international conferences. It enables them to network with other surgeons, receive valuable inputs, gain experience in critiquing papers, present their own papers, and learn from others. It also legitimizes well-conceived and well-organized hiatal hernia and upper GI training programs and allows other surgeons to take measure of surgeons in training.

45.3 Conclusion

The last two decades have seen hiatal hernia surgery made a great leap forward. Today laparoscopic repair of hiatal hernia is considered the standard of care. Advent of new techniques like SILS, reduced port surgery, and robotic surgery throw new challenges every day. In this era of rapid development of technology in medical care, the role of training and retraining (both open and laparoscopic) will become even more important. Laparoscopic hiatal hernia repair has lower incidence of wound infection and pulmonary and cardiac complications, early recovery after surgery, faster return to normal activities, and reduced 30-day mortality than open repair [5, 30, 31]. Also due to paucity of published data indicating improved long-term outcomes after open transabdominal or transthoracic approach, laparoscopic hiatal hernia repair should be used to treat hiatal hernia whenever technically feasible. Today more surgeons are using mesh to augment the crural repair, but continued efforts and refinement of surgical techniques are needed to reduce the long-term recurrence rates. Moreover as laparoscopic hiatal hernia repair is associated with a steep learning curve, we need to establish well-structured upper GI training centers for trainees to minimize the complication rates and to meet patient's increasing expectations:

- Surgical workshops (open, laparoscopic, and robotic) are useful, effective, and indispensable tools for continued surgical education.
- These should be adequately structured.
- Virtual reality simulator is an objective means for evaluating surgical trainees and may help to eliminate potential of actual patient morbidities.
- New technology (OT suite, tele-mentoring, proctoring) is helpful in improving the outcome.
- Continuous practice is crucial to overcome the initial difficulties and steepness of learning curve.

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Anesthesiologic Aspects of Laparoscopic Hernia Repair

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46.1 Anesthesia for Laparoscopic Inguinal Hernia Repair (LIHR)

Laparoscopic inguinal hernia repair (LIHR) has become a well-established surgical procedure. Minimal surgical trauma, reduced postoperative morbidity and shorter hospital stay have made this method an integral part of the general surgical service range in daily surgical routine. By virtue of lower tissue trauma, pain reduction, and associated lower postoperative stress it is considered an extremely attractive method, especially for high-risk patients.

However, the laparoscopic technique leads to specific pathophysiological changes and poses systemic risks and complications. Specific anesthetic risks arise mainly from changes in the cardiopulmonary system as a result of pneumoperitoneum (PP). Prevention and adequate response to respiratory and hemodynamic pathophysiological changes and a precise knowledge of the specific operational procedures are an indispensable prerequisite for both a gentle anesthetic procedure optimally tuned to the individual patient and for the creation of optimal working conditions for the surgeon. Putting the patient in the Trendelenburg position during LIHR adds to the effects of PP mutually influencing hemodynamics and respiratory mechanics.

46.1.1 Respiratory Changes During Laparoscopy

Creation of a surgical PP leads to specific changes of respiratory mechanics and lung function. Rise of intra-abdominal pressure (IAP) leads to an increase in respiratory peak pressure and plateau pressure up to 40% [25], while compliance decreases likewise. The amount of insufflated CO_2, however, does not correlate with the increase in respiratory peak pressure [26]. PP alone causes cephalad translocation of the diaphragm up to 3 cm [2]. General anesthesia and Trendelenburg position enhance this effect [28]. Development of atelectasis and diminishment of functional residual capacity are also promoted [8, 17, 26].

Despite the ventilatory mismatch caused by Trendelenburg position and increased IAP, only moderate changes of intrapulmonary shunt and arterial oxygenation (paO_2) occur. An eventual decrease in paO_2 and development of atelectasis can be countered by increasing the arterial oxygen content and ventilating with positive end-expiratory pressure (PEEP). In an animal model, pulmonary areas with low ventilation-perfusion coefficients (VA/Q) after establishment of PP could be transformed into areas with normal VA/Q, and oxygenation could be improved by ventilation with PEEP (15–20 cm H_2O) [15, 24, 41].

