Newer Concepts and Procedures in Hernia Surgery - An Atlas

Sarfaraz Jalil Baig
Deepraj Bhandarkar
Pallawi Priya
Editors

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Dedicated to those whom I haven't met but will benefit from this book.

Sarfaraz Jalil Baig

To my beloved wife, Pallavi, for enduring me, and my daughter Avanti—the sunshine of my life.

Deepraj Bhandarkar

To all the girls who picked a scalpel as their toy and kicked butts as surgeons—you make some fine role models!
To my mentors, one more than the others, and each one indispensable—for making me who I am.
To all the nurses and paramedics—you make the medical world go round and around.
To my parents—for being the earth beneath my feet.

Pallawi Priya

Foreword

When in the last part of the nineteenth century (1870) Eduardo Bassini wrote his historical paper on his truly innovative surgical procedure, he started the description by saying: 'I'm very sorry to bother all of you with another paper on inguinal hernia repair, as almost all was said in the last centuries…'.

From this everybody can understand how much was and is (and it will be) the interest for the hernia disease. In fact, since the time of Hippocrates, the interest in this pathological condition, which is absolutely the most frequent surgical pathology of humans, moved hundreds of researchers, doctors, surgeons, academics, and in recent years companies and industries, to try to find sophisticated and up-to-date procedure, materials, and approaches.

Hernia surgery has slowly left the position of ancillary part of general surgery to become a new super specialization that requires deep dedication and profound knowledge of specific anatomy, way to approach, materials, new technology, and the real 'love' for the scientific approach.

A really famous American surgeon of the past used to say '…I know hundreds of surgeons that I can choose to remove my gallbladder, but only a few that I wish to have repairing my hernia…'.

Surgeons also often quote what Dr. Cooper wrote: '…no other surgical condition requires a so deep knowledge of anatomy and in the same time a so great technical surgical skill…'.

All this premise easily justifies the florilegia in these last 30 years of continental societies dedicated to this fascinating branch of surgery, hundreds of congresses and meetings, national schools, registers, and mainly dedicated journals.

We had the chance in these years to approach all kinds of surgical challenges, growing in experience and surgical attitude, from the driver position. We had great luck being in personal contact with all the protagonists worldwide in the escalation and preparation for the future.

I consider it a real great fortune to have had the chance to be part of the creation of the Hernia World. Now, this hernia world is a large group of experts who continuously design the path for the correct application of new technology and for the future.

Many of these experts were called by the editors to develop this wonderful text.

From the absolute perfect description of the anatomy, even better than in the past thanks to the facility of the vision given from the close robotic 3-D to the recent possibilities with the extended and enhanced lap approach; from the revival (with new concepts) of the separation of the components to the numerous new possibilities of minimally invasive; from the inguinal primary to the complex situations, all was considered in this text.

All the authors, most of whom are my close friends, are experts in the field of hernia, and frequently authors of our specialized journal *HERNIA*. I have shared fantastic experiences, like the 1st World Conference on Abdominal Wall Surgery in Milan, with many of them. These authors have very well presented the spirit of this innovative book proposed by the editors. My congratulations and wishes of great success for their hard work.

Giampiero Campanelli
University of Insubria
Varese, VA, Italy

Foreword

Greetings from the Institute of Laparoscopic, Endoscopic, Bariatric and Gastrointestinal Surgery.

We are currently navigating unprecedented times in our existence. The practice of hernia surgery is also subject to increasing scrutiny, challenge, and validation. Ubiquitous social media has also penetrated the hernia domain and added to debate, controversy and decision-making. The wide array of decision-making possibilities only makes the subject more controversial and confusing, especially for our younger colleagues.

It is an onerous and difficult task to cut through the maze to present hernia repair in a logical and purposeful manner. Many surgical principles and dictums have stood the test of time and hernia repair is no exception. A coherent approach is required to present newer advances and technology in hernia repair while preserving sound surgical strategy. Robotic hernia repair now adds to the vast armamentarium of options for hernia repair.

I am pleased to be contributing the foreword to a new and exciting publication on hernia repair. The managing Editors (Dr Sarfaraz Baig, Dr Deepraj Bhandarkar, and Dr Pallawi Priya) all have a special interest and expertise in hernia repair. They have conceptualised and curated the contents and presentation of various facets of hernia repair admirably. The contents are contemporary, and contributions are from globally acknowledged leaders in their areas of interest. I am certain that this treatise will be of great interest not only to our younger colleagues but also to the surgeon with a special interest in hernia repair.

I wish to congratulate all contributing authors for their expertise and lucid presentations. This publication will provide a ready reference to recent developments in hernia repair as also technical details and handy tips for surgeons wishing to expand their repertoire in hernia surgery.

Warm Regards,

Pradeep Chowbey
Institute of Laparoscopic, Endoscopic
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Preface

One of the common themes in all hernia conferences we attended recently was an undercurrent of dissatisfaction. Hernia Surgery, which used to be one of the commonest surgeries performed by a general surgeon, has virtually become unrecognizable by a sudden flurry of new techniques, acronyms, and planes. Whispers and grunts of ‘I have become more confused after coming here/seeing this/reading this’ were heard after the conferences and in the WhatsApp and Facebook groups.

We spoke at length about this and came to the conclusion that if we were to utilize the newer concepts to their potential, a single-point resource outlining the usefulness, contraindications, and technical details of the newer techniques was needed. We reached out to the innovators and early adaptors of the newer techniques and concepts, and to our delight, they readily agreed to be a part of the endeavour.

Since surgery for hernia is a commonly performed surgery across the globe, advances in this field must be disseminated to the entire surgical community. An Atlas with chapters contributed by global experts can provide the best understanding and maximal benefit to the readers.

We have kept a standard format for all chapters with plenty of intraoperative photographs of high quality, and detailed illustrations (thanks to the talented Dr. Varun T. Raju, a surgeon illustrator for his beautiful work) to explain these concepts and procedures lucidly. There is an invaluable section on ‘Pitfalls, tips, and tricks’ where the authors have instilled their wisdom and shared their experiences. Many of the chapters have videos by the authors which are useful for elucidating the technical nuances of these procedures.

We consider this Atlas as a ready and comprehensive compendium for surgeons wishing to embark on these newer procedures. Postgraduate trainees and surgical residents wanting to familiarize themselves with the current concepts in hernia surgery will find it all in one place. Surgeons in their learning curve can use this book to revise the finer technical points before performing complex surgeries.

This Atlas can either be read from cover to cover and referred to often as needed. The readers would pick up some new pearls of wisdom with each reading as we realized during the editing process.

Samuel Johnson once said, ‘A writer only begins a book. A reader finishes it’. We leave it to our readers now to pick this book up and turn the pages.

Kolkata, West Bengal, India — Sarfaraz Jalil Baig
Mumbai, Maharashtra, India — Deepraj Bhandarkar
Kolkata, West Bengal, India — Pallawi Priya

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About the Editors

Sarfaraz Jalil Baig is the Director of Digestive Surgery Clinic based out of Belle Vue Hospital, Kolkata, India, with more than 20 years of experience.

He has published over 25 peer-reviewed articles in various national and international journals on hernia, bariatrics and GI surgery. He has authored a book *Nutrition, Obesity and Bariatric Surgery* and co-authored a number of monographs and chapters in books of international repute such as 'Diet, Supplements and Medications After MGB: Nutritional Outcomes; Avoidance of Iron Deficiency; MGB in Vegetarians' in *Essentials of Mini-One Anastomosis Gastric Bypass* by Springer. He is the editor of the book titled *Management of Nutritional and Metabolic Complications of Bariatric surgery* by Springer.

He is the vice president of HSI (Hernia Society of India), an EC member of IAGES (Indian Association of Gastrointestinal Endosurgeons), ex EC member of IASG (Indian Association of Surgical Gastroenterology), and treasurer of OSSI (Obesity Surgery Society of India).

Following his passion for teaching and training, he has been responsible for organizing a number of national-level conferences and workshops. He runs training courses on hernia at his centre and has trained more than 200 surgeons across the globe. He is one of the pioneers of AWR and bariatric surgery in India.

He is the associate editor of *Journal of Bariatric Surgery* and is on the editorial board of *Journal of Minimal Access of Surgery*.

Deepraj Bhandarkar is a Consultant Minimal Access Surgeon at Hinduja Hospital in Mumbai, India. He is considered a national expert in minimal access surgery with over 30 years of experience in the field. He has published over 90 papers in peer-reviewed journals and over 25 book chapters. He is the author of a book titled *A Primer of Laparoscopic Surgery* and was the guest editor of an issue of *Journal of Minimal Access Surgery* (*JMAS*) dedicated to single incision laparoscopic surgery. He served as the associate editor of the *Indian Journal of Surgery* from 2001 to 2003 and was the editor of the *JMAS* from 2004 to 2020. He currently serves as the chief editorial advisor at the *JMAS*. As a sought-after speaker and passionate educator, he has given over 200 podium and video presentations, 300+ invited lectures and 6 named orations. He has been active in various national surgical organizations and has served as the associate secretary of the International College of Surgeons (Indian section), vice president, hon. treasurer and member of the FIAGES and FALS boards of the Indian Association of Gastrointestinal Endosurgeons (IAGES) and as the hon. secretary of Hernia Society of India. He serves as the president of Hernia Society of India. He has been active in minimal access surgical training for over 25 years and was the faculty director at the Center of Excellence for Minimal Access Surgery Training in Mumbai from 2012 to 2020. He is a member of the specialist board for minimal access surgery of the National Board of Examinations.

Pallawi Priya is Consultant, minimal access surgery at Belle Vue Clinic, Kolkata, India. She is on the executive committee of the Hernia Society of India since 2019 and the Obesity Surgery Society of India since 2022. She has a number of articles on hernia and bariatric surgery published in peer-reviewed national journals. She is on the editorial board for the *Journal of Bariatric Surgery* and is the editor of the book *Management of Nutritional and Metabolic Complications of Bariatric Surgery*. She has co-authored chapters in books such as *Comprehensive Laparoscopic Surgery (4th ed., IAGES Academic Publishers), Nutrition, Obesity and Bariatric Surgery and Essentials of Mini-One Anastomosis Gastric Bypass* (Springer). She has been invited as faculty at national and international conferences. Her work has won awards at several conferences.

Part I

Newer Concepts in Inguinal Hernia Surgery

1 Understanding the Critical View of the Myopectineal Orifice (MPO) for Safe Minimally Invasive Surgical Inguinal Hernia Repair

Edward Felix, David Lourié, and Jorge Daes

Safety and efficacy should be paramount in the mind of every surgeon when choosing a surgical approach. Minimally invasive surgical (MIS) inguinal hernia repair is no exception to this rule. The first laparoscopic inguinal hernia repairs were performed over 30 years ago, but acceptance of the technique was limited and accounted for only 10–15% of repairs. With the introduction of a robotic approach however the percent of MIS repairs increased rapidly and now accounts for almost 50% of inguinal hernioplasties [1]. With this rapid growth, we noted that many repairs were being performed without heeding the lessons learned from years of experience which had resulted in recurrence rates of less than 2% and an incidence of chronic pain less than open repairs. A schema unifying all MIS approaches that addresses the issues of safety and efficacy however was not published in a peer-reviewed journal until 2017 when it appeared in the Annals of Surgery [2]. The report outlined nine steps to achieve the critical view of the myopectineal orifice (MPO) of Fruchaud, a concept first introduced by Brian Jacob in 2015 and widely disseminated on the International Hernia Collaboration. Although there are several approaches to a MIS inguinal hernia repair including Transabdominal Preperitoneal (TAPP), Totally Extraperitoneal (TEP), Extended Totally Extraperitoneal (eTEP), Robotic Transabdominal Preperitoneal (R-TAPP), and Robotic Totally Extraperitoneal (R-TEP), they have a single underlying concept which promotes a safe and successful repair. The concept, the steps to achieving the critical view of the MPO, is based on the history of the development of MIS approaches and 1000 of MIS repairs. Each step was developed through careful study of the elements of the repair that contribute to success and those that result in complications or recurrences. It is important to understand that achieving the critical view of the myopectineal orifice of Fruchaud is not just the final view of the MPO but includes the steps of properly attaining the critical view and the steps required to complete the repair after the critical view is obtained. The order in which the steps are performed may need to be varied and will be illustrated but failing to complete every step increases the likelihood of complications and recurrence. This chapter goes through each step and how it should be applied no matter which MIS approach is utilized. Examples of how failing to achieve the critical view may cause the hernia repair to fail are also illustrated.

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Whether the approach is transabdominal or totally extraperitoneal, the critical view of the MPO begins with identifying the anatomy of the pelvis. The initial view of the pelvis of each approach however is quite different. With the transabdominal approach the surgeon directly views the anatomy of the pelvis and the patient's hernia. They must incise the peritoneum to begin the first step of the repair. We recommend making the incision high enough to allow for complete and adequate coverage of all defects and from the anterior superior iliac spine (ASIS) to at least the umbilical artery remnant (medial umbilical ligament). It is a mistake to use a smaller incision because it will limit step 9 and increase the chance of recurrence from improper mesh placement.

When a TEP or eTEP approach is utilized, the anatomy of the pelvis is not apparent until the dissection of the peritoneum off the abdominal wall is completed either by manual dissection or balloon dissection in combination with manual dissection. Again, the peritoneal dissection must be across the midline and laterally past the ASIS to allow for adequate dissection of the MPO and placement of the mesh. As will be emphasized in the nine steps, minimizing the extent of this dissection is one of the major causes for recurrence of the hernia.

1.1 Following Are the Steps to Achieve a Critical View of the MPO

1. Identify and dissect the pubic tubercle across the midline and Cooper's ligament (CL). For large, direct hernias, extend the dissection to the contralateral CL (Fig. 1.1).
2. Rule out a direct hernia. Visualize anatomy through the inflated balloon during totally extraperitoneal and extended totally extraperitoneal repairs to detect a direct hernia before dissection. Remove unusual fat in the Hesselbach triangle (Fig. 1.2).
3. Dissect at least 2 cm between CL and the bladder to facilitate flat placement of the medial and inferior edge of mesh toward the

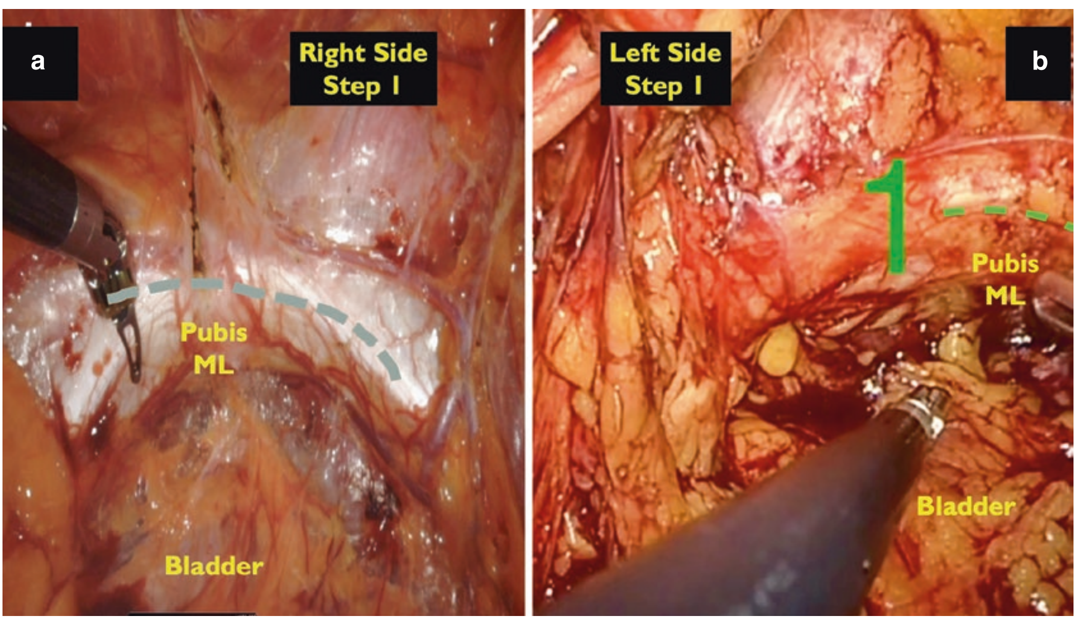

Fig. 1.1 Illustrates the view of the pelvis in patients with hernias after step 1 has been completed. The dotted green shows how the dissection is carried across the midline (ML) of the pubis. (**a**) Is a view of the pelvis after step 1 has been completed during an R-TAPP right inguinal hernia repair. (**b**) Is a view of the pelvis after step 1 has been completed during an eTEP left inguinal hernia repair

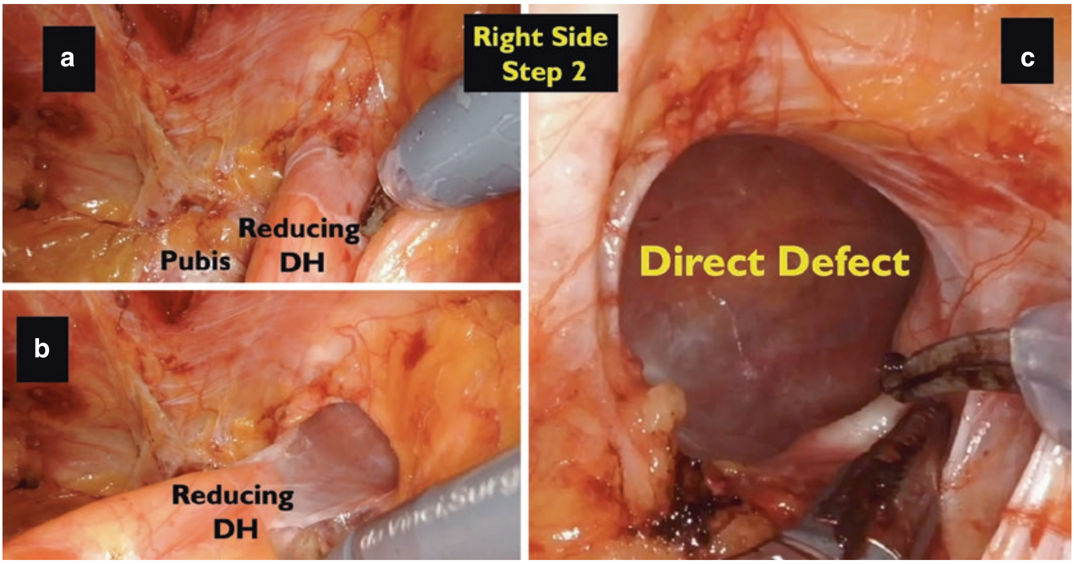

Fig. 1.2 Demonstrates the dissection of the direct or medial space to identify and reduce a direct hernia in step 2. (**a**) The initial identification and reduction of the right direct hernia. (**b**) The reduction continues and the white pseudo sac is visible. (**c**) The hernia has been completely reduced and the direct defect is demonstrated

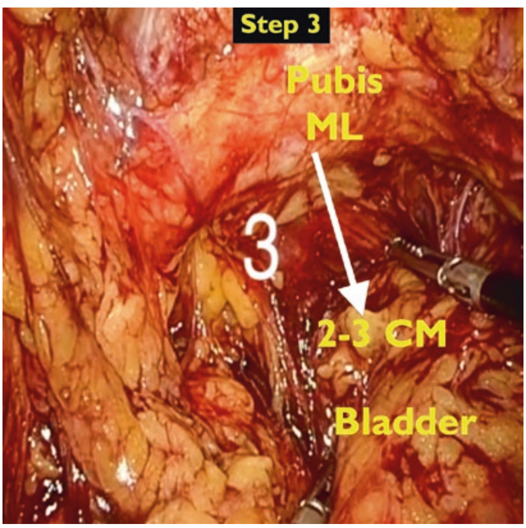

Fig. 1.3 Illustrates the dissection of the space of Retzius in step 3 during an eTEP repair of a left inguinal hernia. The dissection is extended 2–3 cm below the pubis so that mesh placement is not clam shelled by the bladder

space of Retzius thereby avoiding mesh displacement caused by bladder distention (Fig. 1.3).

4. Dissect between CL and the iliac vein to identify the femoral orifice and rule out a femoral hernia (Fig. 1.4).
5. Dissect the indirect sac and peritoneum sufficiently to parietalize the cord's elements. This step is often not completed, especially in a small surgical field. To ensure compliance with this requirement, continue to dissect until the cord's elements lie flat. Then, visualize the psoas muscle and iliac vessels, pull the sac and peritoneum upward without triggering the movement of the cord's elements, and dissect between the cord's elements to avoid missing a tail of the sac (Fig. 1.5).
6. Identify and reduce cord lipomas (which may appear small and unimportant until reduced). Usually lateral to the cord's elements, they should not be confused with lymph nodes (which are generally spared). Most lipomas do not require removal but should be placed above the mesh to help prevent mesh rolling upward (Fig. 1.6a, b).
7. Dissect peritoneum lateral to the cord's elements laterally beyond the ASIS, sweeping it back cephalad well behind the mesh's posterior border (Fig. 1.7).
8. Complete the dissection to achieve the critical view of the MPO (Fig. 1.8), provide mesh coverage, and ensure that mesh and mechanical fixation are placed well above an imagi-

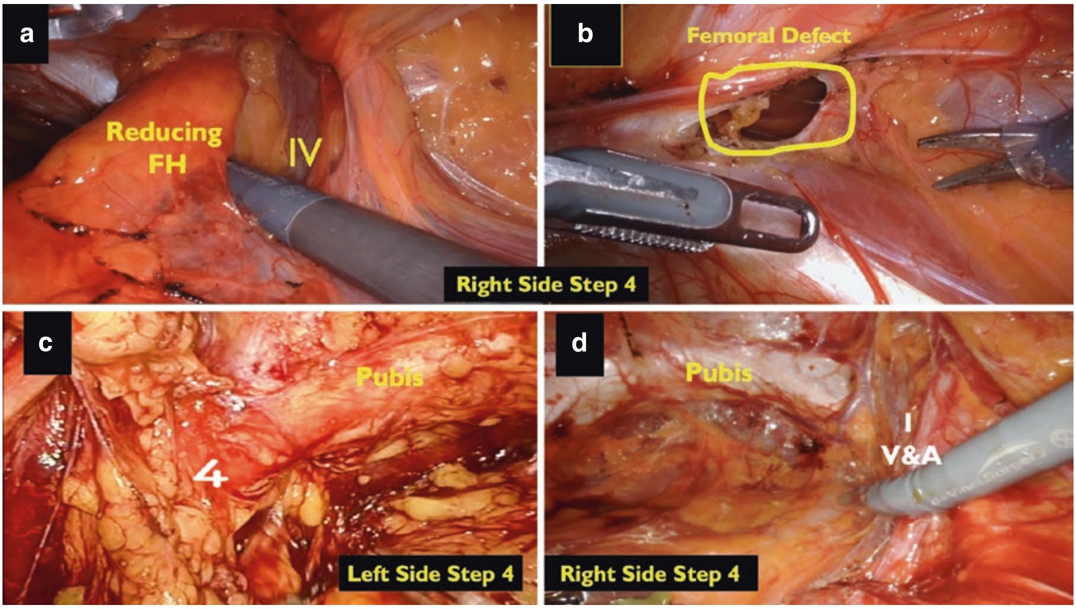

Fig. 1.4 The figure illustrates step 4. The identification of a femoral hernia if present and its reduction. (**a**) During a right R-TAPP the femoral hernia is identified medial to the external iliac vein (IV). (**b**) The femoral hernia has been completely reduced and the circle outlines the femoral defect. (**c**) A TEP inguinal repair on the left where step 4 has been completed and a femoral is ruled out. (**d**) An R-TAPP dissection completing step 4. The iliac vein and artery are labeled (I A&V). The pubis is well seen

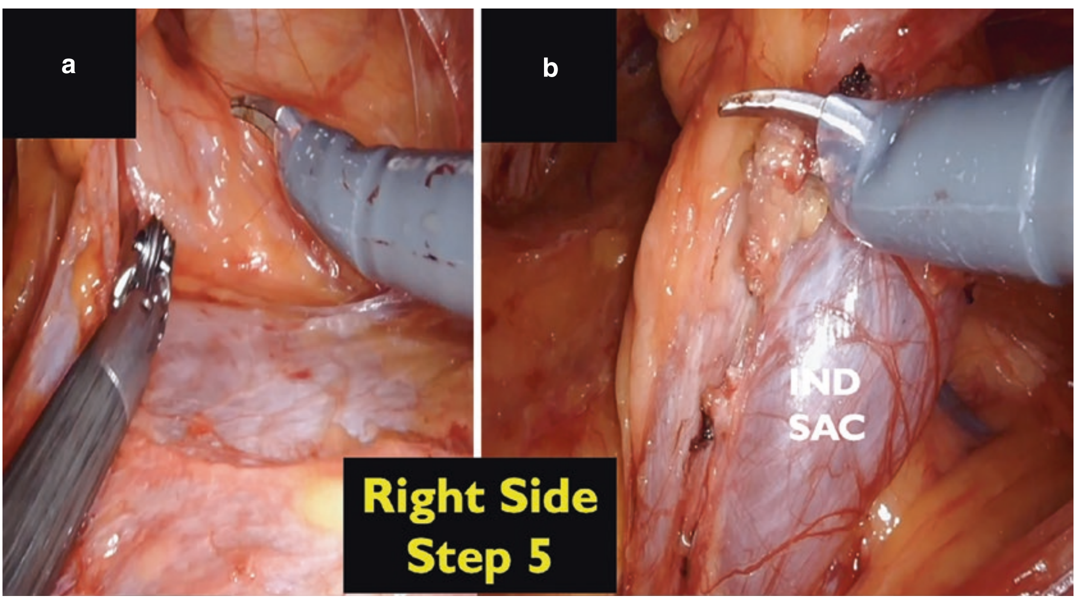

Fig. 1.5 Step 5 is performed by R-TAPP. Demonstrating dissection of the indirect hernia and parietalization of the cord. IND SAC, indirect sac; VAS, the vas deferens; VES, testicular vessels. (**a**) Initial identification of the indirect sac. (**b**) Reduction of the indirect hernia sac. (**c**) Final release of the sac from the internal ring. (**d**) The completed parietalization of the vas deferens (VAS) and the testicular vessels (VES)

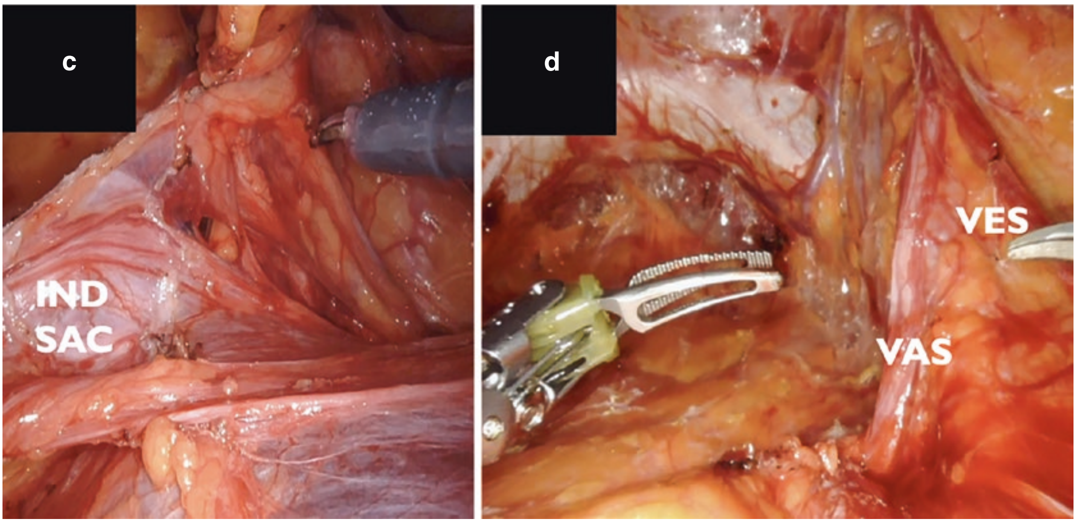

Fig. 1.5 (continued)

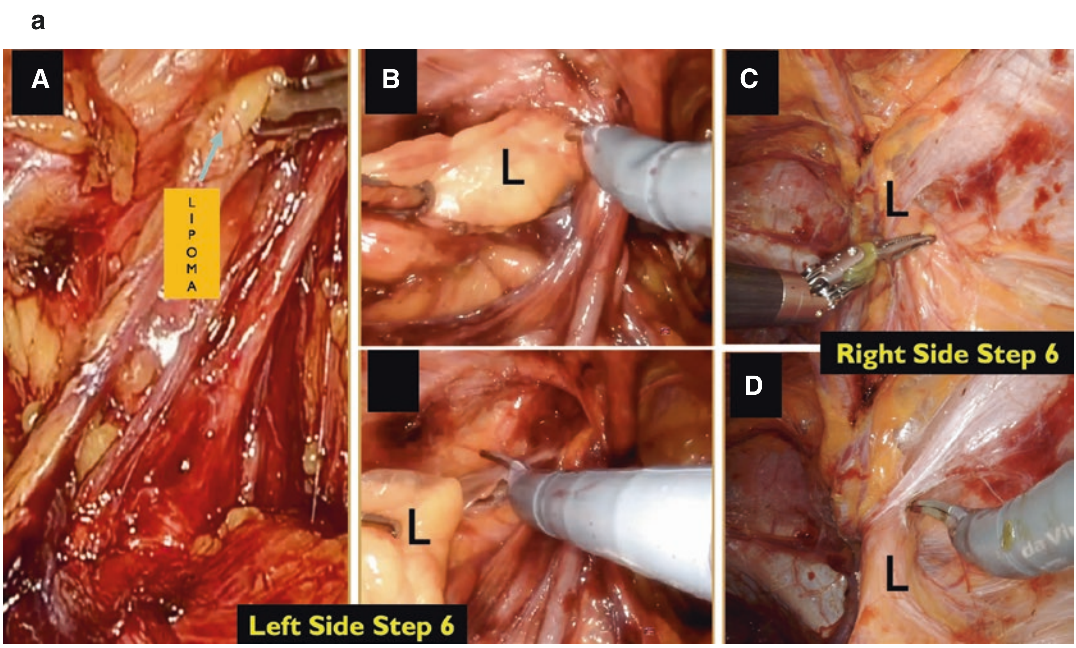

Fig. 1.6 (**a**) Step 6 illustrates the identification and reduction of the lipoma of the cord. (*A*) The lipoma is identified just lateral to the testicular vessels during a TEP repair. (*B*) Reducing the large tail of the lipoma via a R-TAPP repair. (*C*) R-TAPP right inguinal hernia repair identifying the lipoma (L) lateral to the testicular vessels. (*D*) R-TAPP right inguinal hernia repair beginning reduction of the lipoma (L). (**b**) A robotic TAPP demonstrating serial dissection of a lipoma (L). It demonstrates how the lipoma gets larger as the surgeon progresses distally in the canal. (*A–E*) The serial dissection of the lipoma. (*F*) The reduction of the lipoma from the inguinal canal has been completed and the open transversalis sling (TS) is outlined in pink

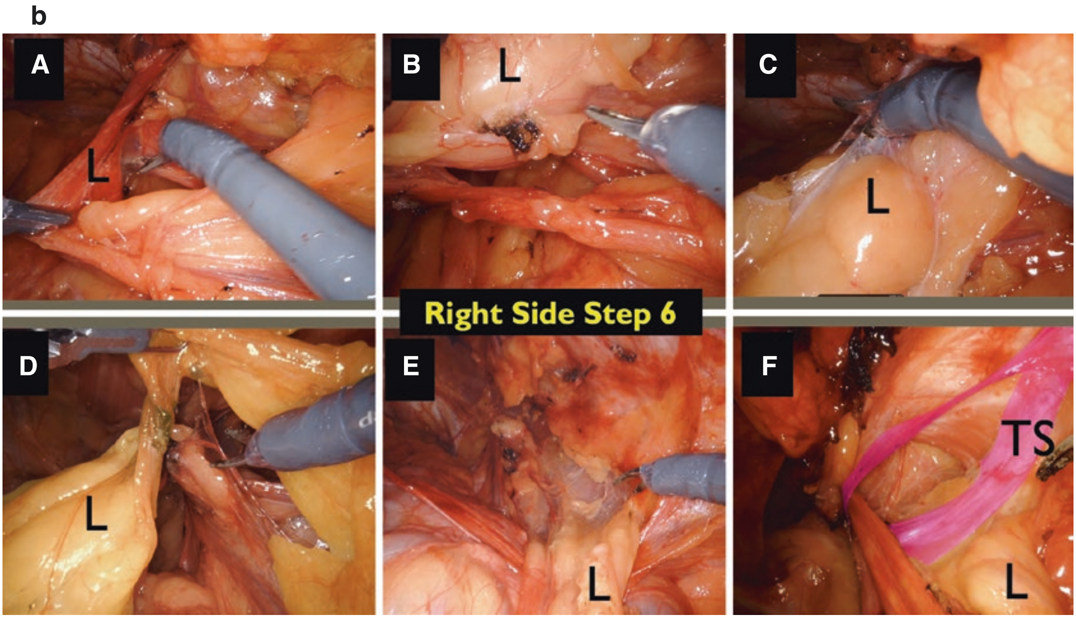

Fig. 1.6 (continued)

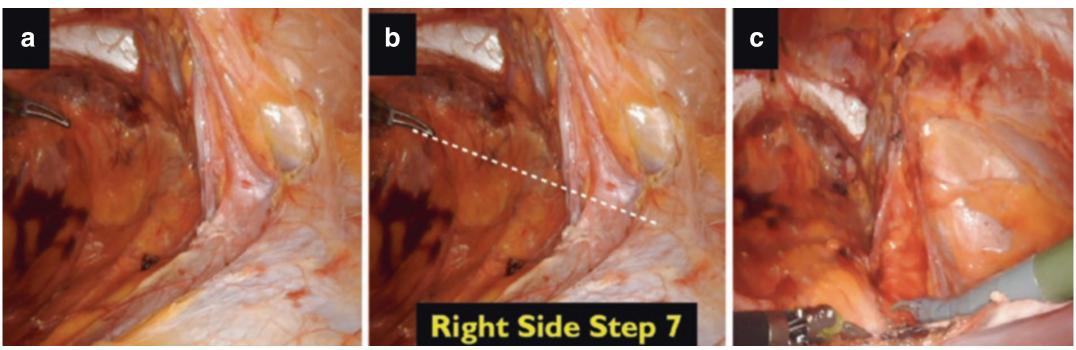

Fig. 1.7 Demonstrates step 7, the completion of the lateral dissection in a right inguinal hernia repair. (**a**) Before the lateral dissection is complete. (**b**) The dotted line represents the imaginary line of Lourié (2 cm posterior and parallel to Cooper's ligament) which demonstrates the dissection is not complete until the peritoneum is dissected well beyond this line to prevent lateral roll up of the mesh, i.e., an adequate landing zone for the mesh. (**c**) Step 7 is completed demonstrating the proper lateral landing zone for the mesh

nary inter-ASIS line and any defects thereby avoiding recurrence and nerve injury, especially to the ilioinguinal and iliohypogastric nerves (Fig. 1.9a).

9. Place the mesh only when items 1–7 are completed, and hemostasis has been verified. Mesh size should be at least 15 × 10 cm, although a larger piece of mesh is sometimes required to cover the MPO. Preferably, choose a mesh that adapts to the contour of the space and the cord's elements. It should not have undue memory. Place it without creases or folds. Avoid splitting the mesh. Ensure that its lateral inferior corner lies deep against the wall and does not roll up during space deflation (use glue or careful suturing if necessary) (Fig. 1.9b).

To demonstrate the importance of following the steps of achieving the critical view of the MPO several cases where surgeons inade-

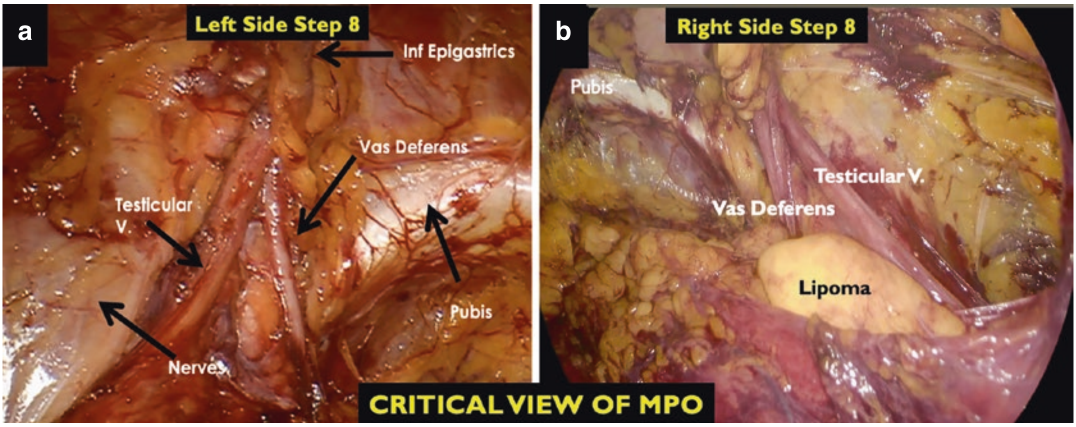

Fig. 1.8 The critical view of the MPO has been achieved and this is the view the surgeon should achieve before placing mesh. The landmarks are labeled. (**a**) Step 8 left side. (**b**) Step 8 right side

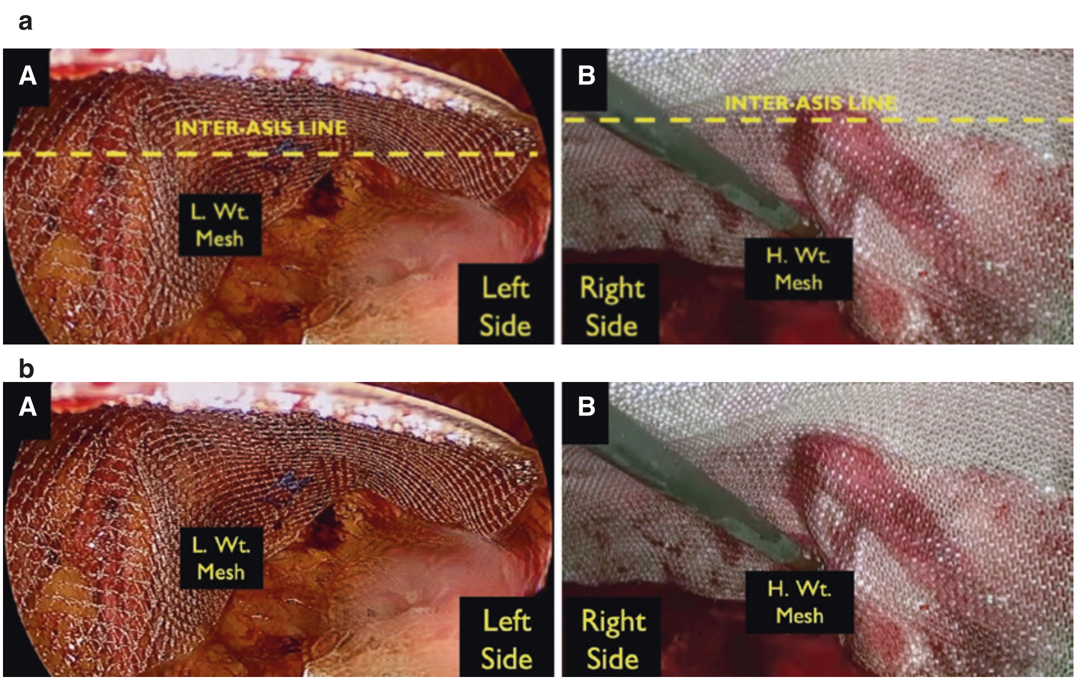

Fig. 1.9 (**a**) The figure demonstrates step 9, how a mesh, large enough to cover the entire MPO, should be placed without folds or wrinkles. (*A*) The left side with a lightweight preformed mesh. (*B*) The right side with a regular weight preformed mesh. (**b**) The inter-ASIS Line (the dotted line) represents the limit for placement of penetrating fixation. If fixation of the mesh is used, no penetrating fixation should be placed below it. (*A*) A left inguinal repair. (*B*) A right inguinal repair

quately performed the steps of the critical view of the MPO are presented. They demonstrate how this results in an inadequate landing zone for mesh placement causing wrinkling, folding, or eventual clam shelling of the mesh (Figs. 1.10, 1.11, and 1.12) In a fourth case, the surgeon failed to identify the lipoma covering the iliopubic tract in step six and this resulted in retained lipoma and a second operation to remove the symptomatic lipoma (Fig. 1.13).

Fig. 1.10 There was an inadequate dissection of the lateral zone, step 7, which resulted in the mesh resting against the peritoneum and will result in clam shelling of the mesh. The arrow indicates the point where the mesh is resting against the peritoneum as the peritoneum is reapproximated

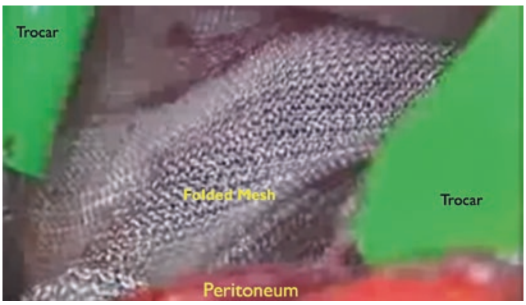

Fig. 1.11 Inadequate dissection of the MPO leads to a folding of the mesh during a TEP repair which will lead to elevation of the mesh as the peritoneum reexpands

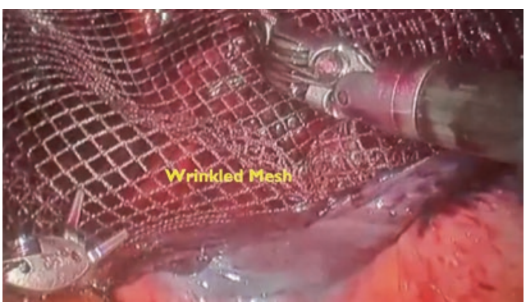

Fig. 1.12 Inadequate dissection of the MPO leads to crinkling of the mesh during a TAPP repair which may lead to increased chronic pain

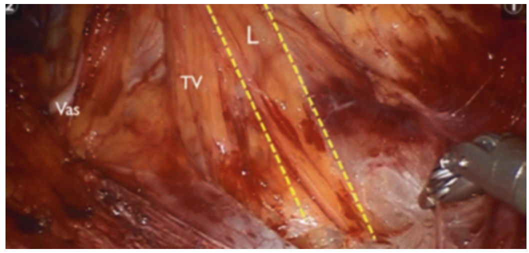

Fig. 1.13 In this case, step 6 was not completed and the lipoma (L) outlined by the dotted lines was not dissected leading to a second operation because of continued symptoms. TV testicular vessel, Vas vas deferens

1.2 Conclusion

Understanding the critical view of the MPO for safe MIS inguinal hernia repair is really understanding the seven steps required to achieve the final view of the MPO and only then applying steps eight and nine to properly place mesh to cover the entire MPO. Again, the order of the steps can be varied according to surgeon preference and the patient's hernia, but no step can be omitted. If steps are omitted or are inadequately completed, we feel that the incidence of recurrence or complications will be increased therefore negating the advantages of an MIS inguinal repair.

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Part II

Newer Procedures in Inguinal Hernia Surgery

2 Inguinal Hernia Repair by Enhanced View Totally Extraperitoneal (eTEP) Approach

Luis Gabriel González, Andrea González, and Esteban Varela

The time has come that almost all cases of hernia can be operated, not only without risks for the patient, but also with almost certainty of success.

William Halsted

2.1 Where Does the eTEP Concept Come From?

This new concept was described by Dr. Jorge Daes, a Colombian surgeon, in 2009. The idea of this novel innovation came from the difficulties faced when operating with the classic Totally Extraperitoneal (TEP) approach, which offers a reduced surgical field with poor tolerance to accidental peritoneum disruption. The inadvertent pneumoperitoneum collapses the workspace thus making the procedure more challenging. Furthermore, with classic TEP, there was a poor ergonomic position, which did not allow variations in the location of the working ports, and in patients of short stature or with a short distance from the umbilicus to the pubis, the difficulty of the TEP technique was also increased [1].

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The new concept developed by Professor Daes was named eTEP, the "e" preceding the acronym TEP meaning extended view or enhanced view. This technique shares the same basis as TEP, in which entrance to the peritoneal cavity is avoided. The main difference lies in the positioning of the camera port, which is located in a more cephalad position and lateral to the midline. This modification provides a larger workspace, a more flexible location of the working ports therefore facilitating the performance of various surgical maneuvers.

2.2 Indications and Case Selection

The eTEP approach is particularly useful in cases of large, or incarcerated inguinal hernias, in obese patients, or in patients with a history of laparotomy, post-bariatric surgery patients (because the approach is made above the redundant skin left after the procedure, not through it as in TAPP or classic TEP), and in those with a short umbilical to pubis distance [1]. In emergency cases, once the peritoneal cavity has been examined and the acute pathology has been

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resolved, the extraperitoneal space is accessed and the inguinal hernia may be treated in a separate space free of contamination.

2.3 Contraindications

Severely ill patients with limited physiological reserve are not good candidates for minimally invasive interventions, especially if the respiratory system is compromised. In these cases, an anterior approach under local anesthesia is recommended (i.e., classic Lichtenstein).

The eTEP approach is not recommended for patients who, due to their occupation (e.g., modeling or athletes), do not accept a more cephalad port access scar. Patients with a history of surgery with an extraperitoneal technique with mesh should not be approached by the eTEP technique. In addition, in cases of pelvic irradiation for cancer treatment (e.g., prostate) that result in increased fibrosis and high risk of injury, an open anterior approach is recommended, according to the existing management guidelines. In expert hands, selected cases with the abovementioned conditions may be approached by minimally invasive technique, but in general, this is not recommended as a standard approach. Large, irreducible or chronically incarcerated hernias, or those with loss of domain should not be subjected to this approach. Lack of proper training in hernia surgery and unfamiliarity with the technique should also be considered contraindications.

2.4 Instruments and Energy Source

- Laparoscopy tower
- Dissecting balloon (optional)
- One 12 mm trocar and two 5 mm trocars
- One grasper
- One Maryland
- One scissors
- Monopolar energy
- Medium-high density macroporous flat mesh
- Fixation device (optional and according to each case)

The eTEP approach allows one to perform an inexpensive procedure, without the use of balloons, advanced energy device or fixation. One may even use fewer resources than with the classic TAPP technique.

2.5 Team Organization, Anesthesia, and Position

Preparation begins from the preoperative period. Patients are made to void urine before entering the operating room as a routine. A urinary catheter is only indicated in patients who have had previous pelvic surgery such as prostate, gynecological, or in the case of a recurrent hernia.

The procedure is performed in majority of patients under general anesthesia. In selected cases, this approach can be performed under spinal anesthesia or even with controlled TAP block or local anesthesia. However, this procedure is reserved only for expert surgeons.

An ergonomic position is essential. It is important to check that the arms are in the tucked-in position while keeping the anesthesia drapes flat during the procedure since it may limit the excursion of the elbow of the surgeon handling the camera.

It is always recommended to record the procedures, as it allows peer review, as well as improving the surgeon's performance and that of the trainees.

The operating room setting depends on the side to be operated upon. A right-sided hernia requires the laparoscopy tower to be placed at the patient's right foot, while the surgeon and assistant stand on the left side. For the left-sided hernia, the setting mirrors right side, this is laparoscopy tower on left side and assistant surgeon on the right. (Figs. 2.1 and 2.2). When the hernia is bilateral, the tower is centered at the patient's feet and if there is a double screen, one is located on each side towards the patient's feet.

Fig. 2.1 Right-sided hernia. Video tower on the right side, surgeon's assistant to the right of the surgeon. Adequate and ergonomic position of the surgical team

Fig. 2.2 Left-sided hernia. Video tower on the left, surgeon's assistant to the left of the surgeon

2.6 Technique and Key Steps

The initial incision for a conventional eTEP is made 5–7 cm lateral to the midline and 3–5 cm above the umbilicus, although as aforementioned, one of the benefits of eTEP is the flexibility to locate the camera port as needed. With experience, it is feasible to approach the extraperitoneal space from any location, even above the costal margin as the innovators of the technique have shown. The distribution of the trocars in the classic TEP approach places the optical port at the umbilicus and two working ports in the infraumbilical midline, giving insufficient amplitude to the dissection and mesh deployment maneuvers (Fig. 2.3). With the eTEP approach, the camera is located more cephalad, and the working ports are placed almost to the level of the umbilicus (Fig. 2.4), even in the case of bilateral inguinal hernias, which result in a more comfortable dissection in cases of large hernial sacs or the manipulation of large mesh.

Fig. 2.3 Distribution trocars in classic TEP. Limited workspace

Fig. 2.4 Trocars of flexible distribution in eTEP. Improves ergonomics and triangulation

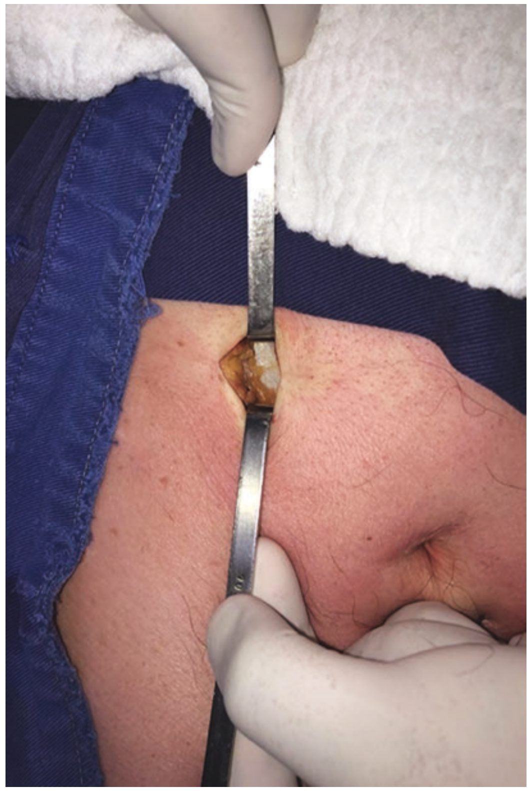

Fig. 2.5 Anterior sheath of the rectus abdominis muscle

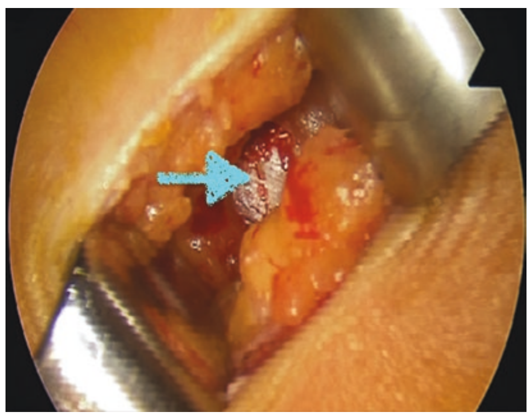

Fig. 2.6 Posterior sheath of the rectus abdominis muscle

To make the first port, a 12-mm incision is made followed by blunt dissection with the spacers or digitally until the rectus abdominis muscle aponeurosis is reached (Fig. 2.5). Next, the anterior sheath is incised, although it seems obvious, it is worth recommending that the cutting edge of the scalpel (11 or 15) always be kept upwards to avoid injuring the blood vessels that supply the muscle and avoid bleeding to keep the operative field clean. Once the muscle is exposed, a careful splitting of the fibers is carried out until the posterior sheath of the rectus abdominis is exposed (Fig. 2.6). Once this site is completed, a retro muscular digital tunneling (Fig. 2.7) is performed in the following fashion:

A. If a dissecting balloon is available, it is inserted until it reaches the pubic bone, then it is withdrawn about 1 cm (Fig. 2.8). Insufflation is performed under direct vision, always trying to identify the anatomic structures and details of the type of hernia to be repaired (Figs. 2.9 and 2.10). An important caution is not to over-insert the balloon or inflate it behind the bony ring of the pelvis, as this generates traction and tears in the blad-

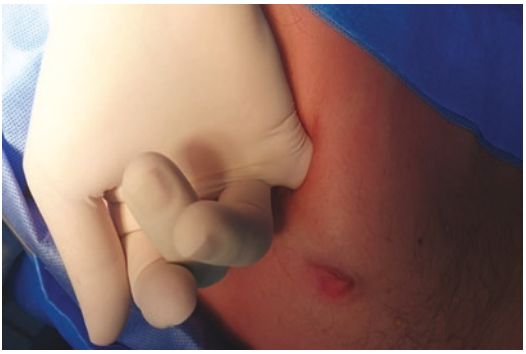

Fig. 2.7 Retromuscular digital dissection

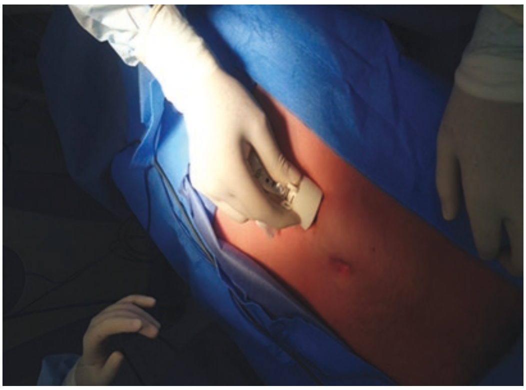

Fig. 2.8 Insertion of trocar with dissecting balloon. Cephalo-caudal direction

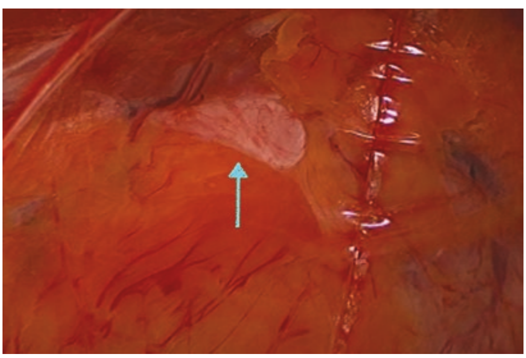

Fig. 2.9 Blue arrow indicates transversalis fascia, elongated. Intra-balloon view. Left side

der, especially in men at the bladder neck due to the fixation made by the prostate. The balloon is left inflated for 90–120 s to achieve mechanical hemostasis by pressure and thus have a drier surgical field. After the dissector

Fig. 2.10 Blue arrow points to a lateral hernia. Red arrow indicates the inferior epigastric vessels. Intra-balloon view. Right side

balloon is removed, a 10/12 mm port is placed and CO_2 is at a pressure of up to 12 mmHg is insufflated. Two 5 mm working ports are placed, depending on the defect to be repaired. Before introducing the working ports, the trajectory is identified with anesthetic needle. It is also recommended the use of a spinal needle, which is longer than a conventional one, which may be of use in tall and obese patients. The first 5 mm working trocar is inserted at the level of the umbilicus and directed towards the pubis. With this working port, the dissection is extended medially and laterally and the second 5 mm port is inserted always visualizing the epigastric vessels. The ports must be positioned in a way that triangulation is achieved.

B. If a dissector balloon is not available, the initial creation of a tunnel with a 12 Hegar dilator and then the insertion of an optical trocar is recommended. The camera lens may be advanced gently until it touches the pubis. The use of CO_2 at high pressures is not recommended, although it is described by some authors, nor is blind dissection recommended with lateral oscillating movements of the telescope since this maneuver can easily cause bleeding. The use of a zero-degree front vision lens is not required [2]. After creating this initial tunnel, a port is introduced at the level of the umbilicus, orienting the trocar towards this space, which, although limited, already gives us direct vision

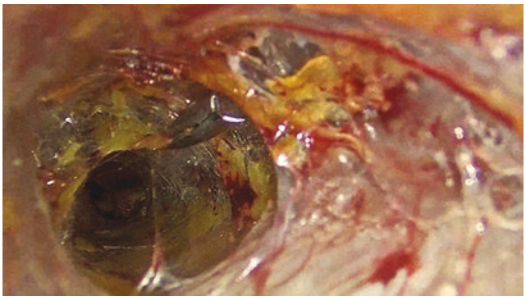

Fig. 2.11 Creation of the space without dissector balloon, the central tunnel, and the insertion of the umbilical port are shown

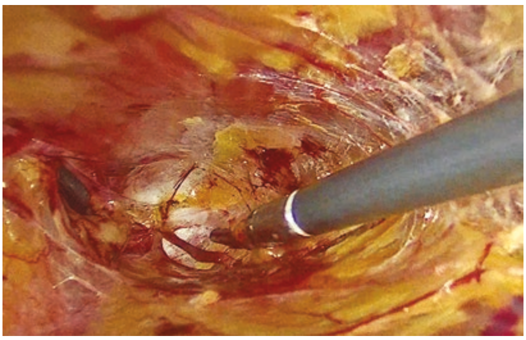

Fig. 2.12 Approach without dissecting balloon. Following step in dissection, done with the umbilical trocar only. The Retzius space is shown

(Figs. 2.11 and 2.12). The trocar is placed with the aid of a spinal needle and a Maryland forceps with monopolar energy is inserted through this port. Some recommend using another type of energy such as ultrasonic or advanced bipolar, but it has been shown that it is not necessary. With this working port, the space created allows the second working port to be inserted for dissection of the inguinal region to be repaired.

The division of the Douglas aponeurotic arch is a very useful maneuver in eTEP. A blunt dissection is performed taking care not to injure the peritoneum (Fig. 2.13). It is important to learn this maneuver if we want to expand the application of the eTEP approach, or to perform TAR from the bottom up. Even a small incision allows the expansion of the space and aids the execution of additional maneuvers. If the vision is not clear

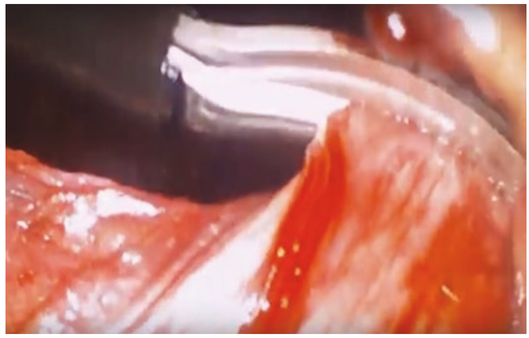

Fig. 2.13 Scissors cutting the Douglas aponeurotic arch, maneuver that allows the expansion of the working space

from the most cephalad port of 10 mm, a 5 mm lens can be used, inserting it through one of the lower ports, allows the surgeon to see from below the peritoneum to be detached.

Once the camera and working ports have been placed and have the appropriate amplitude and ergonomics, the orderly and systematic dissection of the myopectineal orifice of Fruchaud is carried out, following the nine steps of the critical view of safety described by J Daes and Ed. Felix [3].

1. Identifying pubic tubercle and Cooper's ligaments (CL).
2. Dissect direct hernia space in the Hesselbach triangle.
3. Dissect space of Retzius.
4. Dissect between CL and iliac vein to exclude femoral hernia.
5. Dissect peritoneum of indirect hernia sac and parietalize the cord structures.
6. Identify and reduce cord lipomas.
7. Dissect space lateral to cord elements.
8. Establish a critical view of myopectineal orifice (MPO).
9. Mesh placement.

When the dissector balloon approach is performed, steps 1 and 2 are completed with the intra-balloon view therefore it is necessary to be careful of the visual control of the insufflating balloon (Fig. 2.9). If performed without a balloon, the osseous pubic ring is exposed, identifying the pubic symphysis and 2 cm on the contralateral side, which is very important, espe-

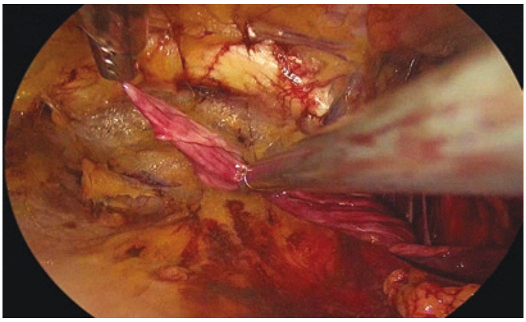

Fig. 2.14 Wide retropubic dissection and lateral hernial sac reduced and rotated on its axis, this should be located behind the mesh

cially in direct defects; thereafter, any fat in the Hesselbach area is removed to rule out direct defects.

For step 3, the retropubic dissection is performed up to 2 cm below the Cooper's ligament to create a space between the bladder and the pubis, allowing the mesh to lie in this space and thus preventing displacement when the bladder is full (Fig. 2.14). Then, the femoral ring is explored (step 4) to rule out hernial sacs or lipomas.

Although every step requires special care, the most demanding one is the dissection of the lateral hernial sac and its detachment from the elements of the cord in men or the round ligament in women (step 5). This must be done gently by exerting traction on the peritoneum medially and a lateral countertraction on the elements of the spermatic cord or round ligament. The elements of the cord must be manipulated by traction and dissecting the areolar tissue around it without grasping them with the forceps, paying special attention as manipulation of the vas deferens can cause postoperative pain due to its innervation. Sharp dissection or energy can be used, if necessary, in very selected cases and away from the deep inguinal orifice to reduce the risk of injury to the genital branch of the genitofemoral nerve. After this dissection, cephalad traction of the sac is made, and it is located behind the mesh (Fig. 2.14). The level of dissection is adequate when, when pulling or mobilizing the peritoneal sac, it does not transmit these movements to the cord, and it stays on the pelvic floor.

Although there is controversy in this regard, in young and nulliparous women, an attempt should always be made to preserve the round ligament, considering that this structure hypertrophies and becomes important during pregnancy. On the other hand, in older postmenopausal women, with parity it can be sacrificed using monopolar energy. We should always verify hemostasis since, due to its vascularization, it may cause postoperative hematomas.

The next step is the inspection of the inguinal canal to rule out and reduce (if present) cord lipomas (step 6). Leaving them in situ will generate a mass sensation in the area and recurrence of the hernia. For this reason, the deep inguinal ring should be explored by exerting external pressure at the level of the abdominal wall and using a grasper the fat pads that are identified are pulled (Fig. 2.15). Typically, the cord lipoma is located lateral to the peritoneum, and when the iliopubic tract is exposed it confirms that there is no longer any fat/lipoma in the inguinal canal. It is important to differentiate the lipoma from other structures such as the lymph nodes. Lipomas are generally lighter yellow, smooth, and shiny with a soft and compressible texture, while lymph nodes are a more brownish yellow, have nodularity that are firmer, typically are not easily compressible, are mobile, bleed easily, and therefore they should not be manipulated. In addition, it is very important to identify the fat that goes with the spermatic fascia along with the cord, characterized by the presence of fine longitudinal vessels that follow the same direction as the cord; this fatty tissue must not be removed.

Step 7 is the lateral dissection to create the Bogros space beyond the anterior superior iliac spine. For this dissection, the superficial fascia with

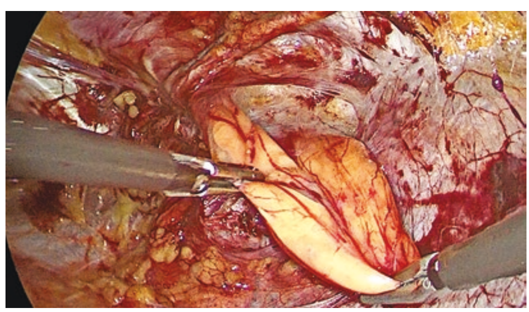

Fig. 2.15 Removal of hernial lipoma from the inguinal canal

its fatty layer must always be preserved, and it must remain adhered to the muscle wall because it is an excellent insulator of the nerve branches and will reduce the risk of chronic postoperative pain [3].

Once the previous steps have been completed, a visual inspection of the entire dissected area (step 8) is carried out to evaluate the critical view of MPO and to verify that there are no bleeding spots or foreign elements. If the previous step is satisfactory, the next step (step 9) is the introduction and installation of a minimum 15 × 12 cm prosthesis, that should be medium to high weight. The mesh is introduced rolled vertically (Fig. 2.16) from lateral to medial, and when it falls into the preperitoneal space it is held from the upper and medial corner and deployed laterally using a grasper, and finally placed in its final position (Fig. 2.17). One of the benefits of working in a large space is the ease of handling large

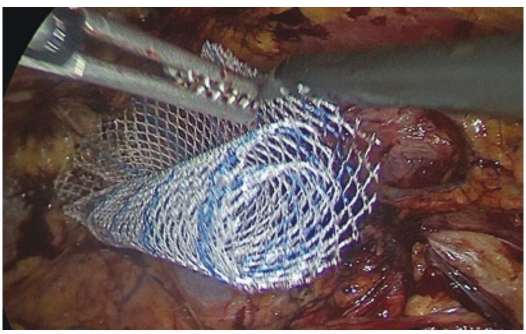

Fig. 2.16 Aspect of the mesh inserted vertically

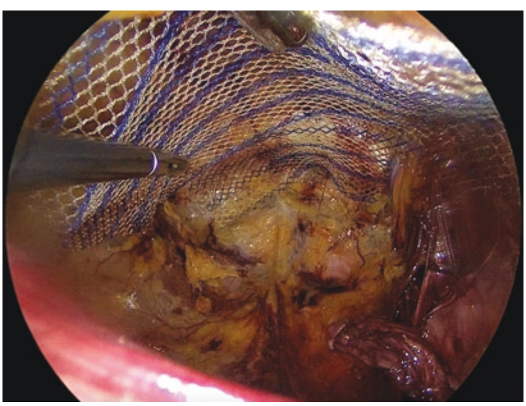

Fig. 2.17 Unrolling of the mesh

prostheses. Routine fixation is generally not required as it is only required for recurrent or large medial defects (M3). If mechanical fixation is required, care must be taken that the tackers land at least 2.5 cm above an imaginary line between the anterior superior iliac spines to avoid nerve injury, particularly to the ilioinguinal nerve. Only four tacks are used, distributed in the following fashion:

- Medial and lateral tacks are applied to the ligament just anterior to the Cooper's ligament without compromising the bone to avoid postoperative osteitis and pubalgia.
- Two superior tacks, one in the upper internal corner of the prosthesis and one just lateral to the epigastric vessels, are applied under visual control.

Other alternative fixation methods include fibrin sealants or the use of self-fixing meshes, options that have not been shown to be superior to the use of selective fixation when used correctly.

With the mesh in its final position, the pneumo-preperitoneum is evacuated in a visually controlled way. The carbon dioxide inlet is closed, one of the 5 mm ports is opened, and it is observed how the cavity collapses, leaving the mesh in its final location [4].