The insufflated CO_2 used to establish the PP is absorbed through the peritoneum, resulting in an increase in the CO_2 partial pressure in the blood. The amount of CO_2 absorbed through the peritoneum is dependent on the surgical procedure and the insufflated amount of CO_2 as well as the intra-abdominal pressure and the duration of surgery. The extent and time dependence of the CO_2 absorption from the peritoneal cavity are subject to intraindividual variability. According to Wurst et al., about 5 min after the application of PP, a continuous increase in CO_2 elimination occurs. The proportional rise in CO_2 could be subdivided into an "instable" period of 30 min after establishment of PP with a rapid increase in CO_2 absorption up to 30%, followed by a "stable" period in which CO_2 elimination rises only by 15% [43].

Increase in CO_2 absorption occurs not only after establishing PP but also after decreasing IAP [3]. IAP of 12–20 mmHg during laparoscopy leads to compression of the venous vascular bed of the peritoneum, thereby preventing further increase of CO_2 absorption. Desufflation of PP allows for higher capillary blood flow leading to better peritoneal absorption and alveolar elimination of CO_2 again [3, 43].

While CO_2 absorption reaches a plateau after correct intraperitoneal insufflation for 20–30 min, extraperitoneal insufflation of CO_2 will lead to a rate of CO_2 absorption of 50% or more. If significant hypercapnia exceeding the "normal" increase of CO_2 levels of up to 40% develops despite adequate modification of ventilation, or if 30 min after establishing PP no plateau has been reached, accidental extraperitoneal insufflation and/or production of cutaneous emphysema, a specific complication of laparoscopic procedures, should be considered [19, 30, 42].

46.1.2 Hemodynamic Changes

Hemodynamic changes during laparoscopy are the result of combined mechanical, autonomic, neural, and humoral effects of controlled mechanical ventilation [12, 26], the establishment of PP and positioning of the patient, as well as the reactions to the used anesthetics.

As it is, mechanical ventilation with PEEP leads to reduced cardiac output in the healthy adult caused by a reduction of left ventricular stroke volume at a constant heart rate [26].

Hemodynamic effects of PP depend essentially on the individual preexisting intravascular volume status and general hemodynamic baseline.

Primarily due to the elevated IAP following establishment of PP, an increase of venous return will lead to abdominothoracic shifting of venous blood. In healthy normovolemic individuals, this results in increased cardiac output. Extreme Trendelenburg position will boost this effect. On the other hand, in patients with latent or manifest congestive heart failure, this rapid increase of preload can lead to acute reight ventricular decompensation. Thus, in this group of patients, IAP should be kept as low as possible (10–14 mmHg), and extreme Trendelenburg positioning should be avoided. Within minutes after installation of PP, a decrease in venous return and thus cardiac output occurs due to the increasing compression of splanchnic vessels and an increase in systemic vascular resistance. Very high IAP (> 30 mmHg) finally leads to extravascular compression of the inferior vena cava with correspondingly massive restriction of venous return [41].

The hemodynamic effects of PP are characterized by a decrease in cardiac output, an increase in peripheral and pulmonary vascular resistance, and an increase in arterial blood pressure [23, 35, 41]. Contradicting information in the literature about changes of cardiac output [31] may result from differences in the study designs [14, 30]. Intrathoracic pressure increase per se leads to a change of the cardiac output measurement. Also cardiac output changes can simply be an expression of anesthetic effects.

However, the increase in systemic vascular resistance is not only based on mechanical factors. This is demonstrated by the fact that the increase persists even after desufflation of the peritoneal cavity. As a result of the surgical procedure and an increase in arterial CO_2 concentration, a sympathicoadrenergic reaction with increase of epinephrine, norepinephrine, and vasopressin serum levels [22, 27, 37] occurs, resulting in activation of the renin-angiotensin system.

As these mechanical, neural, and humoral mechanisms add up, the increase in systemic vascular resistance can be up to 40–50%. Increase in blood pressure and tachycardia may result. For patients with congestive heart failure, this results in an elevated risk of decompensation. Therefore, further stress-induced impairments must be prevented by an adequate level of anesthesia.

If, because of changes in respiratory function due to PP, ventilation is impaired and PEEP must be applied, the negative effect of PEEP on hemodynamics further reducing cardiac output must be taken into consideration.

46.2 Advantages of the Laparoscopic Approach

In numerous studies and meta-analyses, the advantages of minimally invasive surgery in comparison to conventional surgery have been demonstrated [8, 10, 20, 21, 33, 34].

Despite considerable intraoperative pathophysiological changes, the laparoscopic approach still confers significant advantages from anesthesiologic point of view. Concerning intraoperative stress reactions, no striking differences could be found between the two methods [8, 34]. Regarding postoperative pulmonary effects as well as pain quantity and quality, however, the laparoscopic procedure offers significant benefits. This less invasive surgical approach with minor pain-related limitation of respiratory mechanics results in significantly better postoperative pulmonary function with far less impact on vital capacity and functional residual capacity [8, 34]. Furthermore, the laparoscopic approach significantly reduces the need for postoperative opioids with correspondingly better postoperative outcomes and shorter hospital stays for patients. These remarkably positive differences could be confirmed in randomized trials and meta-analyses [10, 20, 33].

From an anesthesiologic point of view, the significantly better postoperative respiratory situation and decreased risk of pulmonary complications make the laparoscopic surgical procedure favorable for the elderly patient with impaired respiratory function. Moreover, the significantly reduced need for analgesics and the shorter hospitalization are great advantages. Extreme elderly patients in particular are already heavily affected mentally and physically by the change from their familiar surroundings to those of the hospital, as well as severe postoperative pain, the related need for heavy pain medication and a frequently long hospitalisation period [11]. These findings are confirmed by our own observations of very old and thus high-risk patients who underwent LIHR at our hospital where these benefits could be seen. Among 124 very old (85–97 years) and predominantly multimorbid patients, not one laparoscopic procedure had to be discontinued or changed to the conventional technique for of anesthesiologic reasons. No enhanced monitoring, nor elaborate care was necessary postoperatively. After 3–16 days, these patients were be discharged from the hospital. No serious postoperative complications were observed in any case [18].

Throughout the observation period of our study (April 1993–September 2003), over 6750 anesthesias for LIHR were performed at our institution. During this time no laparoscopic procedure had to be discontinued or changed to the conventional surgical approach due to anesthesiologic reasons.

46.3 Anesthesia Practice

Theoretically, epidural or spinal anesthesia is possible, for brief procedures (i.e., sterilization, diagnostic needs), as there seems to be an advantage to having an awake and quickly mobilized patient. The patient can compensate an elevated CO_2 by a reflectory increase in ventilation. To cover all nociceptive afferents from the peritoneum at the LIHR, regional block progression up to Th3–4 would be needed. Taking into account the pathophysiological changes brought about by the PP, the necessary positioning of the patient, and the duration of the intervention, regional anesthesia poses high demands on the tolerance and acceptance of the patient. A restless patient in Trendelenburg position with deep and accelerated spontaneous breathing as a consequence of elevated CO_2 is a disadvantage for the undisturbed continuation of a complex surgical procedure. Furthermore, sedating a patient in this setting can lead to severe hypoventilation, hypercapnia, and hypoxia [4].

Consequently, general anesthesia with endotracheal intubation and controlled mechanical ventilation is recommended for LIHR [9]. Endotracheal intubation considerably reduces the risk of aspiration caused by Trendelenburg position and increased IAP during pneumoperitoneum. Process-related hypercapnia and eventual hypoxia can be counteracted by optimizing mechanical ventilation. To maintain intraoperative normocapnia, the clinically significant absorption of CO_2 from the abdominal cavity requires a considerable increase in minute ventilation, sometimes exceeding 40%. Since the amount of CO_2-absorption is subject to large fluctuations, it must be controlled and regulated by continuous end-tidal capnography. Significant and/or sudden changes in end-expiratory CO_2 values must always be checked by an arterial blood gas analysis.