When left unfixed, a grasper can be used on the lateral inferior corner and on the retropubic border to reduce the possibility of creasing or curling of the mesh at the lower edge. Another useful maneuver is to inflate the cavity again and visually verify that the prosthesis does not have wrinkles or displacements that warrant correction. If not, the gas is evacuated, and the working cannulas are removed.

The incision of the anterior sheath of the rectus abdominis is closed with 2-0 polyglactin suture and the skin with intradermal suture.

2.7 Tips and Tricks

In the case of large direct hernia sacs, it is suggested to reduce the elongated transversalis (Fig. 2.18) fascia (pseudosac) and fix it to the

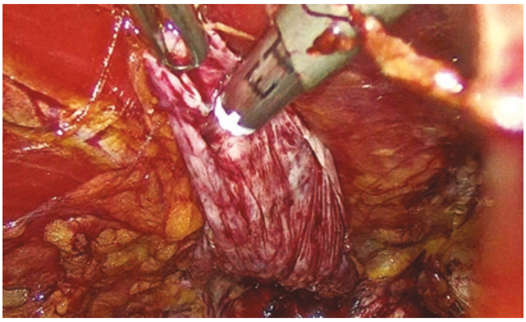

Fig. 2.18 Elongated transversalis fascia in a large direct defect. Reduction and fixation of the fascia to the abdominal wall is shown

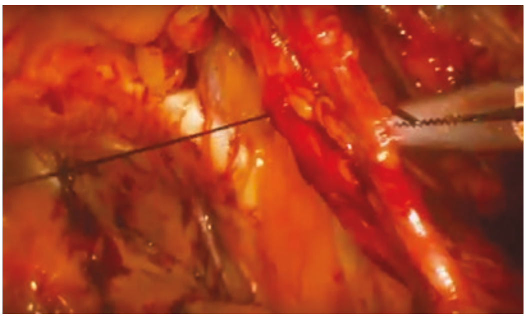

Fig. 2.19 Ligation of a large inguinoscrotal hernial sac

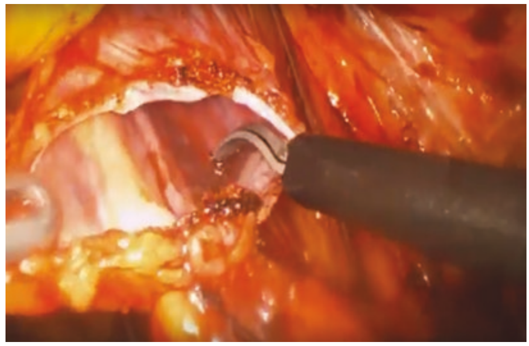

Fig. 2.20 Distal aspect of sectioned inguinoscrotal sac. It is very important to verify the adequate hemostasis

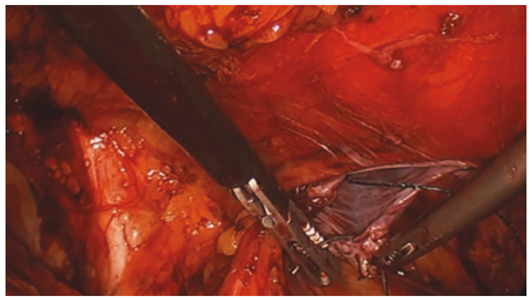

Fig. 2.21 Fixation of the edge of the distal segment of the sac to the anterior abdominal wall with barbed suture

posterior aspect of the rectus abdominis with a tacker or barbed suture. It has been found that this reduces the possibility of seroma formation and gives a greater contact area of the mesh to the wall to achieve better integration of the same.

In large inguinoscrotal sacs, it is recommended to make a proximal dissection of the sac and avoiding a complete reduction to prevent its detachment from the bottom of the scrotum, since this is associated with more complications such as chronic pain, ischemic orchitis, hematomas, and hematoceles. It is recommended to release it from the spermatic cord, ligate it proximally with an endoloop or external suture (Fig. 2.19) and section it, taking care that the edges are completely dry, ensuring hemostasis (Fig. 2.20). This distal sac is then reduced by exerting external pressure and internal traction with a grasper, it is opened at the upper edge to leave a wider opening and then attached from the upper edge to the upper to the medial abdominal wall with a barbed suture or a tacker to maintain the sac opened and reducing the possibility of hydrocele formation (Fig. 2.21) [5].

2.8 Complications and Management

A specific complication of this technique is accidental penetration of the cavity or accidental rupture of the peritoneum. When experience has been gained, these situations can be solved by looking for the edge of the peritoneal defect through which the cavity was entered, pulling the edge of the peritoneum, and performing dissection in a higher and lateral location. It is possible to recover repositioning in the dissection area and recover the preperitoneal dissection space.

An additional advantage of this approach is the good tolerance to accidental peritoneal tears that can generate some degree of pneumoperitoneum. However, unlike the classic TEP, in the eTEP approach, the amplitude of the space is maintained without collapsing allowing the surgery to progress comfortably [6].

Another complication, although not frequent, is the postoperative appearance of hematomas and ecchymoses, most of which do not have clinical significance and resolve spontaneously with conservative management. If the hematoma is very large, it may generate complications (infection, displacement of the mesh, etc.). A CT scan should be performed and an interventional radiology image-guided puncture and drainage of the same is indicated.

Other possible complications that occur very occasionally are bladder injuries. These occur due to traction of the bladder when the balloon is over-inserted behind the pubis, or when there is a history of previous pelvic surgeries that generated scars and fibrotic tissue, which is teared during dissection in steps 1, 2, and 3 of the critical view of safety. Management can be done by minimally invasive technique depending on the location of the injury and the expertise of the surgeon. The bladder is repaired in two layers with sutures and if the resolution of the complication is satisfactory, the hernia surgery is continued as usual. It is recommended to leave a urinary catheter after the repair for 10 days.

Another rare complication is the injury of the external iliac vessels, especially the external iliac vein that may occur when there is a history of pelvic surgery. Treatment consists of initial control of bleeding in the area, by using pressure. Then, the damage is evaluated, and it is decided whether the operation should be converted to an open procedure or can be continued laparoscopically depending on the expertise of the surgeon and the resources available. If this occurs in a tertiary care hospital and if a vascular surgeon is available, their help should be sought.

2.9 Conclusion

In conclusion, the eTEP approach improves ergonomics and facilitates inguinal hernia repair, always allowing the surgeon to work in the extraperitoneal space with all the advantages that it offers. Besides improving groin hernia repair in difficult situations, it has the enormous benefit of introducing the surgeon to a world of new surgical options such as the repair of lateral hernias, lumbar hernias, the possibility of treating chronic postoperative pain (extraperitoneal triple neurectomy), and midline hernias [7].

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3 Robotic Transabdominal Preperitoneal Repair (rTAPP) for Groin Hernia

Desmond Huynh, Shruthi Nammalwar, and Shirin Towfigh

3.1 Indication and Case Selection

As surgery is the only definitive management of inguinal hernias, the primary goal is to perform a safe and effective repair with low risk and low recurrent rates. Most studies support a minimally invasive approach with mesh as the technique with the best short-term recovery, best long-term outcomes, and lowest risk of chronic pain [1]. This is especially true for women with hernias, where a minimally invasive repair with mesh is considered the preferred approach [2].

Laparoscopic approach is considered to be difficult to master, with some suggesting a learning curve of 250–500 cases [3, 4]. The introduction of robotic approach (rTAPP) to the same repair has increased the adoption of minimally invasive approach for inguinal hernia repair, as many find the robotic approach to be technically easier. In a study of 170 rTAPPs completed by three surgeons, the learning curve to achieve 90% proficiency was 43 inguinal hernia repairs [5].

Indications for the application of robotic technology to inguinal hernias are similar to indications for laparoscopic repair. These are listed in Table 3.1. In addition, there are studies that support robotic approach to less conventional or technically more challenging operations, as the robot can provide additional dexterity. Examples include operating for retroperitoneal inguinal mesh removal or in a patient with a history of prior laparoscopic inguinal hernia repair with mesh [6, 7]. In the obese, the robotic platform may confer less resistant tissue handling as compared with laparoscopic surgery [8]. Hernia size is not typically a determinant of whether an open or minimally invasive approach should be chosen. One study introduces a novel non-mesh robotic iliopubic tract repair (r-IPT) for low-risk patients with small inguinal hernias [9].

Table 3.1 Indications for rTAPP

Absolute indications:
Bilateral inguinal hernias
Femoral hernia
Recurrence from prior open inguinal hernia repair
Relative indications:
Female with inguinal hernia
Obesity
Unilateral inguinal hernia
Recurrence from prior laparoscopic or robotic inguinal hernia repair
Concomitant retroperitoneal inguinal mesh removal
Concomitant hernia repair with other robotic surgery, e.g., prostatectomy
Small inguinal hernias in low-risk patients where non-mesh iliopubic tract repair (r-IPT) is feasible

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3.2 Contraindications

Similar to laparoscopic repairs, there are a few contraindications to the use of the robot for inguinal hernia repairs. These are listed in Table 3.2. In order to provide safe and effective hernia repair, it is important that the surgeon always consider the safety of the patient and not place their own eagerness to engage in technologically advanced surgery ahead of the best interests of their patient. For example, robotic surgery implies the need for general anesthesia. Thus, patients who would be intolerable to general anesthesia, e.g., due to cardiorespiratory risk factors, should not be offered robotic surgery. Also, rTAPP involves standard trocar placement in the mid-abdomen. Unlike laparoscopic surgery, there are limited options with robotic surgery trocar placement variations. Thus, if there is a stoma in the area, or there are severe adhesions between the trocar placement and the inguinal hernia, e.g., after pelvic exenteration surgery, then robotic approach may not be the safest option for the patient.

In patients with known Crohn's disease, it is preferred that intraperitoneal operations be limited, and thus the rTAPP may not be the best approach for such patients. In emergent or urgent situations, e.g., incarcerated or strangulated inguinal hernias, many prefer the robotic approach, as they can reduce the hernia contents and address any need for intestinal resection robotically. The surgeon should weigh the feasibility of robotic surgery with the clinical condition of the patient in order to make the safest decision for an operation.

Table 3.2 Contraindications to rTAPP

Absolute contraindications:
Contraindication to general anesthesia
Coagulopathy
Hostile abdomen, e.g., severe intestinal or pelvic adhesions
Prior significant pelvic surgery, e.g., pelvic exenteration
Relative contraindications:
Prior nonsignificant pelvic surgery, e.g., prostatectomy
Crohn's disease
Lower abdominal colostomy, ileostomy, or urostomy
Sepsis with clinical instability, e.g., due to strangulated hernia
Need for anticoagulation

The risk of bleeding with rTAPP is quite low. However, if there is any bleeding, and the patient is anticoagulated for any reason, then there is the risk that clinically significant hemorrhage may go undetected due to the wide preperitoneal dissection; clinically critical hemorrhage following an open anterior approach is less likely [10]. Thus, choosing rTAPP in patients with the need for anticoagulation should be done judiciously and on a case-by-case situation.

3.3 Instruments and Energy Source

At this time, the only robotic surgery option available in the United States is the da Vinci robot platform by Intuitive Surgical, Inc. Thus, the discussion of specific instrumentation will be limited to those from the da Vinci platform.

In general, the robotic approach will require a camera and at least two trocars for instruments. The dominant hand should use shears and the nondominant hand should use an atraumatic instrument (Fig. 3.1). The best choice of atraumatic instrument is one that would not tear the peritoneum and would not crush critical structures, e.g., herniated contents. For the da Vinci, this may be the bipolar fenestrated graspers. Alternatives such as the Prograsp instrument have too strong of a grip to allow for safe hernia repair; the Cadiere™ grasper does not have bipolar capability, making it less efficient of an instrument choice. The newer Force Bipolar is a hybrid instrument which offers varying grip strengths and bipolar capability.

It is traditional to directly sew robotically if there is any need for fixation of the mesh or closure of the peritoneum. This may be different from laparoscopic techniques where tacking and/or fibrin glue may be used for mesh fixation and/or peritoneal closure. Various robotic needle holders are available for this purpose, including those that include a cutting mechanism. In gen-

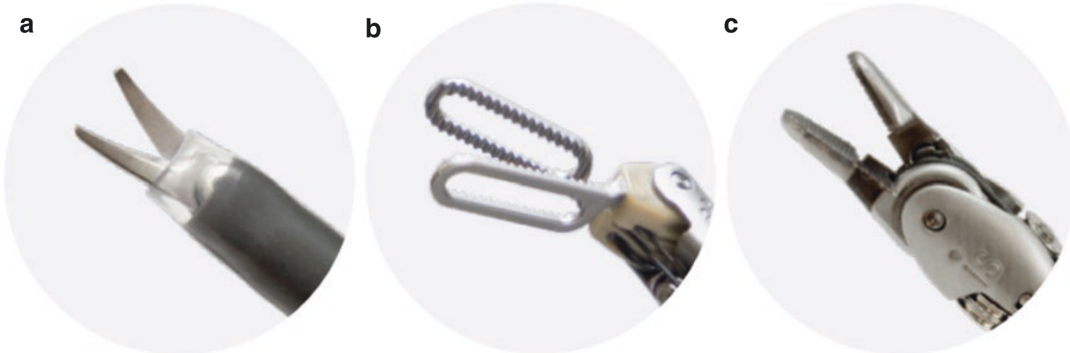

Fig. 3.1 Sample instrument choices for rTAPP using the da Vinci platform. (**a**) Sample shears with monopolar cautery. (**b**) Sample atraumatic grasper with bipolar cautery. (**c**) Sample needle holder with cutting capability

eral, to save costs, try to minimize the use of instruments to no more than three.

Cautery is used judiciously during rTAPP. In general, sharp dissection is preferred around the important nerves and the spermatic cord structures. All other areas may be safely dissected or cut with the additional use of electrocautery. The shears may be connected to monopolar cautery as needed. The atraumatic instrument of choice may be connected to monopolar cautery.

Trocar placement is in a standard manner for most inguinal hernia operations: a central trocar is for the camera, and instruments are placed left and right lateral and in line with the camera trocar. With the da Vinci system, the trocars are usually placed 8 cm apart. Most patients can have their mid-abdominal trocar placed at the umbilicus. In patients with a short torso, the camera and instrument trocars may need to be placed more cephalad, to maintain at least 10 cm distance from the pubis. In some situations, such as larger hernias or more complex operations, the surgeon may wish to add a fourth lateral trocar (Fig. 3.2). This can serve as an Assistant's working ports, e.g., to introduce mesh and sutures. It can also work as a third robotic instrument to help with retraction.

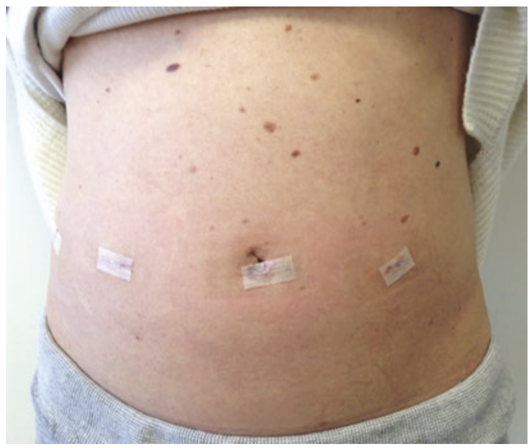

Fig. 3.2 Trocar positioning for rTAPP

Mesh choice is based on the needs of the patient. Most brand-name meshes provide a standard size for mesh, usually 10 × 15 cm to 12 × 16 cm. Mid-weight meshes, >90 g/m^2, are the most frequently used products. Though heavier weight meshes have been associated with higher risk of chronic pain, it may be preferred to use such meshes in very large indirect inguinal defects or broad wide direct hernias [11]. There is a growing trend toward preferring lighter weight meshes, for presumed lower risk of mesh-related chronic pain. However, they are at higher risk of meshoma, hernia recurrence due to mechanical failure, or central mesh fracture [12]. Due to the preperitoneal position of rTAPP inguinal hernia, there is no indication for any coated or barrier mesh. In fact, two studies in 2021, one presented at the Academic Surgical Congress by Todd Heniford's team and another presented at the Western Surgical Association by Michael Ujiki's team, show a higher risk of recurrence and complications when barrier meshes are placed extraperitoneally (Manuscripts are *in Press*).

The mode of mesh fixation can include the use of self-fixating mesh, sutures, tacks, adhesives, or no fixation altogether. While there is little evidence to support one mode of fixation over another, fixation should be guided by similar principles of minimizing chronic pain while preventing migration of the mesh and thereby recurrence.

As part of rTAPP, the peritoneal flap is made and must be closed as the last stage of the operation. This usually involves suture. While some find the barbed stitch more facile than standard absorbable suture, there are risks associated with closure that are discussed later in this chapter.

3.4 Team Setup, Anesthesia, and Position

The patient is placed supine with arms padded and tucked (Fig. 3.3). The patient is placed in Trendelenburg to reduce pelvic contents, as the rTAPP is a transabdominal approach. This allows for safer operating in the groin. The amount of Trendelenburg is dependent on the amount of pelvic content that requires reduction. To protect the patient from sliding off the operating table, padding that offers extra resistance can be added (Fig. 3.4). This is especially important as, unlike laparoscopic surgery, the robot is docked and secured directly to the patient. There is commercially available padding for this purpose as well.

Fig. 3.3 Patient positioning

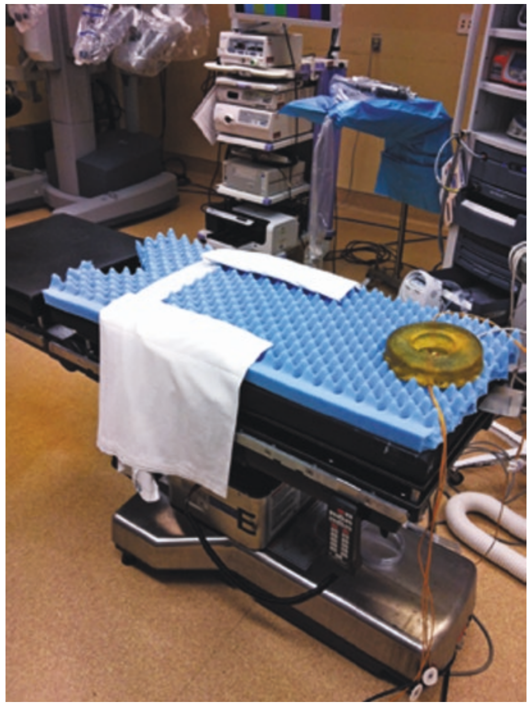

Fig. 3.4 Padding of the operating table to prevent sliding of the patient during Trendelenburg positioning

As is typical for robotic operations, the surgeon is positioned at a distance away from the patient, at the surgeon's console. An assistant is at the bedside, changing instruments and possibly assisting via an Assistant's port. The most recent iteration of the da Vinci robot (Xi) allows for side docking of the robot for all inguinal hernias. The prior models (e.g., Si) require side docking or parallel docking at the ipsilateral side of the hernia or docking in between the legs with the patient placed in low lithotomy.

As with all minimally invasive operations, general anesthesia with full muscle relaxation is the standard. Though there are reports of performing laparoscopic surgery under spinal anesthesia

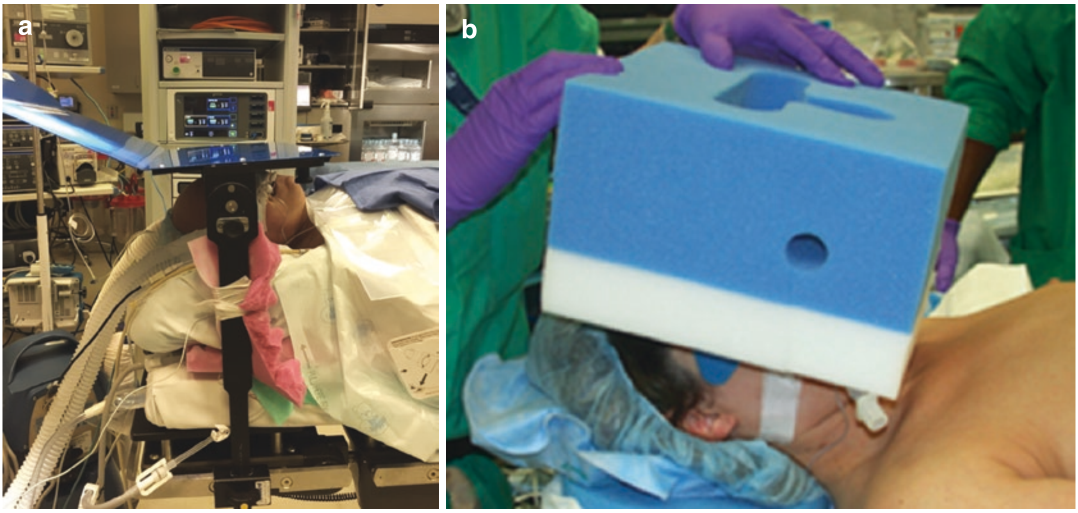

Fig. 3.5 Modalities to help protect the patient's face from the robotic arms during rTAPP. (**a**) Secured metal tray, sometimes referred to as a "butler." The lowest edge of the tray is positioned at the patient's chin level. (**b**) Thick sponge placed over patient's face to protect from robotic arms

or laryngeal mask ventilation without full paralysis, that is not considered safe with the robotic surgery platform. This is because of the risk of the patient moving while the robot is attached to the patient with instruments inside the abdomen.

Maintaining safe use of the robotic platform is of utmost importance. For pelvic operations, such as inguinal hernias, the robotic arms are at risk of hitting and injuring the patient's chest and face during the operation. Thus, it is important that there is clear communication with the anesthesiologist to confirm that there are no robotic arms near the face throughout the operation. The use of a facial barrier, such as a thick sponge or a metal secured tray, can help prevent the robotic arms from hitting the face (Fig. 3.5).

The use of urinary catheterization during rTAPP is not standardized. There are reports that the benefits of urinary catheterization during pelvic surgery outweigh its risks [13]. Standard abdominal preparation is performed sterilely.

3.5 Key Steps

Robotic inguinal hernia repair is performed transabdominally, similar to laparoscopic transabdominal preperitoneal approach (TAPP). The steps have been nicely outlined by Daes, Felix, and others [14, 15]. As with all TAPP, rTAPP starts with an abdominal approach and 15 mmHg CO_2 insufflation. After the intraperitoneal contents in the hernia are reduced, then the peritoneal takedown starts at least 5 cm cephalad from hernia (Fig. 3.6). The initial dissection starts near the anterior superior iliac spine. Initial incision will allow for the CO_2 to help dissect the planes. Wide careful dissection of the myopectineal orifice (MPO) requires safe tissue handling and visual tactile feedback.

Dissection of the MPO is not complete until the critical view is attained (Table 3.3). An example of a completely dissected critical view is shown in Fig. 3.7.

Mesh sizes range from 10 × 15 cm to 12 × 16 cm as needed to fully cover the MPO and provide about 3 cm overlap with healthy tissues. The mesh should be placed flat ensuring no rolling, especially at the lower edge (Fig. 3.8).

The peritoneal flap is finally sutured with a 2-0 or 3-0 PDS in a continuous fashion. This should be meticulous to ensure no contact of the polypropylene mesh with the intra-abdominal viscera. Robot definitely confers ergonomic superiority in suturing compared to laparoscopic approach (Fig. 3.9).

Fig. 3.6 Initiation of rTAPP peritoneal takedown

Table 3.3 Steps to assure critical view of the myopectineal orifice and safe placement of mesh during rTAPP [14]

1. Wide medial dissection
2. Evaluate for and reduce a direct hernia
3. Fully dissect space of Retzius, e.g., 2 cm below Cooper's ligament
4. Evaluate for and reduce a femoral hernia
5. Isolate spermatic cord structures from peritoneum until structures are flat and psoas and iliac vessels are visualized
6. Evaluate for and reduce a cord lipoma
7. Widely dissect space of Bogros toward anterior superior iliac crest
8. Use appropriate fixation to reduce risk of injury to nerves and critical structures
9. Position mesh appropriately, e.g., at least 10 × 15 cm size, without folding, and with full coverage of MPO

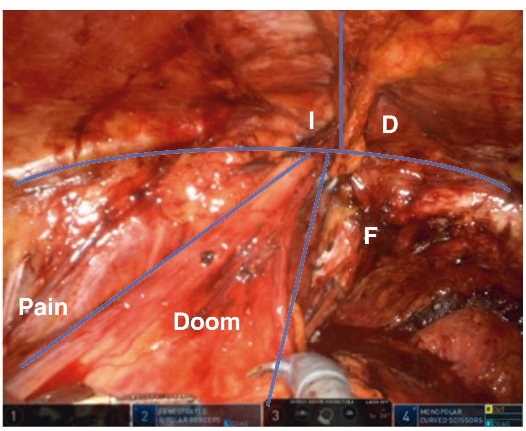

Fig. 3.7 A completely dissected critical view of the myopectineal orifice. This demonstrates the direct, indirect, and femoral spaces as well as the triangles of doom and pain

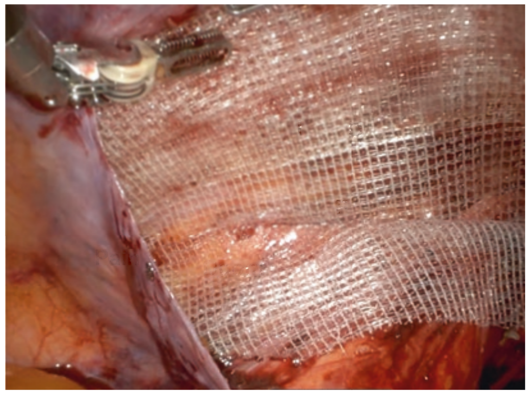

Fig. 3.8 Mesh 15 × 12 cm placed to cover the entire myopectineal orifice

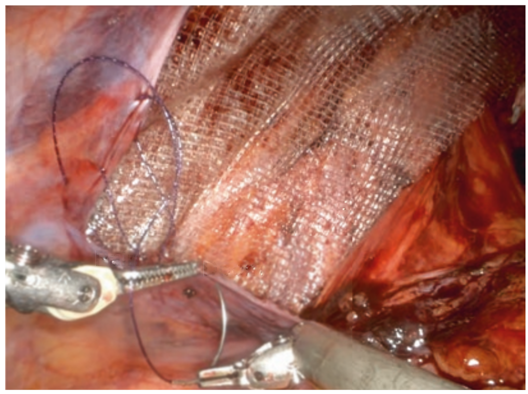

Fig. 3.9 Robotic suturing of the peritoneal flap excluding the mesh in the extra peritoneal space

As discussed, fixating the mesh may or may not be necessary. Direct inguinal hernias are best handled by inverting the redundant transversalis fascia and securing it to the Cooper's ligament or rectus abdominis as part of the hernia repair. This allows for a more secure platform onto which the mesh would adhere, as opposed to bridging a direct defect gap. Fixation is most important for large indirect inguinal hernias, most direct hernias, and femoral hernias.

3.6 Surgical Techniques/Variations

Though rTAPP is considered the standard procedure, some surgeons are adopting an extended

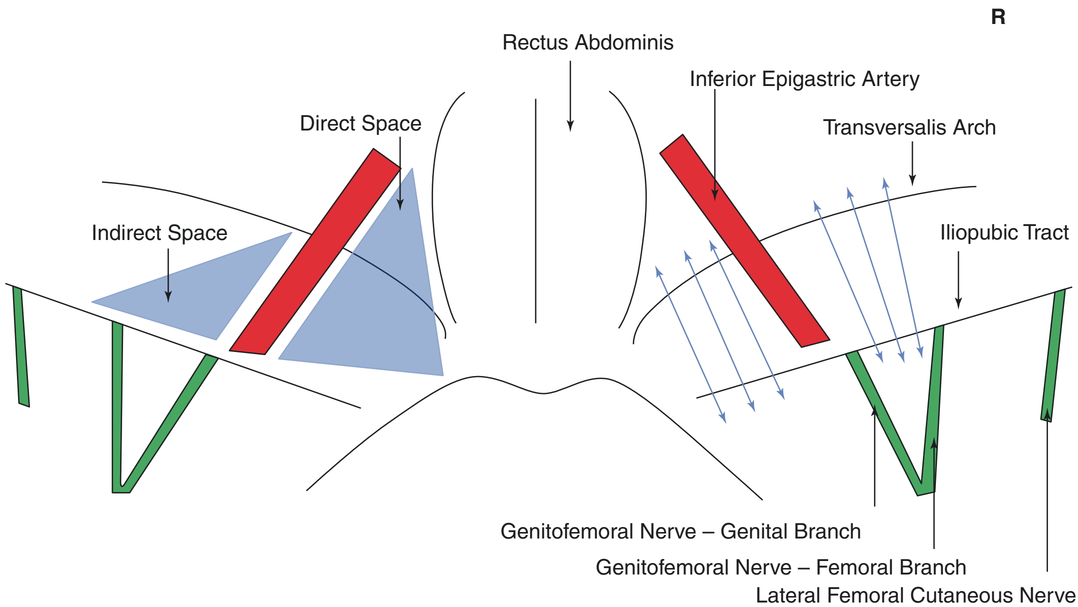

Fig. 3.10 Schematic of robotic iliopubic tract repair (r-IPT). This is the rTAPP view of the retroinguinal and retropubic space. Blue double-headed arrows indicate the suture repair

totally extraperitoneal approach using the eTEP technique. The concepts of eTEP for inguinal hernias are discussed in chapter 2.

Traditional rTAPP is performed with the use of mesh. A novel non-mesh inguinal hernia repair has been introduced as a robotic iliopubic tract repair (r-IPT) [9]. This involves suturing of the transversus abdominis arch to Cooper's ligament (Fig. 3.10). The operation is best performed in low risk patients (e.g., normal to low BMI, non-recurrent inguinal hernias) with small inguinal hernias. It is contraindicated for femoral hernias.

3.7 Tips and Tricks

The key to successful robotic surgery is understanding the limitations of the robotic platform and assuring that all safety measures are taken.

The typical trocar placement is placed perpendicular to skin incision and should not be skived, as it will cause undue strain on the abdominal wall and potentially risk abnormal interactions among the robotic arms and instruments. In patients with obesity, choosing the longer length of trocar (16 cm vs. 11 cm) may reduce the risks of the camera and other instruments from pulling out of the abdomen during manipulation of the robotic arms.

If the arms of the robot are at risk of hitting the patient's face, the trocars can be temporarily pulled up on the abdominal wall. This is sometimes referred to as "burping" the trocars. Also, the camera view can be changed from 30° down to 30° up to help reduce the proximity of the robotic arms with the patient's face.

When operating laterally, depending on instrument placement, the robotic instruments may interact or overlap with each other. For example, this can happen by sewing the lateral edges of the peritoneal flat. Switching instruments can help reduce this problem. Also, placing the lateral trocars 5 cm cephalad to the anterior superior iliac spine can help reduce this problem.

A sterile scrotal preparation can be included, especially if there is a complicating factor to the operation such as an inguinoscrotal hernia or mesh removal operation. Scrotal preparation can allow for access to the scrotum and testicles intraoperatively, such as to help reduce a large hernia or to identify the spermatic cord from surrounding structures.

3.8 Complications and Management

Chronic pain remains a significant complication associated with all inguinal hernia repairs. To minimize the risk of chronic pain after rTAPP, it is important to gently handle the tissues. It is not recommended to grasp any of the spermatic cord structures; the vas deferens should particularly be handled in a no-touch method, as there are small vasal nerves that may be injured. With experience, robotic surgery will allow for visual feedback to compensate for the lack of tactile sensation. Thus, with growing robotic experience, it is important to prevent wide motions of the arms and prevent unnecessary pulling and pushing of the abdominal wall.

Following the safety steps for TEP/TAPP inguinal hernia repairs will assure lower risk of complications. Unfortunately, it has been shown that a significant population of surgeons does not follow the dictums of Daes, Felix, Malcher, and others [16]. In fact a review of the most viewed online inguinal hernia videos demonstrated that nearly 92% of these videos included at least one technical error or high-risk maneuver [16].

As with all TAPP approaches, there is a risk of intestinal injury, bladder injury, and intestinal obstruction due to herniation into the peritoneal flap closure or a peritoneal tear. Careful handling of the robotic instruments is key to reducing this complication. That means, similar to laparoscopic surgery, robotic instruments should not be used if they are not in the field of view, as this places the patient at risk for injury of a nearby organ. Also, the correct choice of instrument will reduce grip strength and thus minimize the risk of organ injury.

For peritoneal closure, many choose barbed sutures due to their ease of use. There are reports of intestinal obstruction if the intestines are exposed to the sutures [17]. Nevertheless, peritoneal closure should be carefully performed and tears should be closed prior to finishing the operation. Failing to repair any tears more than 1 cm wide places that area at risk for internal herniation into the flap [18].

3.9 Conclusion

Endolaparoscopic repair of groin hernias has many advantages. However, it is technically demanding and there is a steep learning curve. Robotic platform confers ergonomic advantages and reduces the learning curve. With increasing availability and expertise, robotic TAPP has become a safe and feasible alternative to open and endoscopic approaches for groin hernia repair.