For induction of anesthesia, all common anesthetics can be used [19, 38]. We prefer induction with propofol (1.5–2 mg/kg body weight) supplemented with sufentanil 5–15 ug. To maintain anesthesia, volatile anesthetics such as sevoflurane and desflurane are suitable with a fast onset and offset. They are easy to control and applicable in minimal flow in an air-oxygen mixture. We combine this with an intravenous opioid, preferably sufentanil or remifentanil. Total intravenous anesthesia can be applied as well, of course. Furthermore the perioperative administration of peripherally acting analgesics is recommended.

Sufficient neuromuscular blockade is advantageous not only for artificial ventilation, but also as an essential tool for optimizing surgical conditions for the surgeon. To minimize pathophysiological changes caused by PP, IAP should be kept as low as possible (12–18 mmHg). Good relaxation of the abdominal wall allows a bulky PP with moderate or low IAP. By optimizing operating conditions, the anesthesiologic management can contribute significantly to the success of the surgical procedure. In our hospital all common muscle relaxants are used. For laparoscopic hernia repair, we use rocuronium (0.5–0.9 mg/kg body weight) or cisatracurium (0.15 mg/kg bw). Continuous neuromuscular monitoring is obligatory.

Immediately after oral intubation, a gastric tube should be introduced to drain air and intestinal secretion. This also reduces the risk of gastrointestinal perforation by blind puncture for CO_2 insufflation. Since the tube is removed at the end of surgery, we do not use the potentially traumatic nasal access.

46.4 Anesthesiologic Monitoring During Laparoscopic Hernia Repair, Special Complications, and Troubleshooting

In order to face potential risks and complications of the specific pathophysiological changes described above, a continuous and sufficient anesthesiologic monitoring is necessary. Repetitive noninvasive measuring of blood pressure, continuous ECG, pulse oximetry, and capnography are obligatory. Besides monitoring ventilation and cardiopulmonary parameters, it is indispensable to monitor IAP at the CO_2 insufflation device.

Even after correct endotracheal intubation, unilateral intubation with its associated vital risk for the patient may occur in the course of LIHR. Flexion and extension of the head alone can move the tip of the tracheal tube up to 3–4 cm in the 12–15 cm long trachea of a normal adult [7]. This, together with a cranial shift of the diaphragm after installation of PP, may cause a tube that has been introduced and fixed just above the carina tracheae to shift, displacing the tube tip in the right (or left) main bronchus and leading to unilateral ventilation [18, 29]. In case of a sudden and unexpected high inspiratory airway pressure during laparoscopic surgery and/or any desaturation, this complication has to be considered.

As especially high-risk patients will benefit from postoperative advantages of the laparoscopic approach, only increased intracranial pressure in a patient is considered an absolute contraindication to this method. During laparoscopy cerebral blood flow increases by up to 50%; thus intracerebral pressure can rise. Severe congestive heart failure, a large intracardiac right-left shunt, or a retinal detachment are regarded as relative contraindications to the laparoscopic surgical procedure.

In patients with preexisting cardiac diseases (hypertension, coronary heart disease, congestive heart failure), a continuous invasive blood pressure measurement should be considered. In the group of patients we evaluated in our study, no enhanced monitoring was required. However, this should always be available for the well-trained anesthesiologist in charge. Continuous arterial blood pressure measurement allows a rapid response to changes in circulation and an easy sampling of blood gas analyses. This is of particular value in pulmonarily impaired patients to verify noninvasively measured SpO_2 and end-tidal CO_2 data and to adjust ventilatory parameters. Especially in elderly patients, installation of PP may lead to a significant increase of the alveolar-arterial CO_2 difference. Reasons may be age-related emphysematous changes, an increase in pulmonary dead space, or a decrease in functional residual capacity [39]. In the elderly patient and/or in case of a ventilation-perfusion mismatch, an invasive monitoring (arterial or capillary blood gas analysis) may be necessary for the correct setting of intraoperative ventilation parameters, additional to measuring end-tidal expiratory CO_2. Monitoring of the cardiovascular situation by using a PiCCO system, a transesophageal echocardiogram, or a Swan-Ganz catheter may be considered for patients with considerably impaired cardiac function.

Continuous capnography allows not only monitoring of CO_2 absorption and hence adjustments in artificial ventilation but also detection of systemic complications. These include the already mentioned subcutaneous emphysema, often caused by a difficult blind introduction of the insufflation needle at the beginning of the procedure or a mismatch of inserted trocar and puncture hole, or, as the result of IAP and/or long duration of surgery. When indicated, immediate control and correction of the insufflation needle and trocar must be done. Occasionally, a reduction of IAP, possibly even a rapid termination of the procedure, can be necessary to avoid extreme expansion of subcutaneous emphysema in the cervical region with a possible obstruction of postoperative spontaneous breathing. The patient should be ventilated until end-tidal CO_2 and arterial oxygen partial pressure with normal respiratory minute volumes are in a normal range or meet the individual preoperative values. Postoperative monitoring must be maintained until almost full regression of subcutaneous emphysema.

Capnography as routine monitoring is also of immense importance to detect the potentially lethal complication of gas embolism. Even at a very early stage and in case of minor amounts of embolized gas, capnography shows a significant drop in the concentration of end-tidal CO_2 long before hemodynamic changes become apparent. Frequently gas embolism is caused by an accidental intravascular insufflation of CO_2 when establishing the PP. CO_2 bubbles entering from established PP into accidentally opened veins may also occur, particularly in hypovolemic patients and in an unfavorable (i.e., head-up) position. Depending on the extent of gas embolism, a decrease in oxygen saturation may evolve alongside the abovementioned decrease in endtidal CO_2. Although ventilatory parameters have not been changed, hypotension and cardiac arrhythmias may also occur. Precordial auscultation confirms the classic "mill-wheel" murmur. A gas embolism requires the immediate termination of CO_2 insufflation and deflation of PP. Further measures correspond to the classical procedure for acute treatment of air embolism, including placement of a CVC with the attempt of aspirating gas from the right ventricle and – in extreme cases – the use of cardiopulmonary bypass. Since, compared with other gases, five times as much CO_2 is needed to cause a hemodynamically relevant gas embolism and since CO_2 is rapidly absorbed, CO_2 embolism with such serious effects is extremely rare. Furthermore, the Trendelenburg position required for LIHR makes cranial vascular invasion of CO_2 bubbles during an already established PP very unlikely. Case reports relate primarily to laparoscopic cholecystectomies with head-up positioning [1, 32, 36]. Accordingly, in laparoscopic incisional and abdominal hernia surgery and especially in laparoscopic surgery of hiatal hernia, this complication seems more probable.

Several case reports deal with the complication of pneumothorax and capnothorax, respectively, during laparoscopic operations [5, 13, 16, 42]. Obviously, a transfer of CO_2 from the abdomen to the pleural cavity is possible despite correct technique and an intact diaphragm and can be explained by diaphragm development and anatomy [40]. However, the excellent diffusion properties of CO_2 usually lead to rapid absorption of the pneumothorax without necessity of a drainage. If the monitored parameters ($ETCO_2$, SpO_2, pulse, blood pressure) allow it and no tension pneumothorax (respiratory pressure!) develops, a chest tube can therefore be avoided [13]. It is believed that the complication of a "pneumo(capno)thorax" occurs more frequently during laparoscopic surgery of the upper abdomen. In a review of 6750 patients with over 10,200 LIHR (34% bilateral), this complication did not occur in our clinic.

As previously mentioned, sufficient neuromuscular block greatly facilitates the surgical procedure. During LIHR the time respectively in between dissection, hernioplasty and wound closure is very short. This increases the risk of residual curarization. It is therefore strongly recommended to use relaxants with short recovery time (rocuronium, cisatracurium, mivacurium) titrating them as needed. An intraoperative relaxometric monitoring of neuromuscular function is desirable and is mandatory before extubation to prevent residual neuromuscular blockade.