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Part III

Newer Procedures in Ventral Hernia Surgery

4 Anterior Component Separation Technique and Its Modifications for Ventral Hernia Repair

Charles E. Butler, John P. Fischer, and Abhishek A. Desai

4.1 Introduction

The anterior component separation (ACS) technique was developed as an alternative to remote myocutaneous flaps and free-tissue transfers for the closure of large abdominal wall defects [1]. ACS is generally preferred over the posterior component separation (PCS) in the reconstruction of large, complex abdominal wall defects as it offers greater medialization of the musculofascia to approximate in the midline [2]. This facilitates reinforced rather than bridged repair, which is associated with a markedly lower hernia recurrence rate and overall complication rate [3].

The hallmarks of the original Ramirez ACS are (1) division of the external oblique (EO) aponeurosis, (2) blunt separation of the EO and internal oblique (IO) muscles, (3) division of the medial aspect of the posterior rectus sheath, and (4) elevation of the rectus muscle off the posterior rectus sheath.

This original open technique however involves creating wide skin flaps overlying the rectus muscles in order to expose the EO aponeurosis laterally, which disrupts the perforating vessels supplying the overlying skin and subcutaneous tissue. This substantially increases the risk of wound complications following open ACS [4, 5].

Several modifications to the original Ramirez technique have been developed to minimize subcutaneous dead space and improve vascularity to the overlying skin. Our preferred technique, the Modified Minimally Invasive Component Separation (MICS), has been demonstrated to halve the risk of wound-healing complications as compared to the original open technique [6].

4.2 Objective

The EO, IO, and transversalis muscles insert laterally into the rectus abdominis complex at the semilunar line. As the plane between the EO and IO aponeuroses is relatively avascular, it can be readily dissected after division of the EO aponeurosis to facilitate medialization of the rectus complex and allow for reinforced repair of large midline abdominal wall defects.

The inferior epigastric vessels penetrate the inferior lateral aspect of the rectus abdominis

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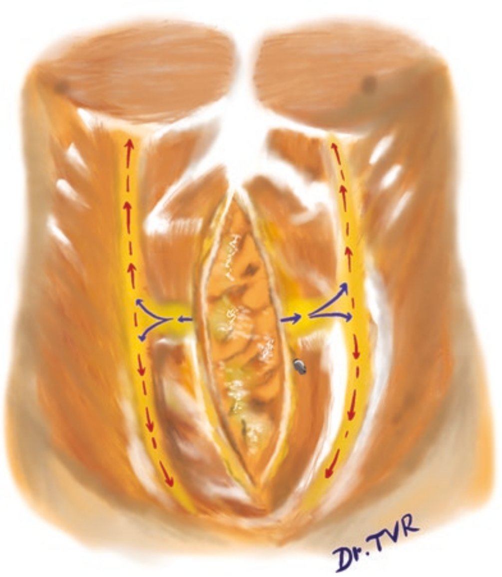

Fig. 4.1 Minimally Invasive Component Separation (MICS) is designed to release the external oblique while minimally disrupting the myocutaneous perforating vessels which supply the overlying abdominal wall and their surrounding subcutaneous attachments. Illustration by Dr. T Varun Raju

muscle, branching off into myocutaneous perforating vessels that provide vascular supply to the overlying abdominal wall. The objective of MICS is to release the EO while minimally disrupting these perforating vessels and the surrounding subcutaneous attachments (Fig. 4.1). This will minimize the amount of dead space left behind after component separation and maximize vascularity to the midline skin and subcutaneous tissues.

The ACS technique maintains attachments between the transversalis and IO muscles. The intercostal neurovascular bundles which vascularize and innervate these structures run laterally in this plane and are preserved with MICS.

4.3 Preoperative Counseling

Surgeons must always consider the overall risks of surgery and anesthesia and the overall health of the patient including any cardiopulmonary comorbidities.

It is critical to establish realistic expectations with each patient, including the anticipated surgical outcome, possible complications (including the risk of hernia recurrence), length of hospital stay, need for drainage catheters (up to 3 weeks after surgery), and commitment to restrictions on activity. Each patient's unique risk for perioperative wound complications, infection, and hernia recurrence must be considered and clearly discussed.

Surgeons may find patient-reported outcomes tools such as the Abdominal Hernia-Q [7] useful in measuring qualitative metrics in their own practice by establishing a baseline for each patient and quantifying their improvement after surgery.

Patients should be encouraged to cease tobacco use for at least 2 weeks before surgery, as smoking is associated with substantially increased risk of morbidity and mortality after abdominal wall reconstruction [8]. Many patients, especially those with obesity, will benefit from participating in pre-habilitative nutrition and exercise programs to achieve safe weight loss before undergoing MICS.

Each patient's risk of perioperative venous thromboembolism should be assessed using the Caprini score [9] or other validated method, and anticoagulation should be administered perioperatively if appropriate.

4.4 Perioperative Pain Control

Preoperative placement of an epidural catheter for anesthesia is highly recommended for patients undergoing MICS. When oral diet is initiated, patients should be transitioned to a multimodal oral analgesia regimen before discharge from the hospital.

Though most patients undergoing MICS will require a brief course of oral opioids postoperatively, patients undergoing abdominal wall reconstruction are generally overprescribed narcotics and nearly one-quarter will require no opioids at all following discharge [10]. Surgeons should discuss the risk of chronic opioid use after surgery with their patients and be careful to avoid overprescribing narcotics.

4.5 Anatomic Considerations

4.5.1 Musculofascia

The most important musculofascial consideration is violation of the semilunar line. Previous surgical incisions and/or trauma that transected the semilunar line can substantially complicate ACS or render the procedure contraindicated on the ipsilateral side. Subcostal incisions, transplant incisions, and open appendectomy incisions traverse the semilunar line and may limit or entirely preclude ipsilateral component separation. Transverse and oblique incisions that cross the semilunar line from the oblique muscles to the rectus muscle complex are relative contraindications to performing ipsilateral ACS.

While they may complicate the procedure and must be carefully considered, stomas, stoma site hernias, port site hernias, indwelling catheters, and other violations of the rectus complex generally are not contraindications to ACS. The surgeon should determine whether the rectus abdominis myocutaneous perforators have been elevated and ligated during previous surgeries, usually in the process of undermining skin flaps laterally over the anterior rectus sheath. Evaluation of these myocutaneous perforators may be done intraoperatively or with preoperative imaging such as contrast-enhanced CT.

The thickness, tensile strength, and overall quality of the existing musculofascia and overlying skin should be carefully assessed. Previous infections or radiation therapy may limit the musculofascia's wound-healing capability and potential for medialization despite component separation. Systemic immunosuppression, comorbidities, and intercostal denervation from previous surgeries can also significantly reduce the quality of the musculofascia and inhibit wound-healing.

4.5.2 Defect

The surgeon must consider the size and location of the abdominal wall defect; hernia repairs in the epigastric or low suprapubic area may be particularly difficult due to a lack of tissue laxity, which limits the amount of musculofascial tissue available for medialization. Potential bacterial contamination, including infected mesh, contamination of the surgical field, inadvertent enterotomy, existing stoma, and/or active open-wound infection, must also be considered.

To reduce the risk of infection, the surgeon should aggressively debride devitalized tissue, give perioperative therapeutic antibiotics, employ pulsatile lavage, minimize subcutaneous dead space, and drain any subcutaneous dead space with closed-suction drainage catheters.

4.5.3 Viscera

Previous surgeries and/or intraperitoneal infections may increase intestinal and visceral adhesions, complicating laparotomy and adhesiolysis before ACS.

4.5.4 Skin

The patient should be evaluated for sufficient availability and laxity of good-quality skin to ensure reliable cutaneous closure over the musculofascial repair. Sufficient tension-free closure must be achieved to reduce the risk of skin dehiscence after surgery. Almost all patients undergoing ACS have redundant, attenuated, poor-quality skin in the midline overlying the hernia sac. This skin can be resected to allow the more lateral, adequate-quality skin to be medialized and serve as the primary closure without tension. The umbilicus can be resected along with the central skin if it is involved in the hernia, if it is considerably thinned, or if it is ulcerated. Previous scars on the abdominal wall also must be considered because they can limit the vascularity available to the central skin and reduce the skin's potential for medialization over the musculofascial repair.

4.6 Selecting Mesh Material and Plane of Mesh Placement

Appropriate selection and placement of mesh is a key component of MICS.

4.6.1 Plane of Mesh Placement

The ACS technique allows for intraperitoneal sublay, preperitoneal sublay, retrorectus, inlay, or onlay mesh reinforcement. It is imperative the surgeon select the most optimal plane of mesh placement for each patient.

Mesh placement in the retrorectus space is most preferred, as it is associated with the lowest rates of hernia recurrence and surgical site infection [11]. This is likely because the retrorectus plane is the deepest location a mesh can be placed in while remaining well isolated from the intraperitoneal viscera.

The surgeon may instead opt for onlay placement in the setting of a contaminated wound, or preperitoneal placement if the posterior rectus sheath has been disrupted by prior surgery or trauma. Primary fascial closure may be unfeasible in the setting of very large abdominal wall defects; these patients are most suitable for inlay mesh placement.

4.6.2 Mesh Material

Macroporous synthetic mesh is generally preferred for the repair of large abdominal wall defects, as it is associated with significantly lower rates of hernia recurrence [12] and complications [13].

However, the surgeon should consider the use of bioprosthetic mesh [14] in the setting of:

- contaminated wounds,
- complex repairs at high risk for developing wound-healing problems,
- high likelihood of cutaneous exposure,
- or unavoidable direct placement of mesh over bowel.

Bioprosthetic mesh may be placed in the sublay, inlay, or onlay planes. When combined with inlay mesh inset, this is generally referred to as Minimally Invasive Component Separation with Inlay Bioprosthetic Mesh (MICSIB) [15]. While the pioneers of the MICSIB technique have demonstrated adequate durability and acceptable hernia recurrence rates up to 7 years following MICSIB using acellular dermal matrix (ADM) [16], other groups have demonstrated exceedingly high recurrence rates with ADM-reinforced abdominal hernia repair [17] and bioprosthetic mesh should generally only be considered in the above settings.

4.7 Operative Technique

4.7.1 Laparotomy and Adhesiolysis

After making a vertical midline skin incision, the surgeon incises the linea alba taking care not to violate the rectus complexes laterally. This musculofascial incision should include any midline hernia defects. The surgeon should palpate intraperitoneally to identify any potential sites of future herniation and include these in the musculofascial incision.

Careful abdominal adhesiolysis, as well as any indicated intra-abdominal or intrapelvic operations, should be performed at this time. A moist, radio-opaque towel can then be placed on the viscera to protect from inadvertent injury before proceeding with MICS.

4.7.2 Development of the Retrorectus Plane

The surgeon incises the posterior rectus sheath immediately lateral to the linea alba. Dissection is continued in the plane between the rectus muscle belly and posterior rectus sheath (Fig. 4.2). Below the arcuate line, where there is no posterior rectus sheath, the preperitoneal fat pad can be elevated in continuity.

4.7.3 Alternative Development of the Preperitoneal Plane

If retrorectus mesh placement is not feasible or not optimal, the surgeon may choose to develop an entirely preperitoneal plane for mesh placement. The preperitoneal fat pad runs vertically

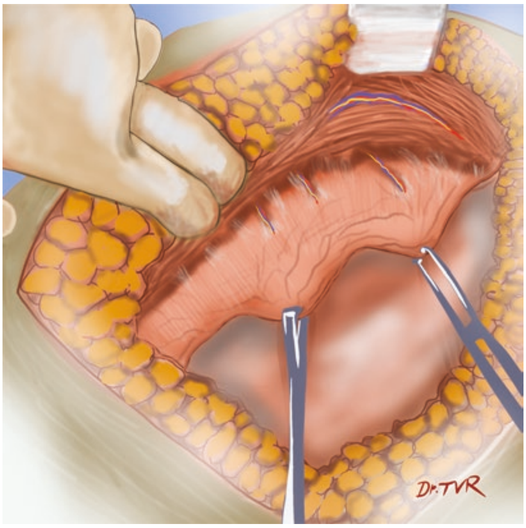

Fig. 4.2 The retrorectus plane of dissection. Illustration by Dr. T Varun Raju

parallel to the linea alba and is most substantial at its superior and inferior apices, near the costal margin and pubis, respectively. Very thin patients and those who have undergone multiple prior surgeries may not have a well-defined preperitoneal fat pad. This plane should be developed at least 5 cm beyond the most cranial and caudal aspects of the abdominal wall defect in order to facilitate adequate mesh inset.

4.7.4 Anterior Subcutaneous Dissection

To facilitate adequate anterior access for mesh inset and fascial closure, the surgeon elevates the subcutaneous tissue from the anterior rectus sheath for 2–4 cm circumferentially. This dissection should extend laterally only to the medial row of myocutaneous rectus abdominis perforators, taking care to preserve these vessels.

Using a narrow Deaver retractor and electrocautery, the surgeon then creates a narrow lateral tunnel incision to access the semilunar line. This access tunnel should be approximately 4 cm wide and extend 2 cm laterally beyond the semilunar line. The hernia sac typically extends laterally toward the semilunar line and can serve as a starting point for this dissection.

Generally, only one tunnel incision centered between the umbilicus and costal margin is required, but a second inferior access tunnel may be required for adequate exposure of the semilunar line depending on the length of the abdominal wall defect and the patient's body habitus.

Anterior subcutaneous dissection should be guided by palpable landmarks, including the lateral edge of the rectus muscle, the lateral edge of the rectus sheath, and the transition from oblique muscle to aponeurosis. Appropriate identification of the semilunar line is an imperative step of MICS.

4.7.5 Initial Incision of the EO Aponeurosis

The optimal location for EO release is through its aponeurosis, approximately 1.5 cm lateral to the edge of the rectus complex. After marking the intended incision site with a pen and confirming appropriate placement, the surgeon creates a 1 cm craniocaudal incision in the EO aponeurosis using either a scalpel or electrocautery. Presence of a fat pad between the EO and IO muscles is a good indication of being in the correct plane. If the rectus muscle is instead encountered, the surgeon should close this incision into the rectus sheath and appropriately identify the semilunar line and EO aponeurosis more laterally.

4.7.6 Blunt Separation of the EO and IO Aponeuroses and Muscles

Via this 1 cm incision in the EO aponeurosis, the surgeon uses a blunt-tip metal Yankauer suction handle (not connected to suction) to bluntly separate the EO and IO aponeuroses and muscles (Fig. 4.3). The instrument should slide easily in the space just lateral to the rectus complex, superiorly over the costal margin and inferiorly toward the pubis. This maneuver frees the EO aponeurosis and muscle from their posterior attachments.

Fig. 4.3 Blunt separation of the external oblique and internal oblique aponeuroses and muscles. Illustration by Dr. T Varun Raju

4.7.7 Creation of Lateral Craniocaudal Tunnel

The surgeon must now create a 3 cm-wide craniocaudal subcutaneous tunnel overlying the EO aponeurosis. This craniocaudal subcutaneous tunnel should run parallel to the vertical midline musculofascial incision and will expose the anterior aspect of the EO aponeurosis, allowing for its release.

The Yankauer tip is introduced into the newly dissected plane between the EO and IO aponeuroses and positioned immediately lateral to the rectus complex. Using a narrow Deaver retractor, electrocautery, and the Yankauer tip as a palpable guide, the subcutaneous tissue overlying the EO aponeurosis release site is elevated superiorly and inferiorly.

4.7.8 EO Aponeurosis Release and Further Separation of the EO and IO Muscles

Again, using the Yankauer tip as a palpable guide to avoid entering the rectus complex, the surgeon uses scissors to divide the EO aponeurosis inferiorly and superiorly (Fig. 4.4). The release should be continued superiorly for at least 8–12 cm beyond the costal margin. As the EO and IO muscles often interdigitate cranially near the costal margin, electrocautery dissection is usually required to develop the plane between these structures (Fig. 4.4).

Sharp and electrocautery dissection between the EO and IO muscles is completed, extending laterally to the anterior axillary line to facilitate maxi-

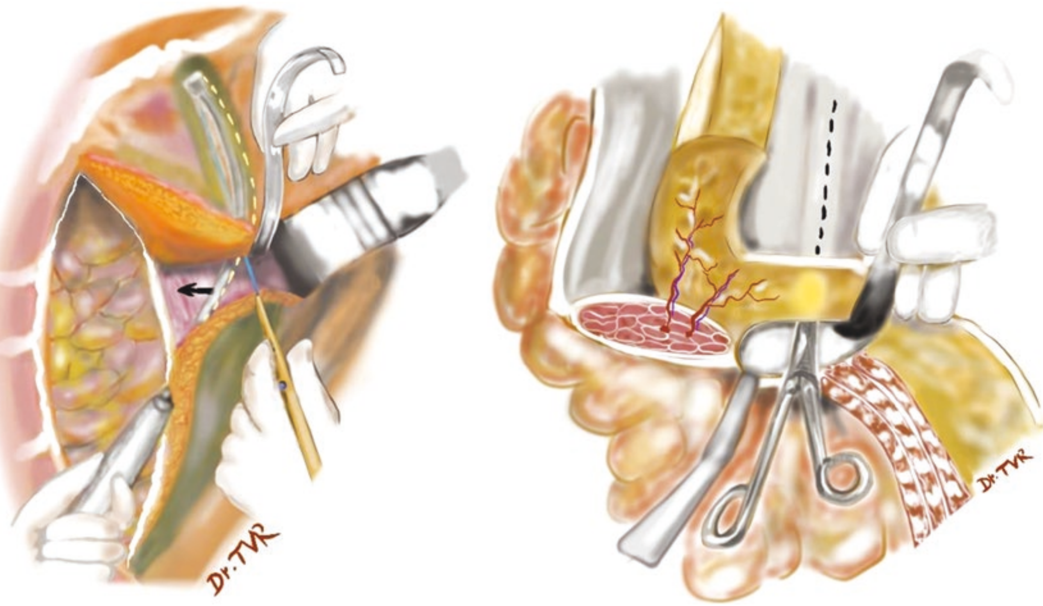

Fig. 4.4 Division of the external oblique aponeurosis. Illustration by Dr. T Varun Raju

mal medialization of the rectus complex. A lighted retractor is often helpful in performing this maneuver. It is critical the underlying IO muscle and aponeurosis are not injured, as this can cause weakness of the abdominal wall and subsequent herniation. The IO muscle should be clearly visible after completed release of the EO aponeurosis.

4.7.9 Contralateral Release

The entire procedure is then performed identically on the contralateral side.

4.7.10 Defect Sizing and Selection of Mesh

The surgeon now places Kocher clamps on the fascial edges of the midline laparotomy incision and applies medial tension to determine whether primary facial closure will be possible.

The surgeon's preferences and the defect's size and condition determine the type of mesh to be implanted. If primary fascial closure is feasible, either the standard MICS procedure or onlay repair can be performed. If primary fascial closure is not feasible, inlay-bridging mesh and the MICSIB technique will be required.

Here we describe the standard MICS procedure for intraperitoneal sublay, preperitoneal sublay, or retrorectus mesh placement, as well as the MICSIB alternative for inlay-bridging mesh placement.

4.7.11 Mesh Inset

The surgeon can now remove the radio-opaque towel and close the peritoneum and midline fascia if appropriate.

Mesh is then inset circumferentially using interrupted #1 polypropylene suture, passing each bite through the full thickness of the musculofascia, through the mesh, and then back through the musculofascia. The surgeon begins by placing the superior-most suture through or around the xiphoid process, and then at 2 cm intervals along the costal margin. The entry and exit points of each bite should be spaced 1.5 cm apart to avoid pull-through, and sutures should be left untied and clamped with hemostats.

The surgeon then places the inferior-most suture to orient the mesh vertically and provide

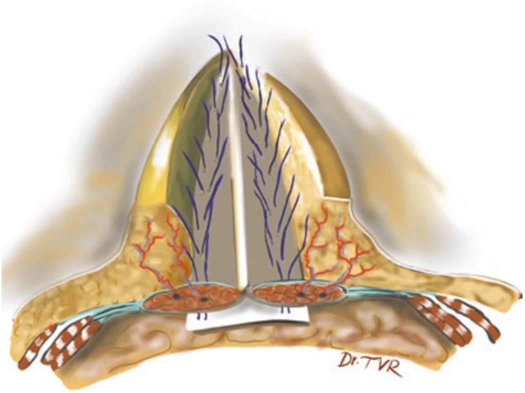

Fig. 4.5 Completed placement of inset sutures for sublay mesh placement. Illustration by Dr. T Varun Raju

physiologic tension. The remaining sutures can then be placed circumferentially in the same fashion to enable primary fascial closure (standard MICS) or bridging repair (MICSIB). The surgeon must be careful to avoid injuring the myocutaneous rectus abdominis perforators while placing these lateral circumferential sutures.

Once all the inset sutures are placed (Fig. 4.5), physiologic tension is applied and the sutures are individually tied. Appropriate physiologic tension of the mesh is a key component of MICS and is necessary to prevent postoperative bulge or early hernia recurrence. Several sutures should be left untied to allow for use of a wide malleable retractor between the mesh and fascia to ensure no intra-abdominal structures are injured during mesh inset and fascial closure. The surgeon must palpate to ensure no intraperitoneal structures are becoming entrapped under the mesh when tying these sutures.

The rectus muscle should be assessed throughout mesh inset to ensure it has not become devascularized or congested. If vascular insufficiency is suspected, the surgeon should ensure the inferior epigastric pedicle has not been occluded by an inset suture. If congestion is due to rectus sheath constriction, a posterior rectus sheath fasciotomy may be performed 2 cm lateral to the midline.

4.7.12 Primary Fascial Closure (Standard MICS)

A closed-suction drain is placed to drain the space between the inset mesh and the overlying primary fascial closure. The surgeon then reapproximates the midline fascia with long-term resorbable monofilament suture while continuing to protect intra-abdominal structures using the malleable retractor. The last few inset sutures can now be safely tied (Figs. 4.6 and 4.7).

4.7.13 Inlay-Bridging Repair (MICSIB)

If primary fascial closure is not possible, the MICSIB technique is required. Any devitalized, attenuated, or severely scarred midline tissue should be resected. After orienting and sizing the mesh, the surgeon marks the anticipated point of overlap to ensure adequate coverage. Using the wide malleable retractor to protect intra-abdominal structures, the mesh is then inset with at least 4–5 cm of overlap between the edge of the mesh and the edge of the musculofascia to ensure a reliable repair. Resorbable sutures are

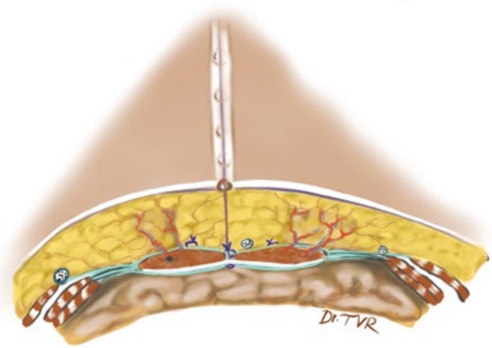

Fig. 4.6 A completed retrorectus repair. Illustration by Dr. T Varun Raju

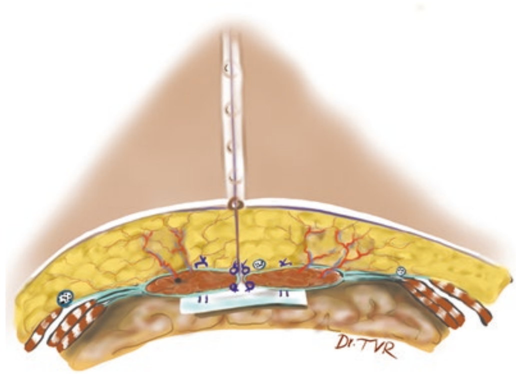

Fig. 4.7 A completed intraperitoneal sublay repair. Illustration by Dr. T Varun Raju

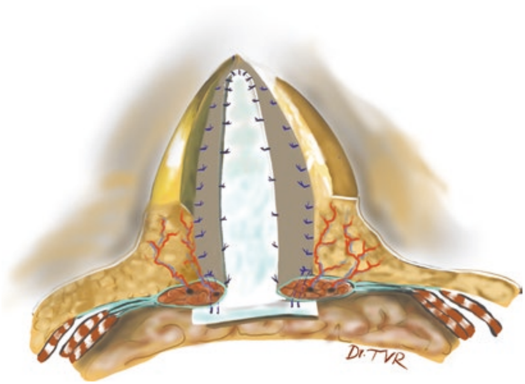

Fig. 4.8 A completed bridging mesh repair (MICSIB). Illustration by Dr. T Varun Raju

then used to tack the fascial edge to the central mesh. The last few inset sutures can now be safely tied (Fig. 4.8).

4.7.14 Skin Resection and Placement of Subcutaneous Drains

The surgeon can now assess skin laxity overlying the musculofascial repair and resect any attenuated, redundant, or devascularized central tissue. The umbilicus can be resected if it is compromised. Large-bore, channeled, closed-suction drains are then placed, exiting in the suprapubic area. One drain should be placed in each lateral craniocaudal subcutaneous tunnel and 2–5 drains should be placed in the central subcutaneous space.

4.7.15 Quilted Subcutaneous Closure and Skin Closure

Interrupted 3-0 resorbable sutures are placed subcutaneously to reapproximate Scarpa's fascia to the musculofascia. Approximately 3-5 sutures are placed vertically between each drainage channel in a quilted fashion, reducing shear and minimizing dead space.

Resorbable interrupted sutures are then used to reapproximate Scarpa's fascia and the dermis in the midline, and monofilament running resorbable subcuticular suture is used to close the skin.

4.8 Postoperative Care

Perioperative antibiotics should be discontinued within 24 h of surgery unless otherwise indicated. Patients should be encouraged to walk on the day of surgery, or the following morning at the latest, to minimize the risk of venous thromboembolism.

Epidural analgesia should be continued until the patient's diet can be advanced and oral analgesia can be tolerated. Generally, patients should start with sips of clear liquid the morning after surgery.

Patients will generally remain hospitalized for 3–6 days following ACS, depending on the complexity of the repair and whether other procedures were performed simultaneously.

Drains can be required for up to 3 weeks after surgery and should only be removed once the output volume is less than 30 mL per day.

Assuming no perioperative complications occur, patients can generally return to light activity after 8 weeks, and transition to normal activity after 12 weeks.

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5 Open Posterior Component Separation: Transversus Abdominis Release (PCS-TAR) for Ventral Hernia

Benjamin T. Miller, Clayton C. Petro, and Michael J. Rosen

5.1 Introduction

Component separation techniques for complex ventral hernia repair, popularized by Ramirez and colleagues in the 1990s, were developed to mobilize myofascial elements in abdominal wall reconstruction [1]. By division of one of the muscles of the lateral abdominal wall, a low-tension midline closure of large ventral hernia defects can be achieved. Reapproximation of the rectus abdominis muscles in the midline optimizes abdominal wall function and enhances patient quality-of-life [2]. The original Ramirez component separation divides the medial posterior rectus sheath bilaterally, followed by elevation of the rectus abdominis muscles off of the underlying posterior rectus sheaths. If further mobilization of abdominal wall elements is needed, an anterior release divides the external oblique muscle lateral to the linea semilunaris [1].

As abdominal wall reconstruction techniques evolved to include transversus abdominis release (TAR), a distinction between anterior and posterior component separation was needed to indicate which lateral abdominal wall muscle is divided. The posterior component separation (PCS) begins with the standard retrorectus dissection described by Rives and Stoppa [3] and is extended laterally after the posterior lamella of the internal oblique aponeurosis and the transversus abdominis muscle are divided. After the release of the transversus abdominis muscle, the preperitoneal space is entered [4].

Essentially a wide preperitoneal dissection, PCS-TAR offers several advantages over anterior component separation for abdominal wall reconstruction. Large myofascial flaps are mobilized and reapproximated at the midline under minimal tension, creating ample retromuscular space for mesh deployment. This well-vascularized space, isolated from the viscera and superficial wound, encourages early mesh ingrowth and is ideal for inexpensive, bare polypropylene mesh. Additionally, PCS-TAR avoids large skin flaps—and the associated morbidity—needed for an anterior component separation [5].

5.2 Indications

Hernias greater than 10 cm in diameter will likely need component separation for repair, although surgeons should be prepared to use component separation techniques for hernias 7–10 cm in diameter. In particular, if a retromuscular repair is planned and the patient has a narrow rectus muscle, the posterior pocket for mesh placement is often not wide enough. The true benefit of

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releasing the transversus abdominis muscle is to provide a tension-free closure of the posterior layer (peritoneum), allowing accommodation of a wider mesh.

5.3 Contraindications

Posterior component separation is not recommended for emergent surgical cases requiring ventral hernia repair. A complex and time-consuming operation, PCS-TAR should be reserved for elective circumstances. In emergent situations, the hernia defect can be closed primarily with interrupted, figure-of-eight #1 PDS sutures [6]. A PCS-TAR should also be avoided in patients with infected mesh, fistulas, or open wounds without a very wide defect. These patients may require a staged approach to ventral hernia repair: infected mesh removal and fistula repair with primary fascial closure, followed by definitive PCS-TAR in 6–12 months. Likewise, appropriate patient selection is critical for successful PCS-TAR. Patients suffering from malnutrition or skin or systemic infections should be optimized before undergoing PCS-TAR. Additionally, obese patients should be counseled on weight loss, diabetes should be well-controlled, and tobacco cessation encouraged. Finally, concomitant anterior and posterior component separation should not be performed, as the abdominal wall can become destabilized, leading to lateral hernias. A relative contraindication in the authors' opinion is the surgeon's lack of detailed understanding of abdominal wall anatomy, including neurovascular and anatomic planes. These operations can be very complex, lengthy, and may result in devastating complications. They should not be performed by inexperienced surgeons without proper training.

5.4 Instruments and Energy Source

A major basic surgical instrument set is needed, which should also include 10 Kocher clamps for fascia retraction, two large Richardson retractors for exposure, reusable clip appliers to ligate blood vessels, and a laparoscopic suture passer for transfascial suture placement. A standard electrosurgery high-frequency generator and an electrosurgical push-button pencil and patient grounding pad are essential. A self-retraining retractor is not necessary; changing the table position during the operation can facilitate exposure, especially during the preperitoneal pelvic and subxiphoid dissections.

5.5 Team Setup, Anesthesia, and Position

All patients receive preoperative venous thromboembolism prophylaxis with 5000 units of subcutaneous heparin and prophylactic intravenous (IV) antibiotics to cover gram-positive skin flora. If performing PCS-TAR under contaminated conditions (e.g., parastomal hernia repair), IV antibiotics with gram-negative and anaerobic coverage are also administered. Patients are supine on the operating table with their arms out, and sequential compression devices are placed on the lower extremities. General anesthesia is induced followed by endotracheal intubation. A urinary catheter is inserted into the bladder. Patients are prepped with chlorhexidine gluconate solution and draped widely in a diamond configuration to expose the costal margins, lateral abdomen, and anterior superior iliac spines. The operating surgeon typically stands on the patient's left side with the assistant on the patient's right.

5.6 Key Steps

- Midline laparotomy with excision of previous surgical scars.
- Complete lysis of adhesions to the anterior abdominal wall.
- Concomitant gastrointestinal procedures are performed and previous mesh is excised. Alternatively, intraperitoneal mesh can be removed after the TAR is complete.
- Place a wet towel over the viscera to protect it during the PCS.

- Measure the hernia defect.
- Perform a Rives-Stoppa retrorectus dissection upto the lateral perforating neurovascular bundles.
- Divide the posterior lamella of the internal oblique aponeurosis just medial to the neurovascular bundles.
- Release the transversus abdominis muscle in the upper abdomen and the aponeurosis of the transversus abdominis muscle in the mid-abdomen.
- Push the transversus abdominis muscle off of the peritoneum, moving laterally and superiorly under the rib.
- Enter the space of Retzius inferiorly and identify Cooper's ligament. Merge the dissection with the contralateral side to fully open the space of Retzius.
- Continue mobilizing the transversus abdominis muscle off the peritoneum to expose the retroperitoneum and psoas muscle.
- Release the posterior rectus sheaths from the linea alba superiorly and merge the superior dissections in the preperitoneal plane below the subxiphoid fat pad.
- Close the posterior sheath with a running, absorbable suture.
- Perform a transversus abdominis plane (TAP) block.
- Deploy mesh in the retromuscular space. Mesh fixation with transfascial sutures should be considered if the surgeon is not satisfied with mesh overlap of the fascial defect.
- Place 19-French channel drains above the mesh in the retromuscular space.
- Close the linea alba with running or interrupted figure-of-eight #1 PDS sutures.
- Close the subcutaneous space and skin with running, absorbable sutures.

5.7 Surgical Techniques/ Variations

5.7.1 Rives-Stoppa Retrorectus Dissection

A generous midline incision is made, and any previous scar tissue is excised. The incision is carried through the subcutaneous tissue in the upper abdomen until native linea alba is identified, ideally 5 cm superior to previous incisions. The linea alba is then divided and elevated with Kocher clamps. A sharp preperitoneal dissection is carried inferiorly just below the linea alba, taking down the hernia sac and adherent bowel, until the peritoneal cavity is entered. As the underlying peritoneum and adhesions are dissected free, the linea alba is progressively opened. After adequate laparotomy is performed, divide all adhesions to the anterior abdominal wall. Be careful not to enter the preperitoneal plane during adhesiolysis, making holes in the peritoneum, because this will make the TAR more difficult. Perform inter-loop adhesiolysis to thoroughly inspect the bowel for injuries or if the patient has a history of bowel obstructions. Repair all serosal injuries and consider a bowel resection for large serosal or full-thickness injuries. After the bowel inspection is complete, place a moist blue towel over the viscera to protect it during the PCS (Fig. 5.1). Before starting the PCS, measure the hernia defect with a ruler.