In laparoscopic surgery, CO_2 to establish PP is applied with a temperature of 20 °C. Lengthy procedures and large quantities of CO_2 can lead to marked and clinically relevant hypothermia [14]. Besides perioperative warming measures (heating blanket/heating pad), monitoring of body temperature is recommended to be able to counteract any further drop in temperature by appropriate measures. Thus inadequate oxygen consumption due to shivering and increased consumption of analgesics in the postoperative period can be avoided.

46.4.1 Intraoperative Patient Positioning

Pathophysiological changes caused by elevated IAP after installation of PP are intensified by Trendelenburg positioning during LIHR. In close cooperation with the surgeon, a compromise between optimum working conditions and adverse effects on the cardiopulmonary system of the patient must be found. An optimal setting for the procedure is created by tucking both arms to the patient's side. This also spares time-consuming repositioning during the procedure if bilateral hernioplasty is necessary. Special attention should be paid to having secure peripheral IV access placed on the patients forearm. If unable to access peripheral veins, either a short IV cannula can be placed in one of the external jugular veins or the placement of a central venous catheter (CVC) may be required. Using an ECG-controlled CVC-system is a valid and cost-effective alternative to the standard radiographic control for correct CVC-placement, while simultaneously avoiding radiation exposure for the patient and staff.

To measure peripheral capillary oxygen saturation, a conventional pulse oximeter can be placed on one finger of the patient's hands. Occasionally a special sensor device to measure SpO_2 at the earlobe or the nose may be needed.

For perioperative neuromuscukar monitoring, acceleromyography of them. adductor pollicis is recommended. Correct application of the accelerometric device may be difficult intraperatively. Combined accelerometric monitoring of m. orbicularis oculi (intraoperatively) and m. adductor pollicis (before intended extubation) solves this problem.

Generally, we recommend establishing the PP in flat supine position, placing the patient in Trendelenburg position only after fully established PP. From our experience, this approach leads to significantly moderated cardiovascular reactions.

46.5 Anesthesia for Incisional and Ventral Hernia (LIVH)

Basic anesthesiologic aspects that have to be considered in laparoscopic hernia repair have already been extensively discussed in ► Chaps. 46.1–46.4. Possible complications in the context of anesthesia for laparoscopic surgery have been discussed in this chapter in detail. The following takes into account only the specifics of this particular surgical procedure.

In contrast to LIHR, for LIVH trocars are inserted predominantly near the left flank of the abdominal wall. The patient's left arm is tucked, his right arm is available for infusion and monitoring.

Intraoperative positioning of the patient follows the localization of the hernia, and Trendelenburg positioning is not required.

After introducing the trocars and establishing PP, adhesiolysis is necessary. In addition to the aforementioned specifics of anesthesia in laparoscopic surgery, the anesthesiologist should be particularly aware of vascular injuries or bowel perforations in the course of this dissection.

The possibility of causing a pleural lesion during dissection at the cranial part of the rectus sheath should be considered. A sudden increase in ventilation pressure indicating the possible development of a pneumothorax (capnothorax) must be evaluated immediately. If there is clinical evidence of a capnothorax, and the patient shows no signs of hemodynamic instability, IAP must be reduced immediately. Pressure–controlled ventilation with positive end-expiratory pressure (PEEP) must be continued. If there is no improvement (sustained high or increasing ventilation pressures) or if the patient shows signs of incipient hemodynamic deterioration, PP has to be deflated and the procedure has to be discontinued immediately. The insufflated CO_2 which penetrated the pleural cavity will be rapidly absorbed. In most cases the procedure can be continued after an appropriate break, with a PP at low IAP (8–10 mmHg). Usually a capnothorax is absorbed spontaneously. The insertion of a chest tube is rarely necessary. Thorough postoperative monitoring of the patient is required until regression of all symptoms.

If after release of the PP, symptoms persist or worsen (persistently high and rising peak airway pressures, developing of hemodynamic instability), a chest tube must be inserted immediately and the patient must be stabilized hemodinamically. Invasive blood pressure monitoring should be initiated at a minimum, and repetitive blood gas analysis should be done. If possible, the procedure should be completed rapidly, and switching to an open procedure has to be considered.

Arrhythmia and cardiac instability with exclusion of a causal capnothorax or CO_2 embolism points to the development of a capnomediastinum or capnopericardium. Unlike during capnothorax, ventilation pressures may appear unchanged.

As in capnothorax

- lower IAP
- adjust artificial ventilation with calculated PEEP and high inspiratory oxygen pressure
- adjust patient positioning from reverse Trendelenburg to supine position
- deflate PP
- make a short break in the surgical procedure.

This will usually be sufficient to gain control of the complication [6].

The indication for extended monitoring with continuous arterial blood pressure monitoring and blood gas analysis should be provided generously. Likewise, postoperative chest X-ray control and monitoring on a suitable intensive or intermediate care station should be considered.

In case of continous or even increasing cardiopulmonary instabiity, the insertion of a tube for mediastinal or pericardial drainage may be necessary. However, such a case is not known to the authors, neither from our own clinical experience nor from case reports. In a capnomediastinum, the positive qualities of CO_2 as the working gas in laparoscopy come into effect: After discontinuing the CO_2-application a rapid and spontaneous absorption of CO_2 takes place with no further action necessary.

A thorough postoperative monitoring of the patient until complete clinical recovery and absorption of CO_2 is a matter of course.

46.6 Anesthesia for Hiatal Hernia Repair (LHHR)

Basic anesthesiologic aspects that have to be considered in the context of anesthesia in laparoscopic hernia repair have already been extensively discussed in the ► Sect. "Anesthesia for the Laparoscopic Inguinal Hernia Repair (LIHR)".

For LHHR as in LIVH, only one of the patient's arms is tucked. Monitoring and IV access have to be administered accordingly. After induction of anesthesia and endotracheal intubation, a gastric tube should be inserted. It serves as a guidance for the surgeon to identify the course of the esophagus and stomach. Insertion of the gastric tube can be difficult especially in large hiatal hernias and if a partial or complete herniation of the stomach into the thoracic cavity exists (upside-down stomach). Under no circumstances should the gastric tube be inserted with force to overcome significant resistance. In that case the tube should be inserted only into the upper esophagus. After establishing PP and introducing the trocars, the gastric tube then can be carefully advanced under visual control of the surgeon and possibly with instrumental support. After establishment of the PP, the patient is brought into reverse Trendelenburg position.

Dissection near the diaphragm and reverse Trendelenburg positioning imply a much greater danger of the possible formation of a pneumothorax (capnothorax) or pneumo(capno)mediastinum. These risks are promoted by working with high IAP. Working with an IAP level of less than 12 mmHg have proven to be advantageous. Under the best possible conditions (suitable anatomy, optimal anesthesia, and relaxation), even an IAP of 8–10 mmHg may be sufficient for an experienced surgeon. Both an accidental laceration of the pleura and a spontaneous cranial and mediastinal spread of CO_2 can lead to the formation of capnothorax, capnomediastinum, or capnopericardium [42].

Appropriate measures to be taken in case of a capnothorax have been extensively discussed in ► Sect. 46.5. If, after reducing IAP and adjusting artificial ventilation, and if the patients hemodynamic condition is stable, the procedure may be continued. If not, PP should be released and the procedure paused. CO_2 will be absorbed rapidly from the pleural cavity. Usually the procedure can be terminated with reduced IAP (8–10 mmHg) after a short break. Meticulous postoperative monitoring is mandatory until the patient has completely recovered.

Insertion of a chest tube to relieve the capnothorax is rarely necessary. However, if airway pressures stays high or rise further after resuming laparoscopy, development of a tension capnothorax with imminent danger of hemodynamic instability must be considered:

When a tension capnothorax is suspected, an instant reevaluation should include:
- Checking depth of anesthesia: is it appropriate?
- Checking neuromuscular block : is it sufficient?
- Checking breath sounds: are they unilaterally decreased or absent?
- Checking for unilateral hyperresonance on percussion.
- If available, ultrasound for detection of capnothorax.