A retrorectus dissection is then performed. After the edge of the linea alba is elevated with five Kocher clamps, the posterior rectus sheath is grasped with a toothed forceps and divided with electrosurgery approximately 1 cm lateral to the linea alba. Identification of rectus muscle fibers

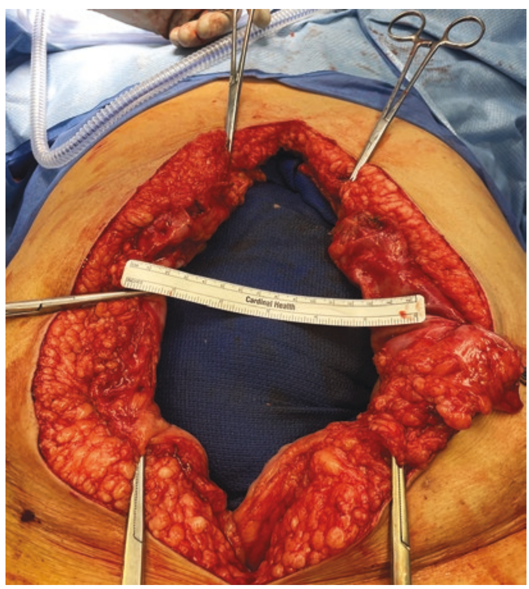

Fig. 5.1 Before posterior component separation is begun, a blue towel protects the viscera

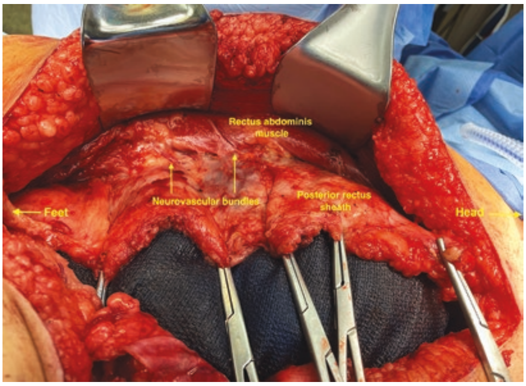

Fig. 5.2 Lateral perforating neurovascular bundles in the retrorectus space

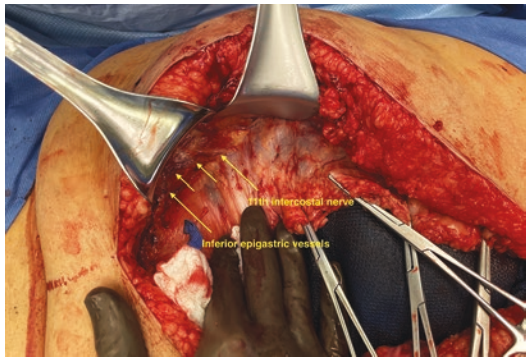

Fig. 5.3 The inferior epigastric vessels and the 11th intercostal nerve form a triangle (short arrows) at the lateral extent of the retrorectus space, the linea semilunaris

indicates entrance into the retromuscular space. Divide the posterior sheath along the length of the linea alba to completely expose the medial retromuscular space. Next, lift the rectus muscle off of the underlying posterior rectus sheath with electrosurgery. Dissection is facilitated by medial retraction on the posterior sheath with Kocher clamps while placing upward traction on the linea alba. Be alert to the inferior epigastric vessels in this plane, but small perforating vessels can be ligated in the medial retromuscular space.

Larger, perforating neurovascular bundles will be encountered as the dissection proceeds laterally (Fig. 5.2); take care to preserve these. Nerve injury can lead to muscle atrophy, impairing future abdominal wall function, and indiscriminate blood vessel ligation may lead to posterior sheath ischemia and subsequent breakdown, potentially leading to intraparietal hernias.

Identification of the neurovascular bundles indicates the lateral edge of the retrorectus dissection, the linea semilunaris (Fig. 5.3). Be careful not to divide the linea semilunaris as this can lead to lateral hernias and abdominal wall destabilization.

If the Rives-Stoppa dissection alone is enough for a low-tension closure of the posterior rectus sheath, the PCS can stop at this point. However, if more mobilization of the posterior abdominal wall elements is needed to isolate the viscera, a TAR is then performed.

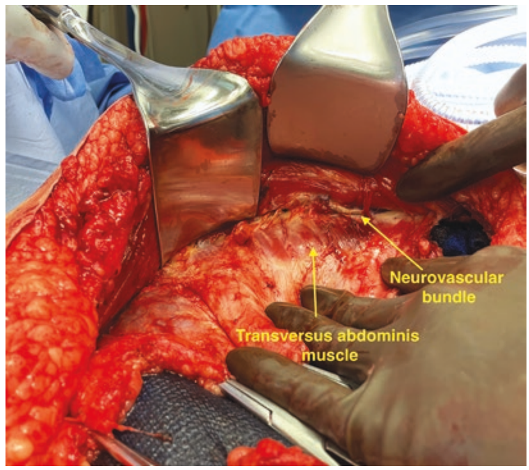

Fig. 5.4 Superior retrorectus dissection with lateral neurovascular bundles and transversus abdominis muscle visible medial to the linea semilunaris

5.7.2 Transversus Abdominis Release

In the upper two-thirds of the abdomen, the transversus abdominis muscle and aponeurosis form part of the posterior rectus sheath, extending medial to the linea semilunaris (Fig. 5.4).

The transversus abdominis muscle belly, robust in the upper third of the abdomen, is encountered just beneath the posterior lamella of the internal oblique. To begin the TAR, divide the posterior lamella of the internal oblique aponeurosis in the upper abdomen just medial to the lateral neurovascular bundles of the retromuscular space (Fig. 5.5).

After dividing the posterior lamella of the internal oblique, the exposed transversus abdominis muscle can be divided with electrosurgery over a right-angle clamp (Fig. 5.6).

Dissection in the plane between the transversus abdominis muscle and the underlying peritoneum is facilitated by adequate traction on the posterior sheath. As the transversus abdominis

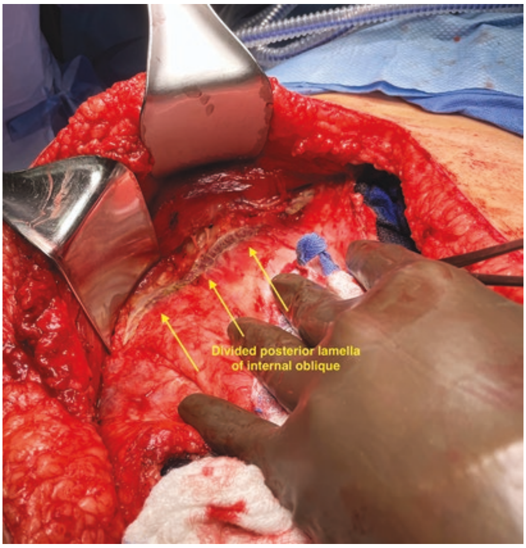

Fig. 5.5 Division of the posterior lamella of the internal oblique aponeurosis in the upper abdomen with transversus abdominis muscle visible underneath

Fig. 5.6 Transversus abdominis release in the upper abdomen

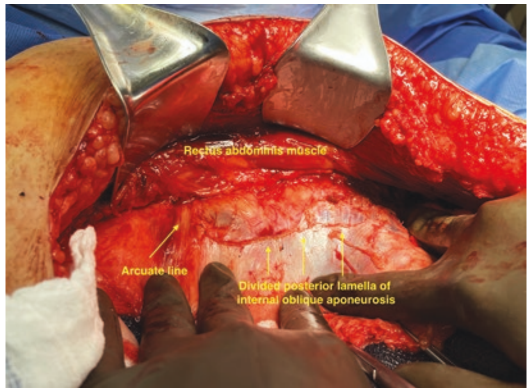

Fig. 5.7 Division of the posterior lamella of the internal oblique and aponeurotic portion of the transversus abdominis muscle in the mid-abdomen

muscle is divided inferiorly, the muscle belly is replaced by aponeurosis. However, the plane between the aponeurosis of the transversus abdominis and the posterior lamella of the internal oblique is often indistinguishable. Continue dividing the aponeurosis inferiorly, past the arcuate line, to completely transect the posterior lamella of internal oblique (Fig. 5.7).

5.7.2.1 Lateral Preperitoneal Dissection

After the posterior lamella of the internal oblique aponeurosis and transversus abdominis muscle is divided, the preperitoneal plane is entered. This plane is developed by bluntly pushing the transversus abdominis off of the underlying peritoneum with a Kittner dissector. The peritoneum can be thin at this point because the transversalis fascia is typically lifted off with the transversus abdominis. If the peritoneum is very thin, leave the transversalis fascia on the peritoneum by advancing laterally in the pretransversalis fascia plane, leaving the posterior layer more robust and resistant to tearing.

As the dissection moves superiorly, the preperitoneal plane will travel under the costal margin. If the dissection proceeds above the costal margin, an incorrect, intramuscular place has been developed. Moving laterally, past the peritoneal cavity, the retroperitoneum is encountered. In the retroperitoneum, the tendency is to con-

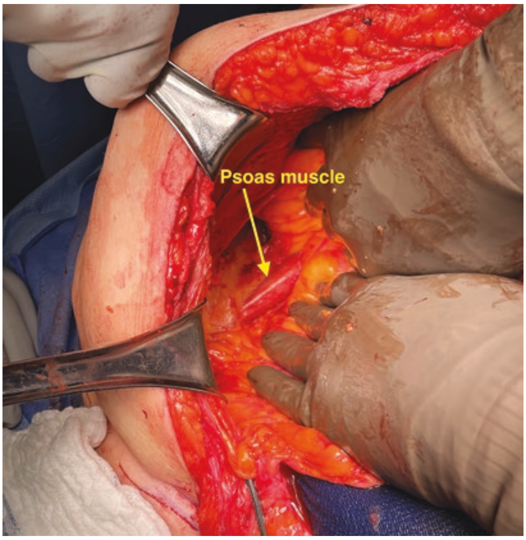

Fig. 5.8 Psoas muscle in the retroperitoneum

tinue the dissection laterally past the quadratus lumborum muscle. If the dissection travels into the lateral retroperitoneal fat however lumbar vessels will quickly be encountered. Instead, find the plane between medial and lateral retroperitoneal fat pads. Dissection in the correct retroperitoneal plane moves down to the psoas muscle (Fig. 5.8). The psoas muscle can then be followed superiorly all the way up to the diaphragm, further mobilizing the posterior layer medially.

5.7.2.2 Inferior Preperitoneal Dissection

Staying medial to the inferior epigastric vessels, carry the dissection bluntly into the space of Retzius until Cooper's ligament is identified. When the contralateral PCS is complete, the dissections in the space of Retzius are connected by sliding a finger along each Cooper's ligament. The preperitoneal dissections from either side are then joined by dividing the tissue between the linea alba and the bladder. In undisturbed tissues, this maneuver can be performed bluntly with a gentle sweeping motion out of the pelvis. If a preperitoneal pelvic dissection has previously been performed, this dissection may need to be done sharply, with care to avoid the bladder. In women, the round ligament is typically divided for full mobilization of the posterior components.

5.7.2.3 Superior Preperitoneal Dissection

To connect the dissections in the upper abdomen, the preperitoneal plane must be identified below the xiphoid. To find this plane, divide the posterior rectus sheath from its insertion on the linea alba and carry it laterally to the prior incision on the posterior lamella of the internal oblique. This maneuver joins the lateral preperitoneal dissection with the retroxiphoid preperitoneal space. Once in the preperitoneal plane, develop the dissection across the retroxiphoid space in the plane between the retroxiphoid fat pad and the peritoneum. Again, adequate traction on the peritoneum will facilitate exposure of this plane. As the dissection advances superiorly, the diaphragm will be lifted off of the peritoneum (Fig. 5.9). Care must be taken not to divide the diaphragm at this point, which may result in a diaphragmatic hernia. Working superiorly, the diaphragm fibers are pushed off of the peritoneum until the central tendon of diaphragm is encountered, the superior-most aspect of the dissection.

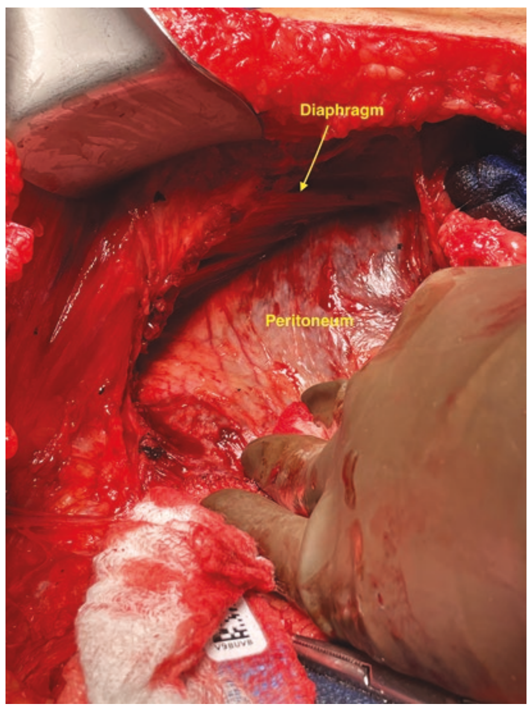

Fig. 5.9 Subcostal preperitoneal dissection beneath the diaphragm

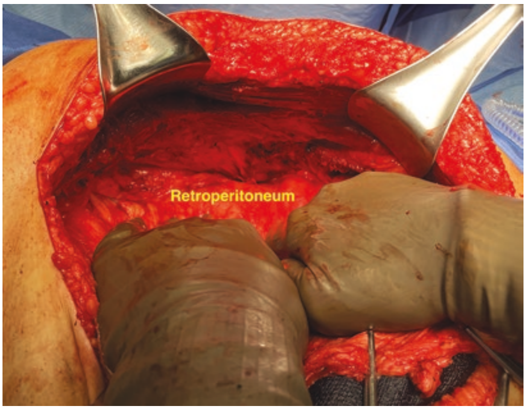

Fig. 5.10 Complete transversus abdominis release with exposure of the retroperitoneum

When complete, the TAR gives full retroperitoneal exposure and allows for closure of the posterior sheath without tension (Fig. 5.10).

5.7.2.4 Mesh Reinforcement and Closure

The posterior rectus sheath is then closed with running, 2-0 absorbable suture. Any holes in the posterior sheath must also be closed with 3-0 absorbable sutures to prevent mesh apposition with the viscera or herniation through the posterior sheath. Larger fenestrations may be plugged with omentum. Rarely, if there is no omentum, Vicryl mesh bridging may be performed. After the posterior rectus sheath is closed, a large, well-vascularized pocket is ready for retromuscular mesh reinforcement (Fig. 5.11). Remember to remove the towel protecting the viscera before the posterior sheath is completely closed.

After the posterior sheath is closed, a TAP block is performed. Each side is injected with 30 mL of 0.25% bupivicaine with epinephrine diluted into 30 mL of saline.

An appropriately sized piece of mesh is then placed in the retromuscular space. A 30 × 30 cm heavy-weight polypropylene mesh is preferred for clean cases [7], while clean-contaminated and contaminated cases are safely reinforced with medium-weight polypropylene mesh [8]. We prefer to place the largest mesh that the retromuscular pocket will accommodate, using 30 × 30 cm or even 50 × 50 cm medium-weight mesh.

At the surgeon's discretion, mesh fixation can be performed with #1 PDS transfascial sutures. If

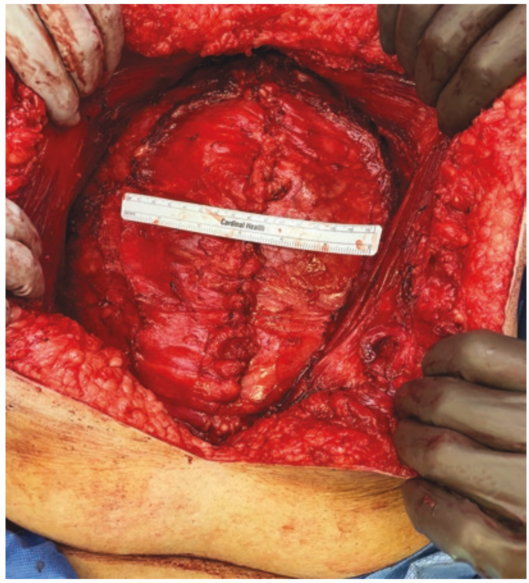

Fig. 5.11 The posterior sheath is closed, creating an ample pocket for mesh

there is insufficient mesh overlap at bony prominences, the mesh may be fixated to Cooper's ligaments, the xiphoid process, or the costal margin. Two 19-French channel drains are left in the retromuscular space. Finally, the linea alba is closed with interrupted or running #1 PDS sutures. Excess skin and hernia sac are excised and hemostasis is confirmed. A subcutaneous drain may be placed. The subcutaneous space is closed with 3-0 rapidly absorbable sutures, and the skin is reapproximated with 4-0 monofilament absorbable sutures. Skin glue is applied to the midline and any smaller stab incisions.

5.8 Tips and Tricks

- Drape in a diamond configuration to ensure adequate exposure for transfascial sutures.
- Dissection lateral to the neurovascular bundles in the retrorectus space will lead to linea semilunaris injury.
- Leave the transversalis fascia on the peritoneum to increase the robustness of the posterior layer.
- Preperitoneal dissection superiorly should proceed beneath the costal margin.
- Change the table position to facilitate the inferior and superior preperitoneal dissections.

- Medium-weight polypropylene mesh reinforcement is safe after concomitant gastrointestinal procedures are performed.

5.9 Postoperative Management

Patients are admitted to a surgical ward postoperatively and placed on an enhanced recovery after surgery pathway [9]. Clear liquids are started the day of surgery, and the patient's diet is advanced with the return of bowel function. Intravenous antibiotics are continued for 24 h postoperatively. Venous thromboembolism prophylaxis with 40 mg enoxaparin daily is started the evening of surgery and continued until discharge. Postoperative pain is managed with patient-controlled and oral analgesia. Retromuscular drains are typically removed before discharge when the output is less than 30 mL per day. Subcutaneous drains may remain beyond discharge until the daily output is minimal.

5.10 Complications

- Wound morbidity: PCS-TAR is associated with wound morbidity rates of 15–20% and surgical site infection rates of 5–10% [10, 11]. Mesh infection rates after PCS-TAR are low, less than 1% in a large series of 428 patients [10].
- Intra-abdominal hypertension: Repair of large ventral hernias with loss of domain may lead to intra-abdominal hypertension and subsequent respiratory complications. Plateau pressure increase during abdominal closure of greater than or equal to 6 mmHg in patients with underlying pulmonary comorbidities, or greater than or equal to 9 mmHg in healthy patients, are associated with postoperative respiratory failure [12]. Thus, consideration should be given to postoperative intubation and intensive care unit admission for patients with elevated plateau pressures after abdominal closure.
- Linea semilunaris disruption: Anteromedial dissection past the lateral border of the retrorectus space during PCS-TAR can result in linea semilunaris transection. This divides the rectus muscle from the oblique muscles, leading to lateral hernias. Bilateral linea semilunaris injuries may result in a "Mickey Mouse" hernia defect on computed tomography (Fig. 5.12). A linea semilunaris injury can be devastating because restoring normal abdominal wall function in these patients may be impossible, underscoring the importance of familiarity with this surgical technique and its associated anatomy.
- Missed enterotomy: A missed bowel injury requires reoperation, possible mesh removal to prevent a mesh infection, and increases the risk for fistula formation. Hence, the bowel must be thoroughly inspected for injuries before a towel is placed over the viscera and the PCS-TAR is begun.
- Posterior sheath breakdown: Bowel incarceration between the posterior layer and the mesh can result from posterior sheath dehiscence

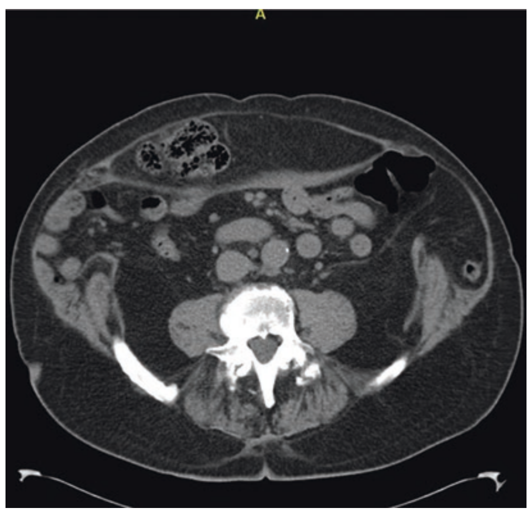

Fig. 5.12 "Mickey Mouse" hernia defect on computed tomography

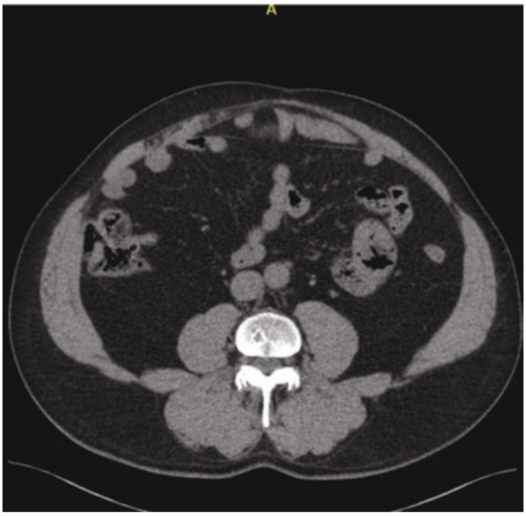

Fig. 5.13 Posterior sheath breakdown on computed tomography

(Fig. 5.13). Undue tension on the posterior rectus sheath closure may place patients at risk for dehiscence or posterior sheath breakdown, leading to intraparietal hernia [13].

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6 Down to Up Posterior Component Separation Technique

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Abbreviations

ACS	Anterior Component Separation
cc	cubic centimeter
EHS	European Hernia Society
MILOS	Mini or less Open Sublay Operation
PCS	Posterior Component Separation
SSI	Surgical Site Infection
SSO	Surgical Site Occurrences
TAR	Tranversus Abdominis Release
VHWG	Ventral Hernia Working Group

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6.1 Indications and Case Selection

The size of the hernia defect is the main factor in choosing between the different abdominal wall repair techniques.

Small or medium-sized defects (up to 7–8 cm) could be approached using minimally invasive techniques (laparoscopic or endoscopic approaches, Mini or Less Open Sublay Operation (MILOS)) or by performing an open Rives-Stoppa technique. The vast majority of defects can be repaired with a Rives-Stoppa technique.

For larger defects (>10 cm) our first option is to perform a posterior component separation technique (PCS). In 2012, Novitsky described the PCS using transversus abdominis muscle release (TAR) [1]; since then, PCS-TAR has been widely used by the abdominal wall surgical community worldwide in the treatment of complex abdominal wall defects and obtaining excellent long-term results.

PCS-TAR is also an excellent technique for the treatment of complex lateral abdominal wall defects, L1–L4 of the European Hernia Society (EHS) classification [2], especially those close to bony structures [3, 4].

Furthermore, PCS-TAR is an ideal technique in the presence of simultaneous midline and lateral incisional hernias and also for the treatment of complex parastomal defects [5–7].

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Nowadays, our choice for treating complex abdominal wall defects is to perform a modification of the Novitsky's TAR, known in the literature as Madrid PCS modification [8].

When treating extreme hernia defects, the use of preoperative optimization techniques is essential. We recommend ultrasound-guided botulinum toxin infiltration for defects greater than 10 cm [9]. We also advocate, in cases with loss of domain (Tanaka index ≥25%) [10], prehabilitation with preoperative progressive pneumoperitoneum [11].

6.2 Contraindications

There is no absolute contraindication to performing a PCS-TAR technique.

A history of preperitoneal or retromuscular repairs, fibrosis of the retroperitoneal plane secondary to severe infections (necrotizing pancreatitis) or previous radiotherapy, as well as an antecedent of anterior component separation (ACS) technique have been considered relative contraindications. In cases of previous retromuscular or preperitoneal repairs, there is an added surgical difficulty as a consequence of the abdominal wall fibrosis generated by the previous mesh, but it is not "per se" a contraindication of PCS-TAR technique. Classically, the performance of a PCS was not recommended in patients with a previous ACS, but recent publications have shown that its association is feasible, when necessary, obtaining good long-term results [12]. As it is a time-consuming procedure, we do not recommend its use in an emergency setting.

6.3 Instrument and Energy Source

It will be necessary to use surgical instruments of different lengths, and it is especially important to use long retractors.

We strongly recommend the use of a LED headlamp device by the main surgeon, as sometimes the operating room lights will not be able to adequately illuminate the deeper areas of the surgical field.

In order to reduce the risk of postoperative bleeding and surgical time, different hemostasis and sealing systems such as *Ligasure*® (Covidien, Medtronic, Minneapolis, MN) or *Ultracision*® (Ethicon endosurgery Inc. Johnson & Johnson, Cincinnati, OH) and *Innolcon*® (Innolcon Medical Technology (Suzhou) Co., Ltd., Suzhou) ultrasonic shears at the choice of the main surgeon.

6.4 Team Setup, Anesthesia, and Position

The surgical team involves the main surgeon who will initially be located on the right side of the patient and two assistants who will be placed in the contralateral position. During the surgical procedure, both, the main surgeon and the assistants, will have to change their initial positions according to the needs of the surgical intervention. A scrub nurse and a circulating nurse are also necessary.

The patient requires general anesthesia to perform the procedure. In order to minimize postoperative pain, the use of epidural anesthesia is controversial in abdominal wall surgery. Some anesthetists team prefer to use preoperative ultrasound-guided TAP block. Nevertheless, we personally like to use an intraoperative TAP block after finishing the PCS because we can see exactly where to place the local anesthesia.

The patient will be placed in a supine position, ideally with both arms tucked by the side. The surgical field extends from the mammary line to the pubis and must reach the posterior axillary line laterally. This surgical field must preferably be disinfected with 2% alcoholic chlorhexidine.

We recommend a bladder catheter placement during the procedure. After surgical intervention, it should be removed to allow early mobilization of the patient in the postoperative period.

The use of central venous line or arterial catheterization will depend on the preferences of the anesthetist and patient's characteristics, although they are not always necessary.

Crossmatched patient's blood must be reserved in the blood bank in case its use is necessary in the perioperative period.

Antibiotic prophylaxis should be administrated prior to intervention, repeating the dose if the operation exceeds 3 hours; we routinely use cefazolin 2 g in clean fields and amoxicillin/clavulanic acid 2 g in cases of any degree of contamination.

6.5 Key Steps

- Preoperative optimization is as important as surgical technique.
- Preservation of the sac.
- "Taking one's time" with adhesiolysis.
- One cannot do a "good" component separation technique without a "good" Rives-Stoppa dissection.
- Preperitoneal dissection first in epigastric area and Bogros space.
- "Down to up" posterior rectus sheath release (posterior component separation).
- Avoiding injuring neurovascular bundles.
- Getting enough overlap.

6.6 Surgical Techniques/Variations

The operation begins through the previous scar that, if unsightly, is resected.

We dissect the hernia sac to the edges of the defect and a longitudinal opening of the sac is performed, dividing it into two halves. One half of the sac should be in continuity with the anterior fascial layer and the other half with the posterior fascial layer [13, 14].

The peritoneal sac is preserved until the end of the procedure with the aim of using it when the posterior layer cannot be completely approximated, avoiding mesh contact with the intra-abdominal viscera. Moreover, preserving the peritoneal sac would allow us to use it in the anterior layer plane to cover the exposed mesh if a bridge repair is necessary, avoiding mesh contact with the subcutaneous tissue. This sac preservation surgery has been one of our main principles since we started performing posterior component separation in 2012. Now it has been recently popularized with the term "peritoneal flap" [14].

A release of the previous adhesions that may exist between the bowel loops and the hernia sac or the abdominal wall is performed thus trying to avoid a possible inadvertent iatrogenic enterotomy during the dissection. It is not necessary to perform a release of the adhesions between bowel loops unless there is a previous history of intestinal obstruction.

After completing the adhesiolysis, we place an extended gauze or a sterile cloth that protects the visceral package during the intervention.

In hernia recurrence cases, the previously implanted mesh is maintained, resecting it only in case of infection, fistula, lack of integration, or dense adhesions that impede adequate dissection of the space used for the new mesh implantation.

In all cases, a complete dissection of the retrorectal space is performed according to the Rives-Stoppa concept [15, 16]. (Fig. 6.1).

We continue opening the medial edge of the rectus sheath, trying to make the section as medial as possible, so that the anterior and posterior rectus sheaths have a similar size. We complete the section of the medial border in a cranial and caudal direction, trying to maintain the *linea alba* integrity that is not affected by the hernia defect. We generally stop the medial incision on the posterior rectus sheath at 6–8 cm from the xiphoid, preserving its anatomical insertion on the costochondral cartilages.

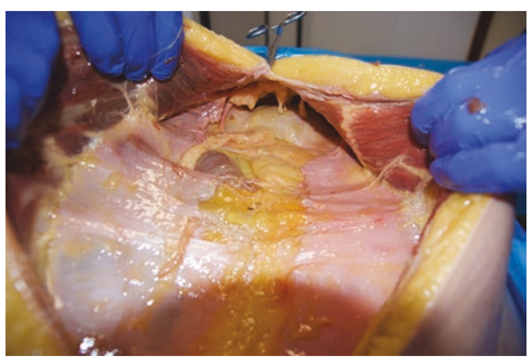

Fig. 6.1 Rives-Stoppa dissection in cadaveric specimen

We extend the cranial retromuscular space dissection beyond the xiphoid process. We must focus on the subxiphoid region since it is possible to confuse the dissection plane and continue the dissection through the diaphragm entering the mediastinum, instead of continuing the dissection as close as possible to the preperitoneal fat [17], keeping the dissection plane under the xiphoid process. Before starting the lateral release of the posterior rectus sheath, we can dissect the preperitoneal space in the epigastric area under both posterior rectus sheaths. When the preperitoneal fat disappears, we decide to go a layer up to the pre-fascia transversalis (pretransversalis) under the transversus abdominis muscle and pre-fascia diaphragmatica (prediaphragmatic) peeling off the fascia diaphragmatica from the diaphragm, following the dome shape of this muscle.

Lateral retro-rectus space dissection over the posterior rectus sheaths must be extended until it reaches the lateral border of the rectus sheath or “ridge.” It is important to preserve the neurovascular bundles that emerge near the lateral border.

Finally, the retropubic preperitoneal space or Retzius space is dissected in a caudal direction, until both Cooper’s ligaments are identified. In M4–5 EHS class cases, we like to dissect the retroinguinal area, skeletonizing the vas deferens/round ligament and parietalizing the spermatic/ovarian vessels.

Usually, we perform the Madrid-PCS modification, which avoids cutting the fibers of the transversus abdominis muscle [15] and try to preserve the anatomical insertion of the posterior rectus sheath on the costochondral cartilages.

Novitsky TAR technique originally described the procedure in a cranial to caudal or “up to down” dissection, cutting the transversus abdominis muscle cranial fibers.

Madrid-PCS carries out the dissection in a caudal to cranial direction or “down to up.” For this dissection it is necessary to identify the arcuate line because it is the point where we begin the section of the posterior rectus sheath, 1 cm medial to the lateral edge of the rectus sheath, avoiding sectioning the neurovascular bundles (Fig. 6.2).

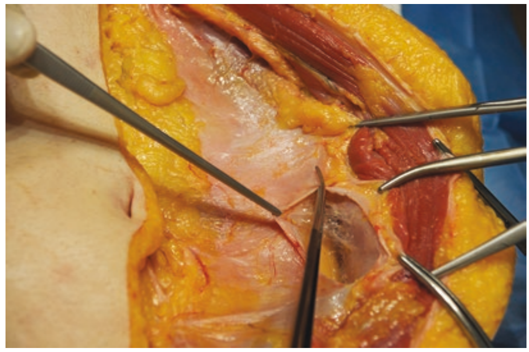

Fig. 6.2 Posterior rectus sheath release in cadaveric dissection

Localizing the *linea arcuata* and its limit with the *linea semilunaris* is easier if the caudal preperitoneal Bogros space is completely dissected [16], taking extreme care in identifying and preserving the inferior epigastric vessels, keeping them parietalized with the fatty tissue that surrounds them within the rectus abdominis muscle.

The posterior rectus sheath lateral section allows us to reach the preperitoneal space located below the transversus abdominis muscle. As we extend the section of the posterior layer in a cranial direction, we must dissect the preperitoneal plane laterally, in this manner avoiding possible peritoneal tearing and facilitating the section and cranial dissection of the posterior layer.

The lateral dissection limit is reached exceeding the posterior axillary line, to visualize the psoas and quadratus lumborum muscles in the posterior abdominal wall.

In the posterior rectus sheath cranial region, the myo-aponeurotic limit of the transversus abdominis muscle is medialized, forming the *linea semilunaris*, which presents a medially concave shape.

While we advance the posterior rectus sheath cranial section, the section line direction follows the *linea semilunaris*, obtaining an oblique (cranial and medial) direction, following the myo-aponeurotic limit of the transversus abdominis muscle thereby avoiding the section of the cranial fibers of the transversus abdominis muscle (Fig. 6.3).

We extend the blunt dissection cranially until we find the subdiaphragmatic plane. As we

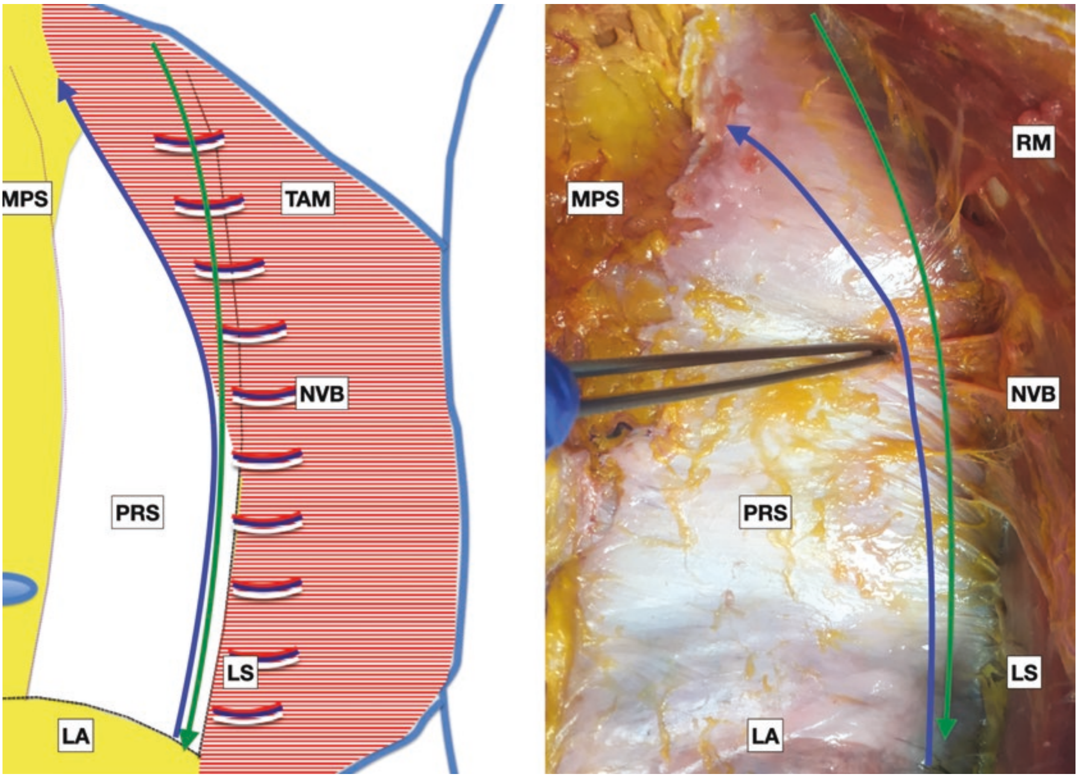

Fig. 6.3 Differences between the PCS-TAR described by Novitsky and the Madrid-PCS modification. Green line: PCS-TAR section line. Blue line: Madrid-PCS section line. LA *linea arcuata* (arcuate line), LS *linea semilunaris*, PRS posterior rectus sheath, NVB neurovascular bundles, MPS midline preperitoneal space, TAM transversus abdominis muscle, RM rectus muscle

already mentioned, in the subdiaphragmatic area, the preperitoneal plane becomes thinner therefore to avoid peritoneal tearing, the dissection plane is changed by peeling off the diaphragmatic fascia from the diaphragmatic muscle, which will give greater consistency to the peritoneal layer. The central tendon of the diaphragm will be our limit of the cranial dissection (Fig. 6.4).

In most cases, the posterior layer can be completely closed using continuous absorbable monofilament sutures (PDS® 2-0, Ethicon, Johnson & Johnson, Somerville, New Jersey, USA).

In case of large peritoneal defects, which do not allow a direct suture due to its fragility, an absorbable mesh can be used, sutured to the edges of the peritoneal defect, replacing the posterior layer [18].

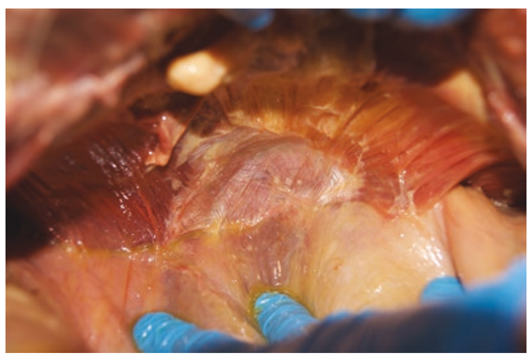

Fig. 6.4 Detail of the subdiaphragmatic area dissection in cadaveric specimen. The diaphragmatic fascia has been peeled off from the diaphragm muscle and the central tendon of the diaphragm is reached

For the reconstructive phase, in our group, a combination of meshes is used in all cases [18].

A 20 × 30 cm absorbable mesh (GORE® BIO-A® Tissue Reinforcement, WL Gore & Associates, Inc. Flagstaff, AZ, USA) is placed over the closed posterior layer. A second large (50 × 50 cm) permanent macroporous polypropylene synthetic mesh (Bulevb®, Dipro Medical Devices SRL, Torino, Italy) is then placed over the first mesh in the widely dissected space. Both meshes are trimmed to fit the dissected space.

Mesh fixation is not carried out systematically in our group. The mesh can be fixed to both Cooper's ligaments and to diaphragm's central tendon. Furthermore, fixation of the mesh could be necessary when a correct overlap of the mesh is not achieved in regard to the hernia defect (for instance in M1 or M5 defects).

We usually perform a transversus abdominis muscle reinsertion to the mesh using continuous slow absorption suture (PDS® 2-0, Ethicon, Johnson & Johnson, Somerville, New Jersey, USA) (Fig. 6.5).

A Blake-type grooved silicone suction drain is placed between the polypropylene mesh and the abdominal wall muscles.

The anterior layer is closed using continuous monofilament long-term absorption sutures (Monomax®, USP 0 or 1, B. Braun, Melsungen, Germany).

When it is not possible to complete the closure of the anterior layer, the edges of the anterior fascia are sutured to the mesh, leaving a bridge, that is covered with the remaining peritoneal sac previously preserved [19].

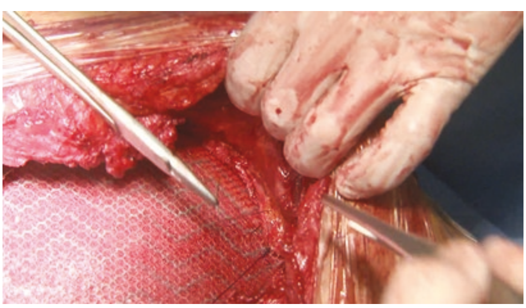

Fig. 6.5 Reinsertion of transversalis muscle to the mesh

6.7 Tips and Tricks

6.7.1 Starting the Surgery

- Open the peritoneal sac as soon as possible and preserve it until the end of the surgery.
- To avoid inadvertent enterotomies, perform adequate adhesiolysis and protect visceral contents with a gauze or a sterile cloth.

6.7.2 Medial Release of Posterior Rectus Sheath

- Open the posterior rectus sheath as near the midline as possible.
- Preserve the integrity of the cranial insertion of the posterior rectus sheath.
- Avoid injuring the intact *linea alba*.
- Keep fatty tissue attached to epigastric vessels.

6.7.3 Lateral Release of Posterior Rectus Sheath

- Start by preperitoneal dissection at the epigastric area (subxiphoid) and at the Bogros space.
- Posterior rectus sheath section 1 cm medial to *linea semilunaris*.
- "Down to up TAR" (bottoms up, TAR up).
- Follow the muscle-aponeurotic limit of the transversus abdominis muscle in the cranial dissection.
- Before continuing the cranial section of the posterior rectus sheath, be sure to perform a correct lateral dissection of the preperitoneal space.
- When the peritoneum thins and peritoneal tearing are unavoidable, it is possible to switch from the preperitoneal plane to the pretransversalis plane to give greater consistency to the posterior layer.

6.7.4 Find the Diaphragm and Psoas Muscle

- In the subdiaphragmatic area the peritoneum thins out. Peeling off the diaphragmatic fascia of the diaphragm muscle to give a greater consistency to the posterior layer.
- "Follow" the dome of the diaphragm muscle in your dissection to avoid mistaken entry into the mediastinum.
- Get an adequate dissection to be able to extend a very large mesh.
- Be careful with the nerves coming out of the psoas muscle.

6.8 Complications and Management

PCS is not a risk-free surgical technique; complications may occur in up to 40% of patients.

There are a series of factors that predispose to the appearance of complications such as obesity, smoking, diabetes, immunosuppression, poor nutritional status, history of surgical site infections, and oncological disease among others. Some of these factors could be corrected preoperatively, reducing the probability of presenting postoperative complications. Therefore, it is essential to encourage the patient in the correction of modifiable factors before operation.

The term SSO was established in 2010 by the Ventral Hernia Working Group (VHWG) in order to standardize postoperative complications after hernia repair. SSO includes the appearance of erythema, seroma, surgical site infection (SSI), hematoma, wound dehiscence, and enterocutaneous fistula formation within 30 days of the operation [20].

6.8.1 Seromas

Asymptomatic seromas do not require treatment and may be followed up.

If the seroma becomes infected or is symptomatic, our first option would be percutaneous drainage, and if this is not effective or if it gets infected, as a second treatment step, we would consider opening the wound and placing negative pressure therapy.

To avoid the appearance of seromas, we recommend the use of drains in the subcutaneous tissue if extended dissections of it have been performed, and maintain them until the volume is less than 25–30 cc for two consecutive days. The use of a binder in the postoperative period could also decrease the appearance of seroma by reducing dead spaces.

6.8.2 Hematomas

The hematomas after a PCS should be managed conservatively. If there is a significant decrease in hemoglobin levels or hemodynamic instability, CT angiography is recommended to identify active bleeding and, if confirmed, we recommend endovascular treatment by embolization of the bleeding vessel. Sometimes, blood product transfusion is required in patients with large hematomas.

Like seromas, the management of hematomas should be conservative and drainage must be considered only if there is suspicion of infection or they are highly symptomatic.

6.8.3 Surgical Site Infection

The Centers for Disease Control and Prevention (CDC) divides SSI into three types: superficial, deep, and organ-space infection [21].

Superficial infections can be managed with antibiotic therapy; sometimes they would require bedside wound opening.

In deep infections, the use of percutaneous drains associated with antibiotic therapy will be necessary. If there is devitalized tissue, a surgical debridement may be necessary.

Organ-space infections may require urgent reoperation if there is hemodynamic instability secondary to sepsis. If the patient's situation allows it, a management similar to the one mentioned for deep infections with percutaneous drainage and antibiotic therapy would be the best option.

Negative pressure therapies also play an important role in the management of the SSI.

6.8.4 Anastomotic Dehiscence or Enterocutaneous Fistula

The appearance of an enterocutaneous fistula is a rare complication after a PCS and is mainly due to inadvertent enterotomies during surgery or anastomotic dehiscence. We strongly recommend visceral protection with sterile cloth during surgery and an intensive review of the visceral package before finishing the procedure.

Its management will be similar to other fistulas including antibiotic treatment, wound care, and nutritional support. We must take special care with the management of the skin in these patients, trying to isolate the fistula from the surgical wound as much as possible; sometimes it may be necessary to perform excision of a mesh segment allowing the fistula to protrude outside. If the patient is stable and has no signs of uncontrolled infection, we recommend delaying fistula repair surgery for at least 6 months.

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7 Peritoneal Flap/Hernia Sac Technique for Midline Ventral Hernia

Andrew C. de Beaux and Barbora East

7.1 Introduction

In abdominal wall repair, the goal is a functioning abdominal wall strong enough to withstand the forces applied to it every day for life. At the same time, it should not be rigid so that bending, twisting, and distension remain possible and painless. Closure of the midline is often quoted as a key step, yet people with a lateral hernia have an intact midline but defective abdominal wall. We like to think of abdominal wall repair as restoring the myotendinous ring, transversely as well as vertically, to restore or at least improve core stability and abdominal wall function.

This chapter describes our technique of peritoneal flap repair of (larger) abdominal wall hernias. For midline hernias, it is firmly based on the more conventional classic Rives-Stoppa repair technique. The name 'peritoneal flap' is actually a misnomer. The 'hernia sac' is not just peritoneum, but is also composed of scar tissue and attenuated abdominal wall fascia. It can be thin and peritoneum-like, but usually it is comprised of much stronger tissue, and indeed it can be difficult to pass the needle through and suture the dense scar tissue layer. We refer to this as the hernia sac technique.

7.2 History of the Hernia Sac Technique

Like so much in surgery, we did not develop the technique de novo but modified a technique first described by the Brazilian Surgeon, Alcino Lazaro da Silva. His technique was first published in the Portuguese literature in 1971 [1], and in 1979 in English [2]. In essence, as demonstrated in Fig. 7.1, the sac of the hernia is preserved during the initial dissection, with the laparotomy through the middle of the hernia sac. Based on the width of the hernia, variable amounts of anterior rectus sheath, and on the contralateral side, the posterior rectus sheath is mobilised to allow midline closure (with a degree of 'rectal diastasis') with a neo linea alba. The hernia sac is trimmed to allow coverage of the bare rectus muscle from where the donor anterior and posterior rectus sheath had been taken—in essence, a three-layer suture technique.

In our technique, there is minimal use of the native anterior and posterior rectus sheaths to facilitate closure, as this 'crossover' fascial layer is not used. Instead, a mesh is placed in the retro muscular space, sandwiched between the anterior and posterior layer closure. A step-by-step schematic to the technique is depicted in Fig. 7.2. We

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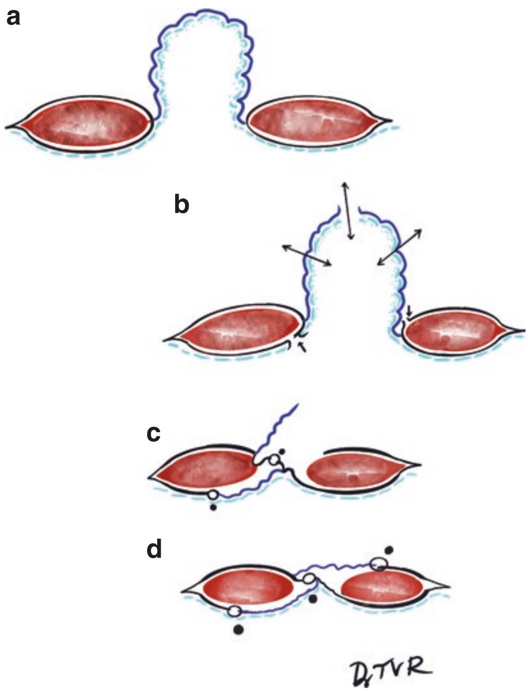

Fig. 7.1 Schematic view of the abdominal wall reconstruction as described by Da Silva in [2]. Laparotomy is through the hernia sac with excess sac trimmed as shown in (**b**). Incision on one side through the anterior rectus sheath and on the other through the posterior rectus sheath—variable position to facilitate midline reconstruction exploiting the retro-rectus plane. The hernia sac is sutured to the posterior rectus sheath to cover the bare muscle posteriorly, and the posterior and anterior rectus sheath sutured to recreate the 'linea alba' as shown in (**c**). The hernia sac is sutured to the anterior rectus sheath to cover the bare muscle anteriorly on the contralateral side as shown in (**d**). Illustration by Dr. T Varun Raju

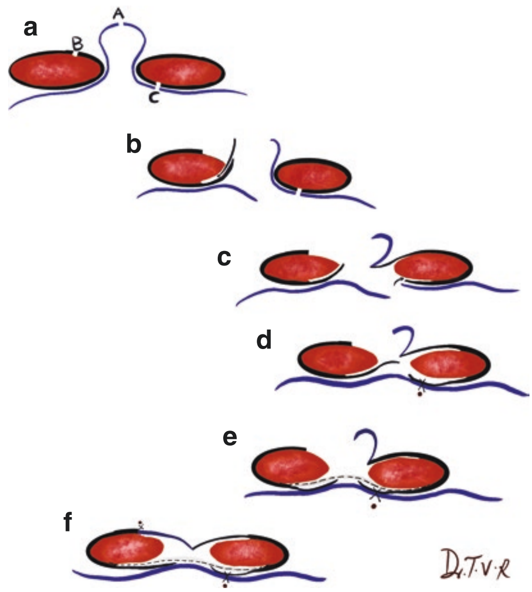

Fig. 7.2 Schematic view of the hernia sac technique as described in [3]. Laparotomy is through the hernia sac at A as shown in a. Incision on one side is through the anterior rectus sheath (point B as shown in (**a**)) allowing the hernia sac to remain attached to the posterior rectus sheath. Incision on the other side is through the posterior rectus sheath (point B as shown in (**a**))—allowing the hernia sac to remain attached to the anterior rectus sheath. Retro-rectus plane dissection is shown in (**b**) and (**c**). Excess sac is trimmed as necessary allowing closure of the posterior layer with reasonable tension as in (**d**), then retro-rectus mesh placement as in (**e**). Finally, excess sac is trimmed as necessary allowing closure of the anterior layer with reasonable tension as in (**f**), minimising the degree of divarication as able. Illustration by Dr. T Varun Raju

first reported the hernia sac technique in 2014, although we had been using it for developing the idea from the 1990s [3]. We have also published a cohort series with midterm follow up in midline and transverse incisional hernias [4, 5], as well as post-liver transplant incisional hernias [6]. A Swedish group using a similar technique has also published their cohort series [7].

A major criticism of the technique is that it is a bridging technique. This may be true, although it is not just mesh bridging, as there is tissue above and below the mesh, the mesh being the filling of the sandwich. In large hernias, there will be a degree of divarication at the end of the procedure. However, this divarication does not manifest like primary divarication of the recti. As the patient does a sit up, there is no midline bulge observed as would typically be seen with divarication. It must be remembered that many patients with large incisional hernias have, for example, missing rectus muscle on one or both sides, some form of denervation, and so on. So, restoration of an anatomically normal abdominal wall, including restoration of the original linea alba may not be achievable. It is also important to mention, that the linea alba is a very thin structure often depicted wrongly in anatomical books giving a false feeling of it being a very strong element of the abdominal wall. Restoration of the myotendinous ring of the abdominal cavity is important for core stability, and abdominal wall function. The hernia sac flap technique appears to achieve this. Indeed, the modified flap technique in the Malmo series had significantly higher patient satisfaction scores than traditional recto-rectus repair with ‘midline’ closure, as well as a reduced risk of recurrence. The reasons for this are not clear. The use of the hernia sac results in less of a reduction in the radius of the abdominal cavity at the time of the repair, and perhaps there is less tension on the ‘linea alba’ suture line. While component separation techniques have their role, and occasionally have to be combined with the peritoneal flap technique, this is rarely the case. Thus, the lateral abdominal wall in midline hernias is not touched, and thus avoids the potential for lateral iatrogenic incisional hernias.

7.3 Indications and Case Selection

The role of the hernia sac repair varies based on your practice. Our practice is based on tertiary referral services of complex abdominal wall repair, with large defects, often with significant cosmetic deformity, thin stretched skin, or indeed excess of skin following weight loss. Thus, abdominoplasty is a frequent component of this operation, and excision of significant redundant skin, if not amounting to a conventional abdominoplasty, is the routine. Indeed, the majority of our open approach utilises the dissection techniques of the hernia sac repair, but if at the time of abdominal wall closure, the hernia sac is not required for closure, it is excised at that point. Occasionally, as seen in frail older patients, the layers of anterior and posterior rectus sheath are attenuated and too poor in themselves for closure in ‘layers’. Here we would resort to an ante-rectus fascia or an onlay technique.

Loss of muscle through devascularisation at previous surgery, denervation, or disuse is not usually prohibitive as the fascial layers are still present. It is the fascial layers that are the key to this repair, not the muscle itself. Once the concept is understood, the hernia sac technique can be adapted to deal with fascia and muscle loss, such as TRAM flap harvest for breast reconstruction, including in some cases, bilateral TRAM flap harvest.

We are not fans of surgery by numbers. As hernia width increases, the ability to easily restore anterior rectus sheath to anterior rectus sheath diminishes. But a smaller width round defect in a short person can be more difficult to close than a wider elliptical defect in a tall person. Weight loss prior to surgery in obese patients makes a big difference too. Again, in the former type of patient/hernia, the hernia sac technique can be useful.

The limitations of the technique are same as the limitations of the Rives-Stoppa repair. In cases where the posterior fascia/peritoneum below the arcuate line has been destroyed, like in urinary bladder excision and some gynaecological surgery, the technique cannot be used due to the lack of a posterior layer. The presence of a stoma is not a problem per se, but some lateralisation of mesh in the TAR plane may be necessary.

7.4 Contraindications

There are a few contraindications. The main contraindication to hernia sac repair is a patient not fit for surgery, because of their significant comorbidity despite optimisation. These criteria are similar for any elective benign procedure and are thus not detailed here.

The technique requires the presence of a hernia sac, so it has no role in the closure of an open abdomen for obvious reasons. It is useful to have a preoperative CT scan for planning purposes.

7.5 Instruments and Energy Source

The instruments needed are those in a ‘laparotomy tray’. Mayo forceps are needed to aid with tissue traction. No further specialist instruments are necessary. Like any laparotomy, sutures and instruments appropriate for the use on bowel are recommended, to manage serosal tears and inadvertent enterotomies. Monopolar diathermy with cutting as well as coagulation settings are the mainstay of energy devices.

7.6 Team Setup, Anaesthesia, and Position

The team setup is typical of a laparotomy. Surgeon is on one side, assistant is on the other. Scrub nurse is on the side convenient for the flow of instruments and supplementary material. Anaesthetist is at the head end.

In the majority of cases, for both midline and transverse incisional hernias, the patient is placed in the supine position. The arms can be tucked in at the side, or in the arms out position. Sometimes, if the incision requires to be very lateral, (because of the position of the hernia or the lateral extent of the abdominoplasty to minimise the lateral ‘dog-ears’) then the arms out position may facilitate this. The ability to break the table, jackknifing the patient in the middle is useful when closing the skin after a low transverse abdominoplasty incision. Prepare the operative field generously. Draping varies depending on the extent of skin exposure required. While the use of adhesive dressings to minimise skin exposure have its role, we do not routinely use these. When used, these need to be removed prior to skin excision and closure to facilitate excision of any redundant skin in an attempt to restore symmetry to the abdominal wall appearance.

The type of anaesthesia is usually general anaesthesia with neuromuscular paralysis. Epidural as a single shot or continuous infusion or not at all may be given depending on patient/anaesthetist choice.

7.7 Key Steps

Making the right decision for surgery, working the patient up right, doing the right operation and doing it right, and looking after the patient afterwards right is key!

Preoperative planning of the Hernia Sac repair is similar to any major abdominal wall repair. Assessment of the abdominal wall musculature and the skin/subcutaneous tissues by clinical examination supported by cross-sectional imaging is essential. Such imaging is also important to rule out cancer recurrence in those whose original operation was for cancer resection or new pathology. Weight loss, optimisation of any comorbidity, and improving exercise tolerance are important as necessary. Also consider other adjuncts like Botulinum Toxin therapy, preoperative pneumo-peritoneum, or intra-perative abdominal wall stretching devices like Fasciotens. Targeted preoperative physical therapy focusing on fixing the pelvic floor—diaphragm dyskinesis, correct breathing, overall activity of core muscles plus training of postoperative way of getting out of bed and exercising is also beneficial to patients with a hernia being considered for major surgery. Getting the patient optimized with their preoperative workup, including smoking cessation, is key. Informed consent is taken after discussing the benefits, risks, and alternatives to the approach. It is advisable to have a thorough chat with each patient on the use of mesh. Due to rising anti-mesh propaganda, it is important for patients’ compliance that they understand some basic facts about its properties and reasons why is it being used in their case. Joint decision-making makes patient outcomes better.

Thereafter, the key steps of the operative technique are discussed in the next section.

7.8 Surgical Techniques and Variations

7.8.1 Step 1: Incision/Laparotomy/Adhesiolysis

Plan the surgical skin incision with the patient prior to surgery so that they appreciate the scar position. Reassess once the patient is anaesthetised, particularly if a hernia is tender to touch which makes preoperative assessment more uncomfortable for the patient. The skin excision might just be a generous skin ellipse incorporating the old scar, or might include a more formal abdominoplasty approach. Either way, you want

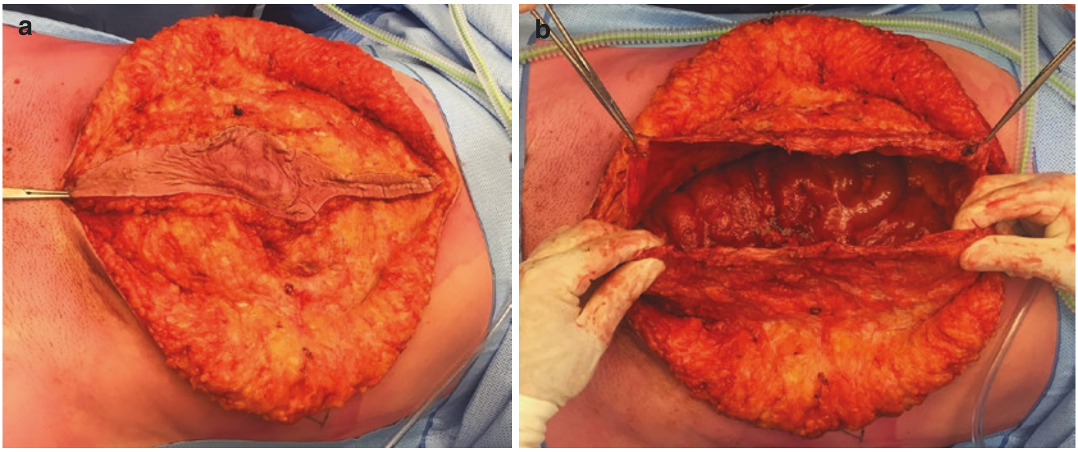

Fig. 7.3 (**a**, **b**) Excision of scar, and raising skin and subcutaneous fat flaps back to healthy anterior rectus sheath in (**a**). Laparotomy through the hernia sac with adhesiolysis of the bowel off the undersurface of the abdominal wall in (**b**). Patient's head is to the right. Reproduced from [4]

to raise skin flaps off the hernia sac to the point where you identify healthy native anterior rectus sheath. Continue the dissection over the anterior rectus sheath for a short distance but try and preserve the skin perforators at this stage (Fig. 7.3a). After this, take the skin and subcutaneous fat off the hernia sac, preserving the whole sac as much as possible. Sometimes, if there is clearly an excess sac, the scar and some of the hernia sac can be excised at this point. But it is a good practice to preserve as much of the sac as possible. This includes when the sac is largely skin graft, as this can be de-epithelialised and used if necessary.

Another option is to start by excising the scar and identifying the hernia sac underneath and then continuing the dissection laterally "sliding on the sack" until a healthy anterior rectus sheath is visualised. This approach might be safer in less experienced hands, as it allows the surgeon to modify the amount of excised skin based on the actual size of the defect (it can be drawn on skin before and skin excision can be still added at the end of the procedure).

The laparotomy is performed through the middle of the hernia sac, taking care of first entry to minimise the risk of inadvertent enterotomy. The sac is divided in line with the original incision back to healthy abdominal wall, (although in some cases this will be from the xiphisternum to the pubic symphysis) Fig. 7.3b. Adhesiolysis of the abdominal contents off the anterior abdominal wall is the usual practice, with interloop adhesiolysis as necessary. If the patient had no obstructive symptoms before the operation an extensive interloop adhesiolysis can make things worse in the future. Keep this in mind and do not forget to ask and document this during the informed consent process.

Cover the dissected bowel and omentum with a large moist pack and you are ready to start the abdominal wall dissection.

7.8.2 Step 2: Retro-Rectus Dissection

In general, for midline wounds, we keep the hernia sac attached to the anterior rectus sheath on the left side and the posterior rectus sheath on the right side. However, if one side of the hernia sac appears thicker and more robust than the other, this stronger sac is kept attached to the anterior fascia. And if the patient has a stoma, we would keep the hernia sac attached to the posterior rectus sheath on the side of the stoma. But again, the aim is to keep the stronger half (if there is a difference) to the anterior layer so this is a final intraoperative decision.

The actual dissection is very similar to a conventional retro-rectus dissection. On the side of the sac attached to the anterior rectus sheath, the dissection divides the posterior rectus sheath just below where it becomes the linea alba (Fig. 7.4a). To minimise bleeding, especially from the inferior epigastric vessels, the trick is to stay right on the anterior surface of the posterior rectus fascia, keeping all tissue including fat dissected up with the belly of the muscle. Dissection is continued to get good overlap, behind the pubic arch and xiphisternum (into the region known as the fatty triangle) as need be. On the side of the sac attached to the posterior rectus sheath, the dissection divides the anterior rectus sheath just before it becomes the linea alba (Fig. 7.4b). This dissection is often a bit more tricky, as the previous mass closure suture often has welded the muscle to the anterior and posterior fascia close to the midline. However, as you dissect laterally underneath the belly of the rectus muscle, the dissection becomes easier. As you near the top and bottom of the dissection, it is important to join up the retro-rectus space with that of the other side, and this is discussed in Fig. 7.5. Once this dissection is done, you are ready to start the closure and effect the repair.

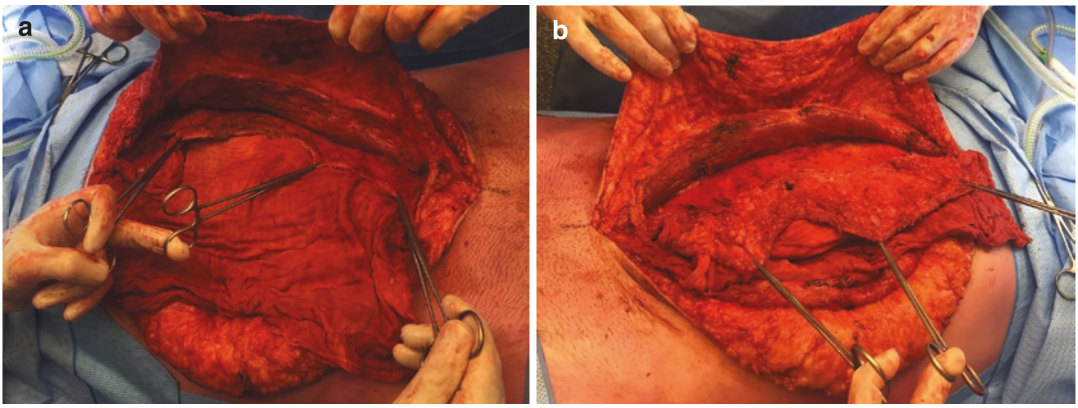

Fig. 7.4 (**a**, **b**) Completion of the peritoneal flap dissection—the hernia sac attached to the anterior rectus sheath on the left (**a**) and to the posterior rectus sheath on the left (**b**). Reproduced from [4]

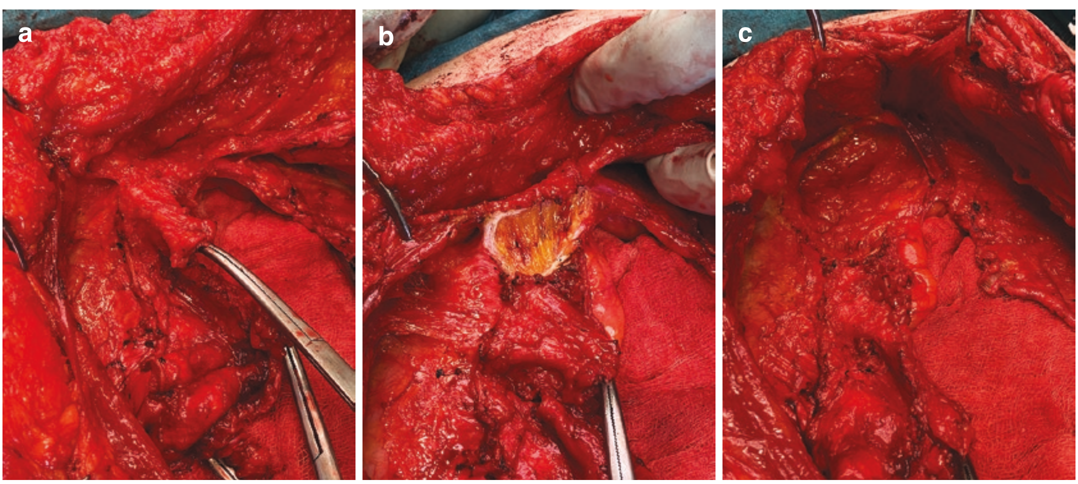

Fig. 7.5 (**a**–**c**) Looking towards the patient's head. The retro-rectus plane on the left and right is seen but in (**a**), the posterior peritoneal flap is still attached to the midline which is the anterior layer. In (**b**), the peritoneal flap is now disconnected from the anterior layer, and dissection in the midline is starting just underneath the linea alba. In (**c**), the dissection is complete and the posterior rectus sheaths as they attach to the linea alba have been divided, to create a good upper midline overlap for the mesh

There will be times when the hernia sac is either very thin, nonexistent, or so full of holes, that the only option is to excise the sac and resort to component separation techniques, as described in other chapters. But this is rarely the case.