A tension capnothorax must be treated by inserting a chest tube. At this point, invasive blood pressure monitoring should have already been initiated. After hemodynamic stabilization has been achieved, the procedure should be finished as soon as possible. Converting from a lparoscopic to a conventional surgical approach must also be considered.

In capnomediastinum, in contrast to capnothorax, airway pressures may not be altered. Predominant signs are cardiac instability and arrhythmias without evidence of causal capnothorax or CO_2-embolism. As in capnothorax, adjusting artificial ventilation parameters, lowering IAP or relieving PP, and supine repositioning of the patient should be first-line interventions. Eventually a short break in the procedure could be warranted. This should be sufficient to address this complication. Usually no further steps need are necessary, as CO_2 is absorbed quickly [6].

In any case the anesthesiologist should have switched to invasive blood pressure monitoring now. Postoperative chest x-Ray must be considered. After the complication has been addressed the patient needs to be monitored in the ICU or an intermediate care unit.

Unlike during capnothorax, with capnomediastinum ventilation pressures may appear unchanged. Cardiac instability, despite exclusion of a causal capnothorax or CO_2 embolism, points to this complication. As in the case of a capnothorax, lowering the IAP and adjusting the mechanical ventilation with calculated PEEP and high inspiratory oxygen pressure are usually sufficient to control this complication in our experience. Sometimes reducing the level of reverse Trendelenburg to a more neutral position, deflation of PP and short break in the procedure may be necessary [6]. The indication for extended monitoring with continuous arterial pressure monitoring and blood gas analysis should be provided generously. Likewise, postoperative chest X-ray control and monitoring on a suitable intensive or intermediate care unit should be considered.

The insertion of a tube for mediastinal or pericardial drainage may be necessary in case of continuing and increasing cardiopulmonary instability. However, such a case is not known to the authors, neither from our own clinical experience nor from case reports. In a developed capnomediastinum, the positive qualities of CO_2 as the working gas in laparoscopy come into effect: After discontinuing the CO_2, a rapid and spontaneous absorption of CO_2 takes place with no further action necessary.

Thorough postoperative monitoring of the patient until complete clinical recovery and absorption of CO_2 is a matter of course.

46.7 Summary

Laparoscopic hernia repair comes with specific anesthesiologic risks. Establishing the pneumoperitoneum leads to distinct changes in hemodynamics and respiratory mechanics, both affecting each other. Peak and plateau pressures during mechanical ventilation increase up to 40%. To the same degree, pulmonary compliance diminishes. The characteristic changes in hemodynamics due to pneumoperitoneum are a decrease in Cardiac output, an increase in systemic vascular resistance and an increase in arterial blood pressure. These changes are amplified by placing patients in perioperative positions such as Trendelenburg position in LIHR or reverse-Trendelenburg position in LIVH and LHHR.

In laparoscopic incisional ventral hernia repair, adhesiolysis is necessary with the implied risk of enterotomy and vascular injury. Surgical dissection of the cranial rectus muscles and near the costal margin, can lead to laceration of the pleura. A sudden increase in inspiratory pressure is the first sign of a developing capnothorax which must be evaluated instantly.

After intubation for a laparascopic hiatal hernia repair, a gastric tube must be inserted, usually under visual observation by the surgeon. Dissection near the diaphragm, high mediastinal dissection and reverse Trendelenburg positioning, bear the risk of capnothorax, capnomediastinum or capnopericardium.

It is important for the anesthesiologist involved in a laparascopic hernia repair, to have knowledge about common complications along with the necessary equipment needed to handle these complications. Through close cooperation between the anesthesiologist and surgeon, laparoscopic hernia repair can be successfully accomplished with a low rate of complications, particularly in the elderly and high-risk patients.

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Supplementary Information

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