7.8.3 Step 3: Closure of the Posterior Rectus Sheath, Hernia Sac Complex

Remember to remove the abdominal pack before this step is completed! Rarely, you may need all of the hernia sac attached to the posterior fascia, but usually you only need some of it. Excise the excess but err on the side of leaving more than less. We start the closure from either end, using a heavy, looped slowly resorbable suture, on a sharp but non-cutting needle. However, with increasing evidence around the small stitch small bite closure techniques, we are using 2/0 slow resorbable suture more frequently. We place all the sutures, using a plication type suture, passing the needle from above through the tissue and then back through from below on the same side, and then the same on the other side until they meet in the middle (Fig. 7.6a). Once these sutures are all placed, we tighten the suture line spreading the load of the sutures along the whole wound length. In this way, abdominal walls that look impossible to close come together (Fig. 7.6b). There is usually some tension but we think that a tension-free repair of the abdominal wall is a myth, as the abdominal cavity has a resting pressure above atmospheric, so there is always tension on the abdominal wall. The knot in the middle needs to be secure. A degree of elasticity in the peritoneal flap helps minimise changes in intra-abdominal pressure on closure, such that a significant rise in ventilatory pressures or postoperative abdominal compartment syndrome is rare.

It is important to mention, that the posterior layer usually comes together easily and under a lot less tension than the anterior. So, you should not really be in trouble at this point of the operation. If you are, then a component separation is likely necessary.

It is important to mention that in some smaller defects the edges of the posterior and/or anterior sheath actually do come together and none of the sack ends up being used. In either scenario, the maximum amount of the sack is half of the original one (actually a bit less by the time suture bites are taken into account as well as any elasticity in the flap being taken up), so the gap between the muscles is maximum half of the original one

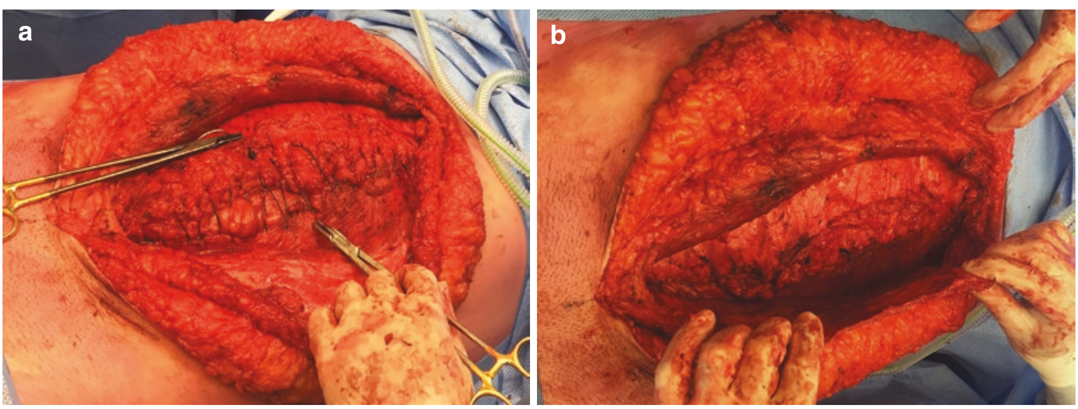

Fig. 7.6 (**a**, **b**) Closure of the posterior layer. The posterior rectus sheath on one side is attached to the peritoneal flap of the other side. The sutures are placed from either end of the wound to meet in the middle as shown in (**a**). The suture is then tightened and the knot tied as shown in (**b**). It is usual to get posterior rectus sheath together at the inferior end, and often the superior end, but towards the middle of the incision, increasing the width of the peritoneal flap is utilised to facilitate posterior layer 'closure'. Again the patient's head is towards the right of the image. Reproduced from [4]

which has several clinical benefits. The volume reduction of the abdominal cavity is less than conventional Rives-Stoppa, resulting in less increase in intra-abdominal pressure at the end of the procedure. It often abolishes the need for component separation and thus any inadvertent nerve injury, which might affect abdominal wall function and denervation bulges in the future.

7.8.4 Step 4: Mesh Placement

The use of a usual large pore synthetic mesh is our standard for nearly all cases. We are currently using a polypropylene, 3.2 mm pore size and 48 g/m^2 mesh. While the weight likely does not play much role in the repair, porosity seems to be important based on more recent evidence. It is also important to keep in mind, that stretching the mesh can change the shape and size of the pores and one can easily change a large pore mesh into a small pore one simply by mishandling it. Occasionally, with increasing contamination, or when the mesh has been used before but became infected, we have used slowly resorbable mesh. We need more follow up to know if this is worth the large increase in mesh price and what will happen to the patient's intact abdominal wall once the mesh gets degraded. The mesh should lie flat and fit the pocket. The mesh is secured in position with a few interrupted slowly resorbable sutures, attaching the mesh to the posterior rectus sheath, taking care not to pass the needle deep and catch bowel, or place the suture near a visible nerve.

It is possible to minimise the risk of bowel injury even more by using glue—either fibrin, which is expensive or histoacryl, which is actually cheaper than the suture itself. However, it does require some skill to be able to apply it correctly.

We do not believe in transfascial sutures. The role of the suture fixation is to keep the mesh flat and it does not really contribute to the strength of the repair. Indeed, we often do not place sutures below the arcuate line but ensure good mesh overlap inferiorly. We nearly always place a drain superficial to the mesh, but this is mainly to allow the instillation of an antibiotic and local anaesthetic solution into the deep space once the anterior layer is closed. Although the evidence for this in terms of postoperative pain relief and prevention of mesh infection is weak, it is crucial to keep in mind the position of the epigastric vessels when placing the drains. A simple step like this can lead to significant blood loss if the drain is placed through a blood vessel of note.

7.8.5 Step 5: Anterior Layer Closure

Anterior layer is closed with a looped slowly resorbable suture on a sharp non-cutting needle. Again starting the suture at either end and working towards the middle of the wound, using the same plication style suture technique as above, the sutures are placed about 5 mm in from the cut edge of the anterior rectus sheath, and a variable amount in from the edge of the peritoneal flap, to allow closure. All the sutures are placed to the middle before the slack in the suture is taken up and several throws to create a square knot tied. Using the same sutures, a second layer of continuous plication is inserted from the middle to either end, varying the width of the bites taken to

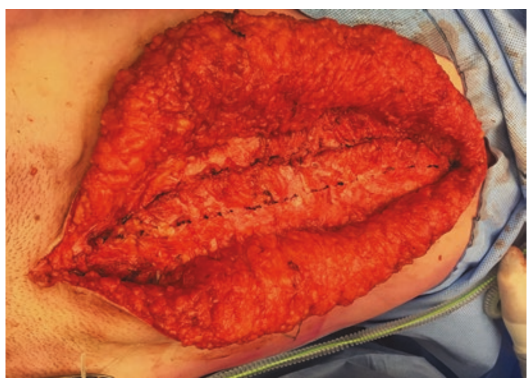

Fig. 7.7 Closure of the anterior layer. Again, the anterior rectus sheath is together at the top and bottom, but the peritoneal flap is used as necessary to effect closure—as demonstrated by the inked line making the medial edge of the anterior rectus sheath. Again the patient's head is towards the right of the image. Reproduced from [4]

create an even tension along the whole length of the scar (Fig. 7.7). The second layer of sutures does even the 'tension' along the length of the incision, but it also protects the knot of the first layer—suture fracture near the knot or the knot unravelling as not laid square is a risk with any suture closure.

This layer is usually harder to close. But it usually comes together if all the steps above were followed. Do not try to tighten each stitch as you insert it. You are a lot less likely to tear the tissue if you follow the abovementioned recommendation.

7.8.6 Step 6: Skin and Subcutaneous Fat Closure

Drains in the deep space will depend on the size and nature of the operation. Any further excess skin is excised at this point. Minimising the dead space with quilting sutures and a rapidly absorbing suture to the subcutaneous fat is often used. The skin is closed with an absorbable subcutaneous suture and a tape covering the whole length of the scar is applied. The role of closed negative pressure dressings and abdominal wall binders is still not well researched, but we use these adjuncts with increasing frequency.

The hernia sac technique is a useful technique also in the repair of incisional hernia after TRAM flap harvest. The operative steps are shown in Fig. 7.8. While lateral dissection from the posterior rectus sheath to the plane between external and internal oblique is not usually recommended (as it divides the segmental neurovascular supply to the rectus muscle on the same side, remember after TRAM flap harvest—the muscle is missing! As dissection proceeds cranially and caudally, you will start seeing rectus muscle again. At this level, the dissection laterally in the inter-oblique plane stops, and dissection is limited only to the lateral edge of the rectus muscle again as in a conventional Rives-Stoppa dissection.

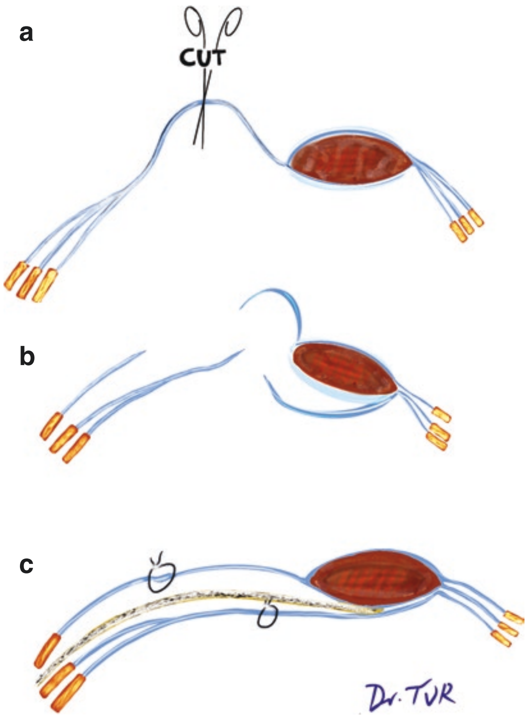

Fig. 7.8 Schematic view of the hernia sac technique following unilateral TRAM harvest incisional hernia. Laparotomy is through the center of the hernia sac—which is usually stretched posterior rectus sheath as shown in (**a**). Then, retro-rectus dissection is done on the non-TRAM flap side, and on the TRAM flap side, the inter-oblique plane is entered as shown in (**b**). Again keep the hernia sac on one side up to anterior rectus sheath, and the hernia sac down to the posterior rectus sheath as shown in (**b**). At the top and bottom of the dissection where there may still be some rectus muscle left, veer back to the midline as the dissection at the top and bottom will be as for a conventional retro-rectus dissection. Closure is shown in (**c**)—the internal oblique, transversus abdominis complex with the hernia sac is sutured to the posterior rectus sheath of the other side, mesh sandwich and then the external oblique aponeurosis is sutured to the hernia sac attached to the anterior rectus sheath of the other side. Illustration by Dr. T Varun Raju

7.9 Tips and Tricks

7.9.1 Skin Excision

Do not be too radical at the start of the procedure—it is easy to excise a bit more skin at the time of closure than to try and stick some excised skin back!

For beginners, we recommend you to focus on the hernia and if it is not your field of expertise start the abdominoplasty together with a plastic surgeon. This operation is not a primary cosmetic surgery and increasing morbidity by combining it with badly performed abdominoplasty is counterproductive.

Draw your incision lines on the skin before you prep and drape. Especially if the patient will be prepped and draped in your absence, to ensure that draping exposes enough laterally.

Patients with no obstructive symptoms rarely benefit from extensive adhesiolysis so keep this in mind. And while small bowel injury with no spillage does not mean you cannot use a mesh, it sure is a worry in the postoperative period! Prevention is better than cure.

Operate slowly, especially when heading below the arcuate line and towards the lateral edge of the rectus muscles. An overlooked blood vessel can slow you down a lot, and an injured nerve can mean an unhappy patient.

Some patients demand to keep the umbilicus. In large midline hernias, it is impossible to spare it in most cases. Talk to your patient before the operation and make sure it is well documented. It is possible to create a new umbilicus, but it can pose a risk of wound morbidity. The umbilicus is perhaps dirtier than we think.

It is sometimes hard to know the size of the mesh and even when the retro-rectus space is developed and posterior layer is closed, how do we measure it? It has various shapes! By wiping the mesh all over the skin (it does not matter if it has been prepped, it is not sterile at this point anymore anyway), you are only introducing infection and skin-mesh contact should be prevented. The easiest is to use the whole mesh, place few sutures—two in cranial and caudal pole and several on the edges and then trim it, adding more sutures to hold the mesh flat as you go as necessary.

Be careful with inserting any drains through the rectus muscle. Obviously, avoid the inferior epigastric vessels, but vessels within the muscles can also bleed, and often do not stop bleeding on their own accord.

7.10 Postoperative Care, Complications, and Management

Careful work up, including Inj Botulinum toxin and weight loss where necessary, and the use of the hernia sac (which allows a slightly greater diameter to the abdominal cavity and thus a greater intra-abdominal volume), allows even very large hernias to be repaired with little in the way of increase in airway pressures at the end of the procedure. Failure of extubation at the end of the procedure is a very rare event.

Any drains in the retro-rectus space are removed at 48 or 72 h no matter the drainage volume. However, we would be cautious of removing a drain giving 500 mL of fresh blood. Subcutaneous drains typically remain until discharge. And if they are still producing over 50 mL a day, then the patient may well go home with the drain(s) in. While drains are a potential route for infection in the subcutaneous compartment, this has not been our experience. Prevention of a seroma is perhaps better than any cure. Additional steps in addition to drains are raising the skin flaps preserving some fat on top of the anterior fascia, ligating the larger perforating vessels as lymphatics are thought to be associated with these, are quilting sutures to minimise the dead space at the time of closure.

Early oral fluids and diet are given as tolerated. No further antibiotics are given routinely. Ten milligram intravenous metoclopramide three times a day may shorten the period of ileus. Mobilisation is encouraged immediately and advice is given on how to get up excluding the anterior abdominal wall by rolling on the side first and using arms to verticalise. This helps the patient mobilise sooner as it is a lot less painful.

Similarly in convalescence, the patient is given little in the way of exercise or weight lifting restrictions, except to work within their level of discomfort. Compression underwear and vests may lead to faster mobilisation and a lower seroma rate.

7.11 Wound Complications

This is a common consequence of open abdominal wall surgery. Again prevention with prophylactic antibiotics, weight reduction, control of comorbidities especially diabetes mellitus, and malnutrition will all have small net gains. Method of closure, vascularity of the skin, and the use of dressings such as NPWT and skin glue also help. Diabetes control perioperatively is very important as a single episode of glycemia above 10 can sabotage a good outcome. Perioperative hypothermia will also play a negative role in wound healing.

Wound breakdown, and indeed partial anterior fascia breakdown can usually be salvaged by appropriate wound irrigation, and VAC therapy followed by skin grafting as necessary.

Gross contamination with the mesh bathed in pus, or as a consequence of bowel injury, is nearly always best served by removal of all the mesh, VAC therapy. The resultant recurrent incisional hernia can be managed again once skin healing has occurred.

7.12 Conclusion

This is a useful technique to have in your tool box for abdominal wall repair. The simplicity of the procedure is evident. It can be used in any primary or recurrent incisional hernia repair as long as there is a hernia sac.

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8 Peritoneal Flap/Hernia Sac Technique for Transverse Ventral Hernia

Barbora East and Andrew C. de Beaux

8.1 Introduction

We have discussed the peritoneal flap or hernia sac repair for midline ventral hernias in the previous chapter. In this chapter, we discuss the use of the technique in transverse ventral hernias, both medially, where the scar involves the recti, and laterally, where the scar involves the lateral muscles. Again, the name "peritoneal flap" is actually a misnomer. The "hernia sac" is not just peritoneum but is also composed of scar tissue and attenuated abdominal wall fascia. It can be thin and peritoneum-like, but usually it is comprised of stronger tissue.

For small transverse wounds, when there is no extension beyond the lateral edge of the recti, repair is similar as described in the proceeding chapter. Just remember that everything is rotated by 90°, so keep your orientation during the dissection, and preserve the neurovascular bundles. Most transverse scars will involve the lateral muscles with the recti on one side, perhaps both sides, and sometimes the lateral muscles on both sides also. The dissection laterally is between the oblique muscles [1, 2] (Fig. 8.1). The attachment of the internal oblique and transversus abdominus muscles is to the costal margin, while the attachment of the external oblique is to the anterior surface of the 5th–12th ribs (Fig. 8.2). This anatomical arrangement makes it possible to get good mesh overlap above the ribs in cases of transverse or subcostal incisions that run close to the costal margin. In addition, the relatively avascular plane with little in the way of motor nerves in the inter-oblique "space" makes this plane the one of choice.

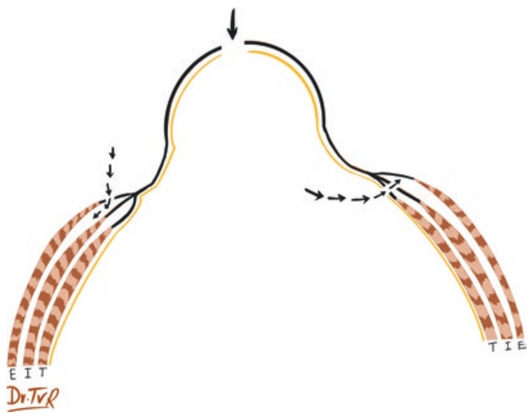

Fig. 8.1 Schematic diagram of the hernia sac technique in the inter-oblique plane, keeping the hernia sac attached to external oblique on one side, and to internal oblique/transversus abdominis on the other. Illustration by Dr. T Varun Raju

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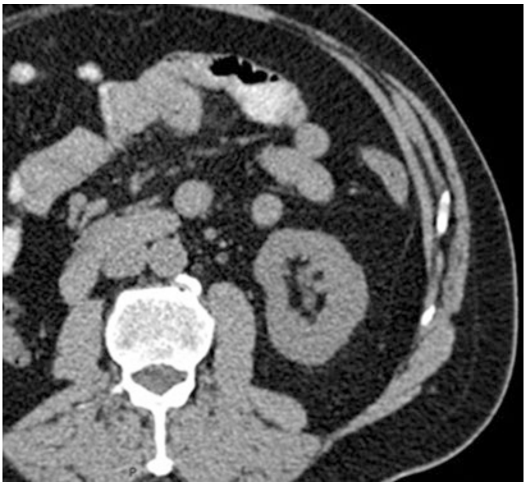

Fig. 8.2 Computed tomography slice of the left abdominal wall at the level of the costal margin. The internal oblique attaches to the costal margin while the transversus abdominis attaches to the undersurface of the costal margin. The external oblique in contrast has no attachment to the costal margin

8.2 Indications and Case Selection

This is our go-to operation for larger ventral hernias in subcostal wounds (such as after open cholecystectomy, upper GI, and HPB cancer resections) and transverse wounds (vascular and colorectal surgery), where in addition, redundant skin or ugly scar excision is part of the procedure. The dissection technique is combined with the techniques for midline dissection in cases such as ventral hernia after liver transplantation with a reverse L-shaped incision [3].

All three lateral abdominal wall muscles attach to the iliac crest, so for such lateral hernias close to the iliac crest, preperitoneal dissection is generally an easier place for mesh placement to gain sufficient overlap, although the use of the hernia sac may still be used as necessary.

8.3 Contraindications

The main contraindication to hernia sac repair is a patient not fit for surgery, because of any significant comorbidity. These criteria are similar to any elective benign procedure and are thus not detailed here. The technique requires the presence of a hernia sac, so it has no role in the closure of an open abdomen for obvious reasons.

8.4 Instruments and Energy Source

The instrumentation is focused around a "laparotomy tray." No further specialist instruments are necessary. Like any laparotomy, sutures and instruments appropriate for the use on bowel are recommended. Monopolar diathermy with cutting as well as coagulation settings are the mainstay of energy devices.

8.5 Team Setup, Anesthesia, and Position

The team setup is typical of a laparotomy. The surgeon is on one side, the assistant is on the other. Scrub nurse is on the side convenient for the flow of instruments and supplementary material. The anesthetist is at the head end.

In most cases of transverse incisional hernias, the patient is placed in the supine position. Sometimes, if the scar runs around to the back, placing the patient with the affected side up may be necessary. One or more arms often need to be out, especially if the incision and dissection are required quite laterally. The operative field is prepared generously. Draping varies depending on the extent of skin exposure required.

The type of anesthesia is somewhat anesthetist dependent but will center on general anesthesia with neuromuscular paralysis. Epidural is used as a single shot or continuous infusion or not at all depending on patient/anesthetist choice.

8.6 Key Steps

Making the right decision for surgery, working the patient up right, doing the right operation and doing it right, and looking after the patient afterward right is key! Preoperative planning is important and is on similar lines as discussed for midline ventral hernias.

8.7 Surgical Techniques and Variations

8.7.1 Step 1: Incision/Laparotomy/Adhesiolysis

This is very similar to that described for midline hernias. The scar is excised and skin flaps are raised toward healthy anterior rectus fascia and the external oblique aponeurosis.

The laparotomy is performed through the middle of the hernia sac, taking care of first entry to minimize the risk of inadvertent enterotomy. The sac is divided in line with the original incision out to healthy abdominal wall at either end of the scar. Adhesiolysis of the abdominal contents of the anterior abdominal wall is the usual practice, with interloop adhesiolysis as necessary (Fig. 8.3).

The dissected bowel and omentum are covered with a large moist pack and you are ready to start the abdominal wall dissection.

8.7.2 Step 2: Retro-Rectus, Inter-Oblique, and Crossover Dissection

The principle of the hernia sac repair is the same as for midline ventral hernias, although the dissection is a bit more difficult. Both superiorly and inferiorly, you may have to find your way into two or more "spaces," and then convert them to a single space for the insertion of the mesh. In general, the hernia sac is attached to the anterior rectus sheath and external oblique superiorly, and the posterior rectus sheath and internal oblique/transversus abdominis inferiorly.

The lateral dissection is between the external and internal oblique for several reasons. The main neurovascular plane is between internal oblique and transversus abdominis. The external oblique does not attach to the costal margin, so there is no hernia too close to the rib margin that cannot be repaired with good mesh overlap using this approach. Entering the correct plane laterally is usually straightforward. It is facilitated by continuing the cut through the abdominal wall laterally until a fraction beyond the old scar, effectively back to healthy muscle/aponeurosis layers. The three muscle/fascia layers are usually evident at this point (Fig. 8.4). Dissection between external and internal oblique is carried out laterally and then superiorly and inferiorly toward the midline until the slip from internal oblique that joins up to the anterior rectus sheath is encountered. Then the retro-rectus space is developed. After that, the slip of internal oblique as it runs up to form part of the anterior rectus sheath is divided, merging the retro-rectus space and the inter-oblique space. It is inevitable that one or two segmental nerves will be cut as this division of the slip of internal oblique takes place. But on the inferior flap, these nerves were already divided more proximally at the time of making the original incision. So in practice, this has little if any additional denervation effect on the recti muscles (Fig. 8.5).

If the original incision was close to the midline or crossed the midline, then dissection to the contralateral side may be necessary for sufficient mesh overlap. This is done using the dissection techniques now well known in TARUP and eTEP procedures. The posterior rectus sheath is divided as it forms the linea alba. Dissection continues in the preperitoneal space toward the other side, and then the retro-rectus space of the contralateral side is opened by again incising the posterior rectus sheath just lateral to the linea alba and continuing the dissection deep to the rectus muscle, exploiting the retro-rectus space (Fig. 8.6).

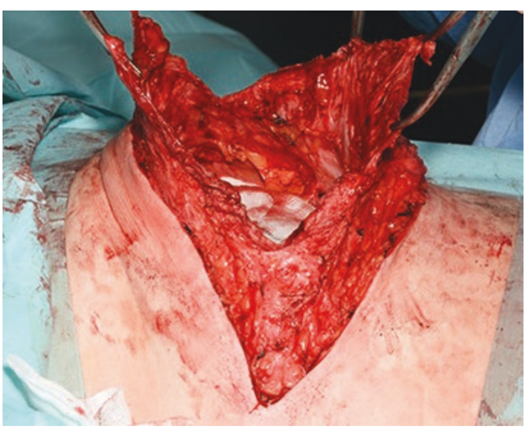

Fig. 8.3 Laparotomy through the hernia sac in a right subcostal wound. (reproduced with permission from [2])

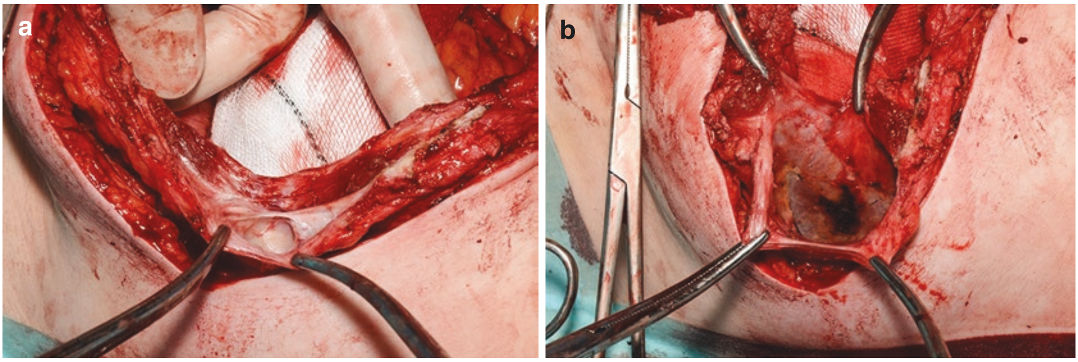

Fig. 8.4 (**a**, **b**) Extending the incision laterally back to healthy abdominal wall allows the three muscle layers that make up the lateral abdominal wall to become evident as shown in (**a**) (The two artery clips are on the external oblique layer). Then dissection between external and internal oblique can be undertaken as shown in (**b**)

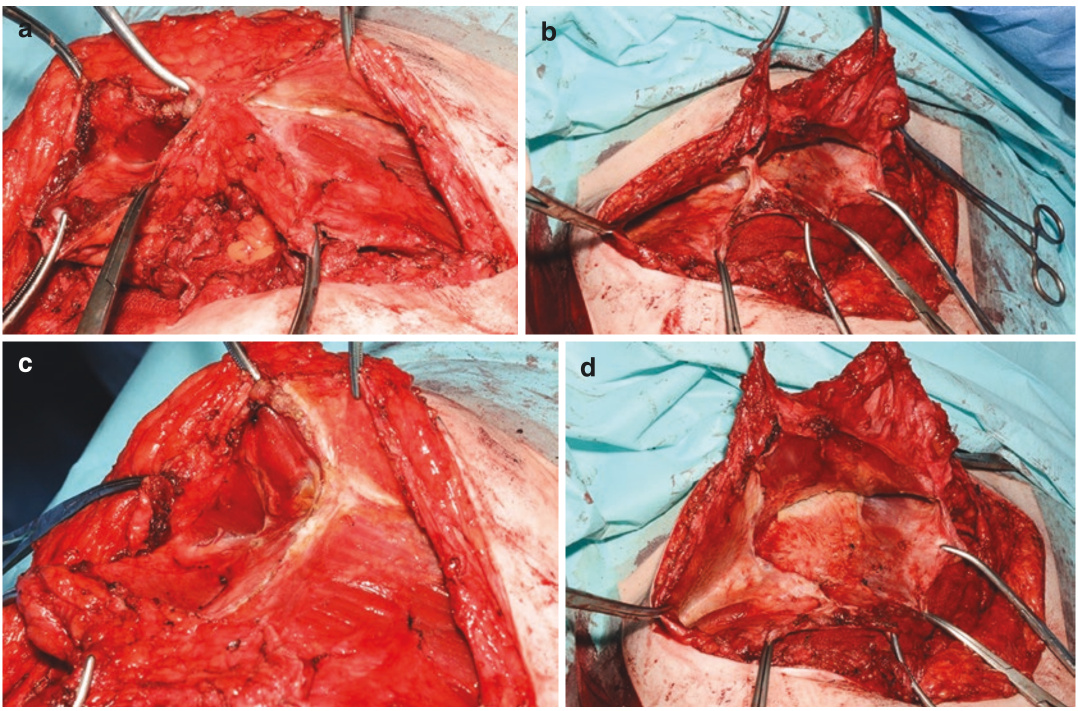

Fig. 8.5 (**a**–**d**) Dissection between exterior and interior oblique laterally and in the recto-rectus space medially looking toward the feet in (**a**) and the head in (**b**). The peritoneal flap is attached to the posterior complex inferiorly and the anterior layer superiorly. The slip of internal oblique is divided to make one space in preparation for closure and mesh placement, as shown in (**c**, **d**). ((**d**) reproduced with permission from [2])

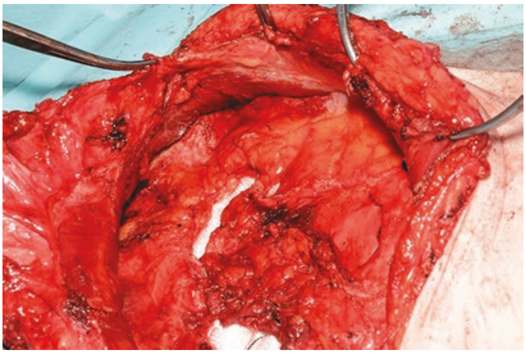

Fig. 8.6 Crossover dissection medially to gain access to the retro-rectus space on the contralateral side

8.7.3 Step 3: Closure of the Posterior Layer, Mesh Insertion, and Anterior Layer

Closure of the posterior layer, mesh insertion, and closure of the anterior layer are as described for midline hernias (Fig. 8.7). Excess skin and subcutaneous tissues are trimmed as necessary and closed as previously described for midline ventral hernia repair.

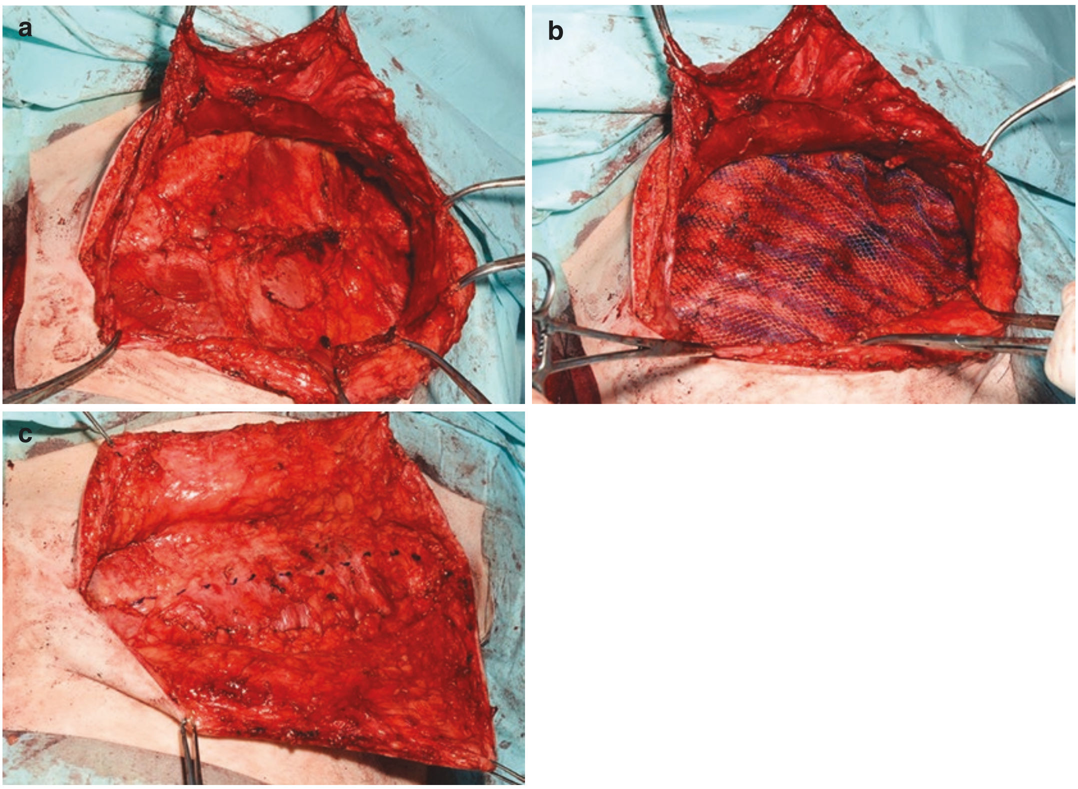

Fig. 8.7 (**a**–**c**) Closure of the posterior layer (**a**), mesh insertion (**b**), and closure of the anterior layer (**c**). The inked line denotes the amount of peritoneal flap used in the anterior layer "closure." ((**b**, **c**) reproduced with permission from [2])

8.8 Tips and Tricks, Postoperative Care, Complications, and Management

These have been discussed in the previous chapter when considering the hernia sac technique for midline hernias.

8.9 Conclusion

This is a useful and reproducible technique to have in your toolbox for abdominal wall repair. It can be used in any primary or recurrent incisional hernia repair as long as there is a hernia sac. It also works well in reducing the deformity in denervation bulges—as while muscle may have wasted, the aponeurotic layers will still be present.

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9

Subcutaneous Onlay Endoscopic Approach (SCOLA)

Flavio Malcher, Cristiano Claus, Leandro Totti Cavazzola, and Diego L. Lima

9.1 Introduction

Diastasis recti (DR) is frequent and is defined as distancing from the muscular borders of rectus abdominis in the midline greater than 2.2 cm [1]. It is characterized by bulging in the anterior wall of the abdomen and is often confused with hernia. DR is usually asymptomatic and with no risk of complications [2, 3]. Most patients with DR are treated conservatively and with physiotherapy [3]. Surgical treatment is usually considered an esthetic procedure performed by plastic surgeons [1]. DR management in concomitant epigastric and/or umbilical hernia cases is controversial and poses challenging questions in the surgical community [4–7]. However, concomitant presence of DR is one of the most important factors associated with recurrence after midline abdominal hernia repair [8].

There are two surgical approaches to address DR with concomitant ventral hernias: plication by anterior and posterior approaches. Open repair of midline ventral hernias allows for anterior DR plication but requires a large midline incision. Laparoscopic ventral hernia repair offers a posterior approach for DR plication by minimally invasive technique but is ergonomically challenging for the surgeon [9, 10].

Correa et al. in 1995 and Champault et al. in 1999 proposed a new endoscopic technique for DR with concomitant ventral hernias, a subcutaneous onlay repair with anterior plication of DR [11, 12]. Champault et al. was the first to describe the use of endoscopy and insufflation of CO_2 above the fascia to create a subcutaneous plane [12]. Since then, this surgical technique has been published by various authors under different names [1, 9, 13–21]. Despite its minimal variations, the authors follow the same technical approach: development of a subcutaneous or preaponeurotic space, plication of DR from an anterior approach, and repair of the hernias with onlay positioning of the mesh [22].

9.2 Indications

The main indication is patients with primary or incisional midline abdominal hernia associated with concomitant DR. Literature shows that midline defects in these series varied from 1 to 4 cm and DR from higher 2 to 4 cm. Obesity is not an absolute contraindication, but patients with excess skin or subcutaneous fat and prior abdominoplasty present with worse outcomes.

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Absolute contraindications are patients with coagulation disorders, cirrhosis, and patients not candidates for general anesthesia. Relative contraindications are non-midline hernias, large hernias (despite there is no consensus between the authors on the size limit), and patients with prior abdominoplasty of previous onlay mesh repair of a midline hernia.

9.3 Surgical Technique

Both laparoscopic and robotic approaches have been described in the literature [9]. The difference between the surgical approaches is related to the size of port and docking of the robotic system. Surgery is performed with the patient under general anesthesia. Antibiotic prophylaxis is carried out at the time of anesthetic induction. Urinary catheters or nasogastric tubes are not routinely used.

9.3.1 Patient and Surgical Team Positioning

For laparoscopic approach, the patient is placed in supine position with slight spine extension and open lower limbs. Surgeon is positioned between the patient's legs and the assistant laterally. In the robotic approach, the abdomen might be flexed with the hips located at the level of the flex joint of the table, allowing fewer collisions of the arms of the robot against the lower limbs.

9.3.2 Trocar Placement

A small 2 cm transverse incision just above the pubis is performed. The subcutaneous tissue is dissected until one reaches the anterior aponeurosis of the rectus abdominis muscle. Preaponeurotic plane is dissected with monopolar cautery, 4–5 cm superiorly and laterally with a thin and long retractor aid to create enough space to insert the trocar for optic through this small incision. A subdermal purse-string suture or a balloon port to seal the skin around is necessary to prevent gas leakage. Two assistant 5 mm or 8 mm (if a robotic approach is used) ports are positioned 5–6 cm laterally (Fig. 9.1). In patients with previous C-section incision, ports are placed on this incision.

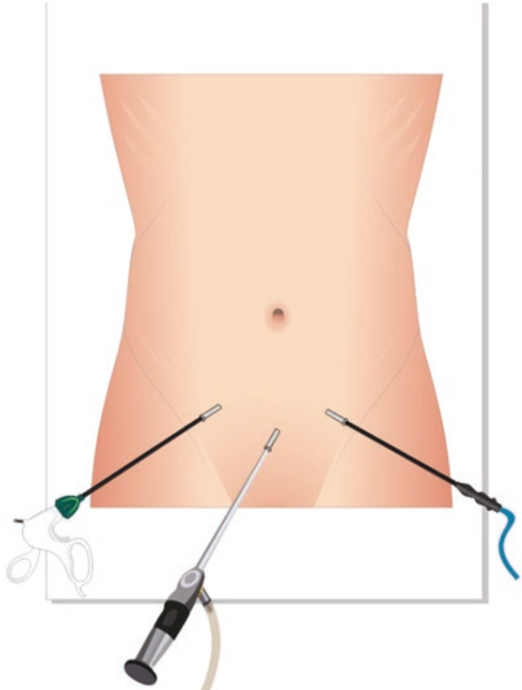

Fig. 9.1 Positioning of the trocars at the lower abdomen/suprapubic region

9.3.3 Subcutaneous Dissection

Cutaneous abdominal flap is dissected in a preaponeurotic plane from the pubis to the xiphoid as described in a traditional abdominoplasty, sharply just above the aponeurosis, not preserving areolar tissue, to the level of the subcostal margin. CO_2 insufflation pressure is maintained at 6–10 mmHg. Grasper and a hook or hot scissors are the most commonly used devices. Before proceeding with medial detachment, we recommend first extending the lateral dissections. Release of umbilical stump and dissection of any hernia sac present in the midline can result in the creation of pneumoperitoneum, so we leave this step for the end. If pneumoperitoneum occurs early during the procedure, it may decrease the operative field (Fig. 9.2). However, if it occurs

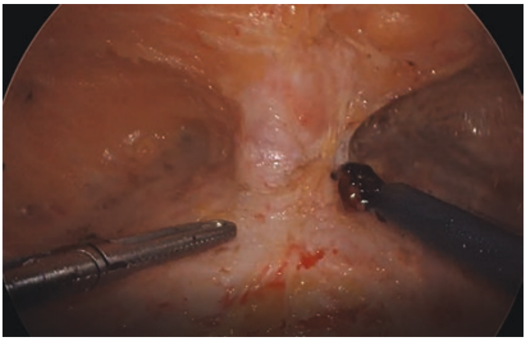

Fig. 9.2 Creation of the preaponeurotic plane from the pubis to the xiphoid

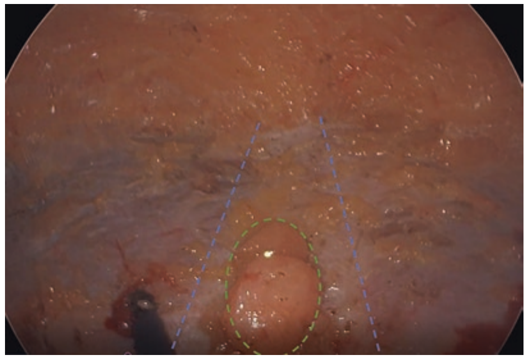

Fig. 9.3 Identification of the hernia defect (green circle) and the diastasis (blue dotted lines)

only after almost complete dissection of the flap, it tends not to interfere significantly with the procedure. Hernia sacs are found as projections from the aponeurotic muscle plane toward the upper subcutaneous tissue (and usually containing the preperitoneal fat). Primary hernia sacs are more easily dissected than incisional ones due to fibrosis, and the hernia content is reduced to the abdominal cavity.

At the beginning of our experience, we tended to perform wider lateral dissections, at least 10–12 cm on each side. However, there is a potential relationship between the extent of dissection and the occurrence of postoperative seroma. We no longer recommend a wide lateral dissection. Currently, a narrower dissection can be performed, depending on the size of the hernia/diastasis and whether or not a mesh is to be deployed. In cases of DR alone or associated with small defects or patients who do not desire meshes, dissection of 5–8 cm on each side appears to be sufficient. For the cases where the mesh placement is proposed, the space must be sufficient to accommodate a mesh with an overlap of 3–5 cm. At the end of the dissection, it is easy for the surgeon to identify the hernia defects and the diastasis (Fig. 9.3).

9.3.4 Midline Closure

At this stage, placing the patient in a position with the abdomen slightly flexed facilitates the suturing (for laparoscopy). In cases of DR not

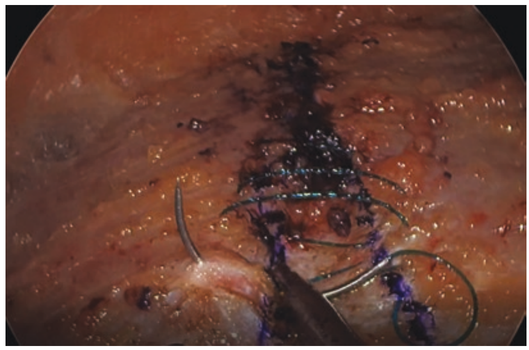

Fig. 9.4 Plication with single continuous suture with barbed suture, from the xiphoid to at least 2–3 cm below the umbilicus, bringing the anterior edges of the rectus abdominis muscles together, and correcting the DR and eventual hernia defects

associated with hernia or associated with small primary hernias (less than 2 cm) we perform the repair through a single continuous suture, from the xiphoid to at least 2–3 cm below the umbilicus, bringing the anterior edges of the rectus abdominis muscles together and correcting the DR and eventual hernia defects (Fig. 9.4). Proper technique to avoid intra-abdominal contents, only taking bites of the anterior fascia, should be followed.

Barbed sutures definitely facilitate this step and allow better closure at the midline. For larger defects or incisional hernia, we close the hernia defect with a monofilament polydioxanone suture first and subsequently carry out the diastasis plication as described above.

Some patients may have diastasis extending to the lower abdomen. In these cases, the repair is best performed by continuing the suture through the small incision made to create the initial space with proper retraction, since, by laparoscopic or robotic approach, the ports may be too close.

9.3.5 Mesh Placement

The use of mesh depends on the size of the hernia and patients' expectations. In our initial experience, we used mesh in almost all cases. However, more and more patients only with DR seek surgeons to undergo SCOLA technique as well as some patients who do not want repairs with mesh. In these situations, the mesh can be avoided. A ruler is introduced to determine the length from the xiphoid to at least 2–3 cm caudal to the plication and the width of the lateral dissection. A medium-weight polypropylene or monofilament polyester mesh with large pores is inserted through the (11 mm) trocar in craniocaudal direction and unfold laterally overlapping the whole plication for at least 3–5 cm. We do not recommend the use of biological meshes due to the risk of postoperative seroma.

A suture placed on the upper edge of the mesh retrieved with a transfascial needle helps to position and to keep it at the level of the xiphoid (Fig. 9.5).

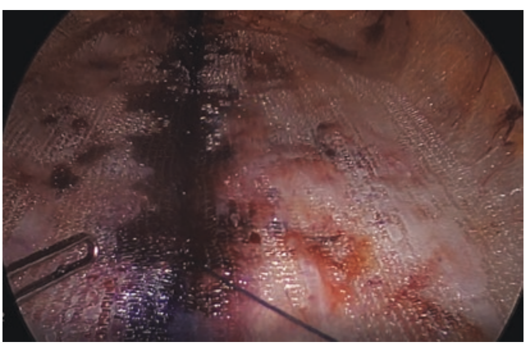

Fig. 9.5 Self-gripping mesh positioning with midline fixation with an additional running suture. Additional fixation with fibrin glue is also noted

9.3.6 Mesh Fixation

Mesh is usually fixed with sutures. Two or three suture lines, usually running for a faster surgery, are performed on the lateral edges (and in the center) of the mesh. Recently, other interesting options have been used such as self-gripping meshes or surgical glues.

We do not recommend the use of tackers. Although it is a quick and easy technique to fix the mesh, tacks should be used carefully. In addition to the potential increase in the risk of pain, tacks can be palpated through the skin, especially in thinner patients. Costs also tend to increase with this alternative. Irrespective of the method employed, it is important to emphasize that mesh should be properly secured in an *onlay* position.

In sequence, adequate fixation of umbilicus stalk back to the musculoaponeurotic plane is performed through a few simple sutures (Fig. 9.6).

The last step is placing suction drains in the subcutaneous space, through the same trocarincisions, in order to reduce the risk of postoperative seroma and its potential complications.

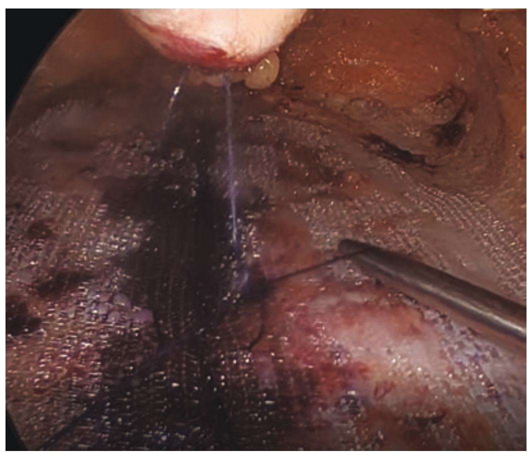

Fig. 9.6 Adequate refixation of umbilicus stalk back to the musculoaponeurotic plane is performed through few simple sutures

9.4 Postoperative Management

Patients who undergo SCOLA technique are usually discharged within 24 h and should be on antibiotics for no longer than 24 h. Opioids should not be prescribed. Patients should use NSAIDs and paracetamol if necessary.

Patients should use compressive abdominal binders for at least 4 weeks and should not lift weight for 6 weeks after the procedure. Abdominal numbness may happen and resolves within a few months.

9.5 Complications

The most common complication of this surgical technique is seroma formation. Studies have reported seroma formation varying from 4.7% to 81% of patients. Seroma formation results primary from the subcutaneous dissection and onlay mesh position [23]. As seroma is the most common complication, it is recommended the use of suction drains for at least 7–10 days. Drain is generally removed when the volume is less than 30 mL/day. Management of seromas can be conservative or aspiration with fine-needle aspiration.

Other complications are hematoma, surgical site infection (SSI), postoperative pain, cutaneous skin necrosis, and hypercapnia. There were no reports of visceral injury due to fascial suturing in the literature. Surgeons should be aware that a safe fascial plication should include only the anterior rectal sheath.

9.6 Different Names for the Same Procedure

A recent systematic review of the literature has shown that this technique has been published with nine different names by different authors worldwide [22]. All authors describe techniques with the same concept: a minimally invasive approach with the development of a subcutaneous or preaponeurotic space, plication of diastasis from an anterior approach, and repair of the hernia with onlay mesh positioning (Table 9.1).

There are a few differences reported by these authors: type of mesh, fixation, division, or detachment of the anterior layer of the rectus sheath, incision in the rectus sheath, and release of the external oblique muscles to decrease tension.

Table 9.1 Various published acronyms for minimal access subcutaneous onlay repairs

Authors	Country	Year	Name of the technique
Luque et al.	Spain	2015	FESSA
Köckerling et al.	Germany	2017	ELAR
Claus et al.	Brazil	2018	SCOLA
Köhler et al.	Austria	2018	MILAR
Barchi et al.	Brazil	2018	SVAWD
Muas et al.	Argentina	2019	REPA
Medina et al.	Argentina	2019	PELM#
Brendel et al.	Chile	2020	REPA
Kler et al.	UK	2020	TESLAR
Gandhi et al.	India	2020	EPAR
Dong et al.	USA	2020	SCOLA
Luque et al.	Spain	2020	FESSA
Cuccomarino et al.	Italy	2021	REPA

Modified from Malcher et al. Endoscopic onlay repair for ventral hernia and rectus abdominis diastasis repair: why so many different names for the same procedure? A qualitative systematic review. Surg Endosc. 2021

9.7 Conclusions

Early reports from the literature showed that the SCOLA technique is safe and effective with good results and excellent patient satisfaction. A better standardization of the technique and its name with larger sample and longer follow-up is necessary to assess the usefulness of this surgical technique. We hope future studies with a common single term can share their results to produce better outcomes for patients.

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10 Endoscopic and Endoscopically Assisted Mini or Less Open Sublay (EMILOS and MILOS) Mesh Repair of Abdominal Wall Hernias

Wolfgang Reinpold

10.1 Introduction

Primary abdominal wall and incisional hernia repair figure among the most frequent operations in surgery. The main cause seems to be genetically determined insufficient crosslinks between the collagen molecules. The risk of incarceration is about 1% per incisional hernia and year. Since the advent of synthetic mesh, recurrence rates have been reduced from 25–60% to below 15% [1]. The open sublay mesh implantation based on techniques of Jean Rives and René Stoppa and the laparoscopic intraperitoneal onlay mesh repair (IPOM) is the internationally leading procedures for the treatment of incisional hernias [1–4].

In open sublay repair, the alloplastic mesh is inserted via a large skin incision between the peritoneum/posterior rectus sheath (PRS) and the abdominal wall. Today the sublay mesh position is considered most advantageous because direct contact of the alloplastic material with bowel and other viscera is avoided. The disadvantage of the procedure is the major access trauma which is associated with higher infection rates and more acute and chronic pain. Despite the advantages of keyhole skin incisions, the pain level after laparoscopic IPOM repair is significant. A further concern is an implantation of a nonabsorbable foreign body inside the abdominal cavity, which is a risk factor for the formation of future adhesions to the bowel and damage to the viscera. In addition, traumatic mesh fixation to the pain-sensitive peritoneum and abdominal wall with several staples, clips, tacks, or sutures is mandatory with an IPOM [1–4]. Expensive implants with adhesion barriers on the area facing the bowel have to be used. Reoperations have shown that all IPOM prostheses can lead to massive adhesions and do not provide safe protection for the viscera. The abovementioned concerns and risks of the traditional techniques have led surgeons around the world to look for new minimal invasive ways of ventral hernia repair [4–14].

10.2 The E/MILOS Concept (MILOS and EMILOS Operation)

With the aim of further reducing the complications and pain in abdominal wall hernia repair, we developed a new minimally invasive technique—the endoscopically assisted transhernial mini or less open sublay (MILOS) repair.

If after initial mini open dissection, endoscopy with capno-preperitoneum is used, the procedure is denominated EMILOS operation (endoscopic mini or less open sublay operation). MILOS and EMILOS (E/MILOS) are endoscopic hybrid procedures of total extraperitoneal ventral hernia repair.

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The E/MILOS repair allows the transhernial retromuscular/preperitoneal insertion of large sheets of standard meshes via a small incision and anatomical reconstruction of the abdominal wall. Using the E/MILOS technique the abdominal cavity is neither burdened with alloplastic mesh material nor foreign body mesh fixation devices. The E/MILOS operation with minimal invasive transhernial access avoids major trauma to the abdominal wall [8, 10, 12–14].

10.3 MILOS and EMILOS Repairs

The MILOS repair consists of two operative phases. EMILOS repair adds phase three:

1. Mini open dissection with standard open repair instruments.
2. Transhernial dissection with light-armed laparoscopic instruments under direct view (Fig. 10.1) or with gasless endoscopy.
3. Endoscopic dissection with capnopreperitoneum (EMILOS): After mini open transhernial dissection a preperitoneal/retromuscular space of at least 8 cm diameter (phases 1 and 2) is created. Phase 3 involves transhernial insertion of a port system and CO_2 insufflation. The operation is continued endoscopically with standard laparoscopic instruments and a 30° MIS optic in the transhernial position (Fig. 10.2). The EMILOS repair is an endoscopic total extraperitoneal ventral hernia operation (VTEP).

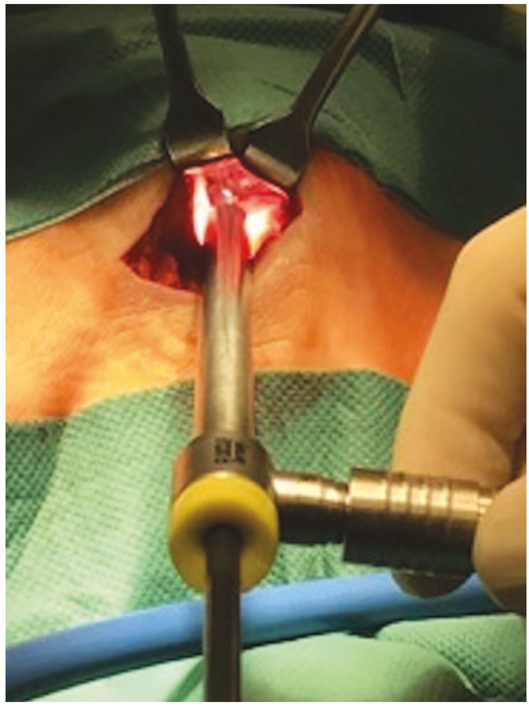

Fig. 10.1 Transhernial dissection of the preperitoneal/retromuscular plane using the Endotorch TM

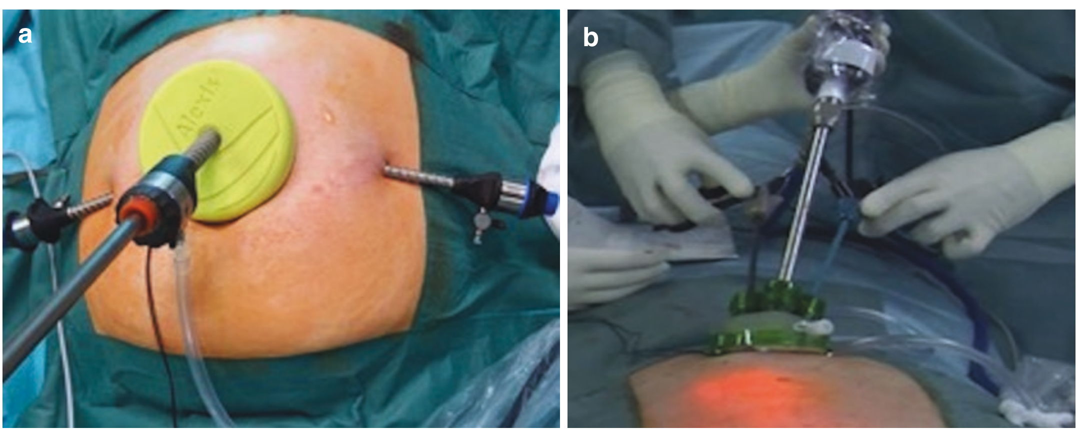

Fig. 10.2 (**a**) EMILOS operation of midline hernia: transhernial insertion of 10 mm camera port with capped wound protector (Alexis TM, Applied Medical) and two 5 mm working ports. (**b**) EMILOS operation with single port

10.4 E/MILOS Definitions

Incision length and mesh size definitions of E/MILOS operations: in all E/MILOS operations the skin incision has a maximum length of one-fourth of the largest mesh diameter. Incisions of 2–< 6 cm are called "mini open" and incisions of 6–12 cm are "less open."

MILOS and EMILOS Repair: The MILOS operation can be performed in a mini open manner with light-armed laparoscopic instruments either under direct vision (Fig. 10.1) or endoscopically assisted.

EMILOS repair: After transhernial mini open dissection of extraperitoneal space of at least 8 cm diameter, closure of the abdominal cavity, transhernial insertion of an optic port device, and CO_2 insufflation, the procedure can be continued endoscopically as total extraperitoneal ventral hernia repair (VTEP) using either standard trocars (Fig. 10.2a) or a transhernial single port (Fig. 10.2b) [8, 12, 13]. Port positions can be adopted according to the individual hernia defect size and location. Our first EMILOS operations in 2009 were performed in transhernial single port technique (Fig. 10.2b; [8]) which is technically demanding due to the narrow parallel alignment of laparoscopic instruments and MIS optic. Therefore, we changed our technique to the use of standard ports which allow better triangulation (Fig. 10.2).

Today, at our institution, almost all primary and incisional abdominal wall hernias are operated on with the MILOS/EMILOS technique. E/MILOS instruments are shown in Fig. 10.3.

Fig. 10.3 Set of E/MILOS instruments

Small hernias with a hernia defect diameter smaller than 1.5 cm are treated with a suture repair and extremely large hernias with an open sublay approach and open TAR.

10.5 Indications for MILOS and EMILOS Repair

The MILOS technique is used in operations with a maximum mesh size of 15 cm diameter. If larger meshes are implanted, we perform an EMILOS repair.

The E/MILOS technique allows the extraperitoneal dissection of the whole retrorectus compartment and both lateral compartments. If necessary, very large synthetic meshes can be implanted in a minimally invasive manner. Posterior component separation (TAR) can be performed using the E/MILOS technique. Thus, a sublay repair of the entire abdominal wall is possible.

10.6 The Surgical Steps of the E/MILOS Repair of Midline Hernias

10.6.1 Phase 1

Step 1: The E/MILOS operation starts with a small skin incision directly above the center of the main hernia defect (Fig. 10.4).

Step 2: Identification and mobilization of the hernia sac (Fig. 10.5). If necessary, incision of the hernia sac and liberation of the incarcerated viscera.

Step 3: Small incision of the peritoneum for diagnostic laparoscopy if adhesions or other intra-abdominal pathologies are suspected.

Step 4: Redundant portions of the hernia sac which may later pose a risk of bowel obstruction are excised. Before performing this step consider that portions of the hernia sac may have to be preserved for later tension-free closure of the posterior layer!

Step 5: The edge of the hernia defect (hernia ring) is circumferentially exposed and elevated with sharp clamps (Figs. 10.6 and 10.7).

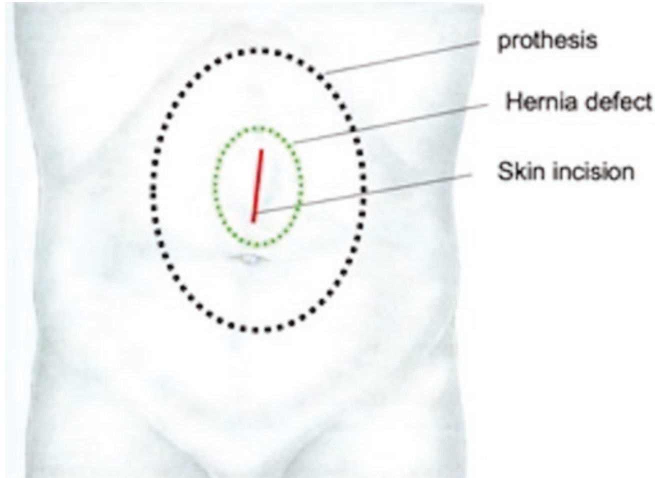

Fig. 10.4 Mini open incision above the center of the main hernia defect

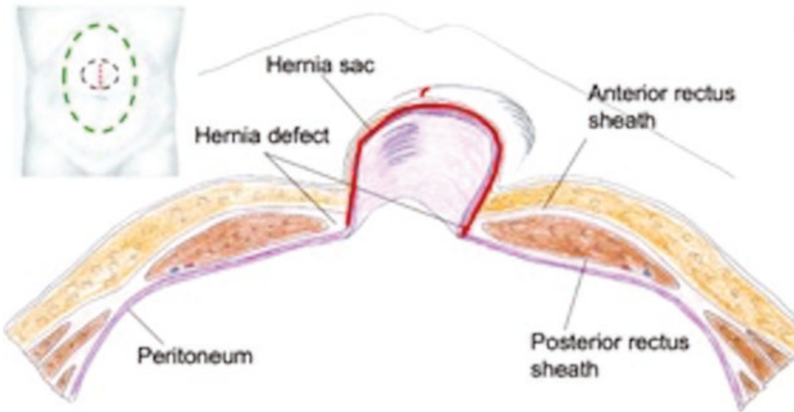

Fig. 10.5 Identification and mini open dissection of the hernia sac

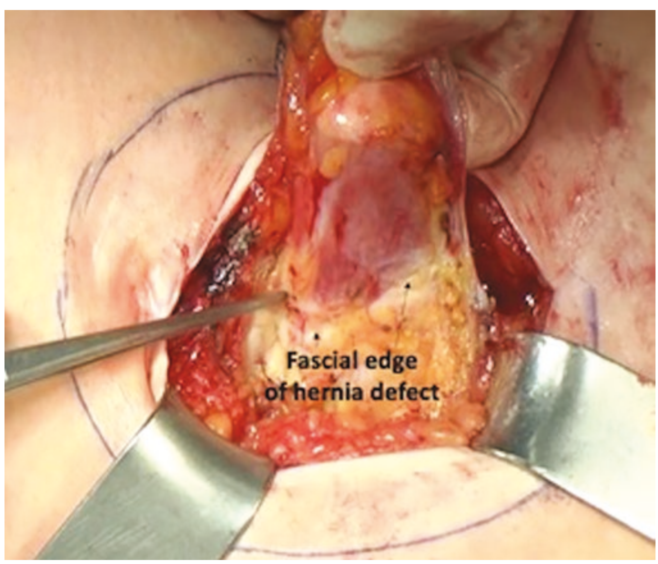

Fig. 10.6 Complete mobilization of the hernia sac and circumferential identification of the hernia ring

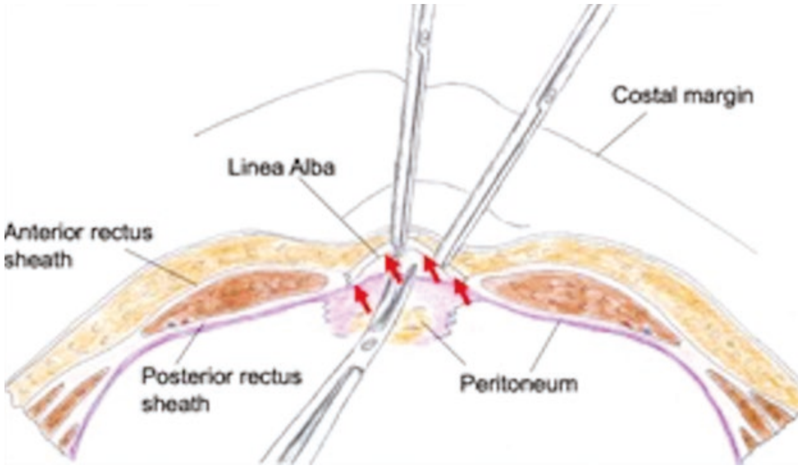

Fig. 10.7 Circumferential dissection of the fascial hernia ring

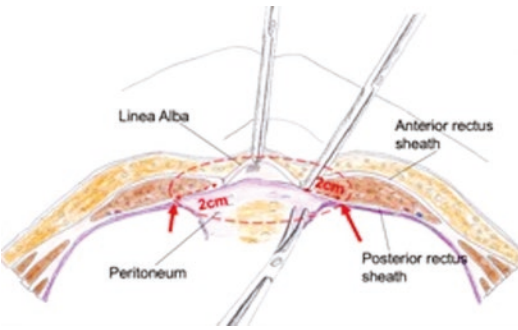

Fig. 10.8 Circumferential mini open detachment of the peritoneum from the abdominal wall with a radius of 1–2 cm

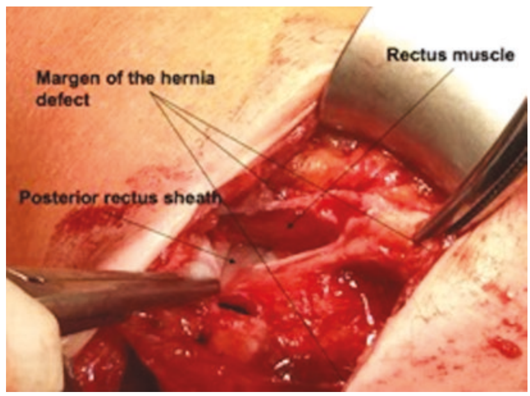

Fig. 10.9 The posterior rectus sheath is medially incised

Step 6: The neck of the hernia sac and adjacent peritoneum is circumferentially detached from the fascial edge of the hernia defect and abdominal wall all around for a distance of at least 2 cm (Fig. 10.8). In hernia defects with a diameter of less than 3 cm, the fascial edge of the hernia ring must be minimally incised at 3 o'clock and 9 o'clock, to allow the mini open transhernial preperitoneal dissection.

Step 7: The posterior rectus sheath is incised on both sides about 1 cm lateral to the medial border of the rectus muscle (Fig. 10.9). Retromuscular dissection starts with a blunt-tipped curved clamp. The rectus muscle is mobilized from the PRS on both sides (Fig. 10.10).

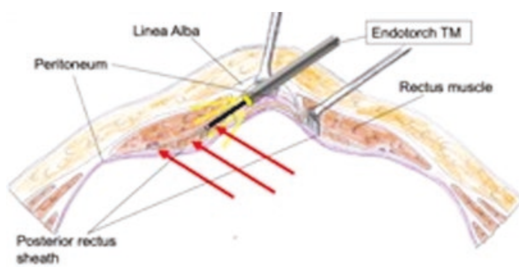

Fig. 10.10 Dissection of the posterior rectus sheath

10.6.2 Phase 2

Next, the mini open dissection with light-armed laparoscopic instruments starts (Figs. 10.1 and 10.11). The sharp clamps are removed. The abdom-

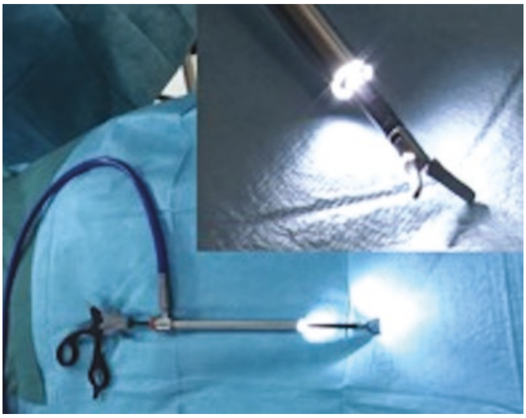

Fig. 10.11 Endotorch TM with laparoscopic grasper

inal wall around the hernia defect is now exposed with narrow rectangular retractors of different sizes (Fig. 10.1). The transhernial preperitoneal/retromuscular dissection around the hernia gap is performed either under direct visualization or endoscopic view using laparoscopic instruments armed with a 10-mm light tube which was specifically designed by our working group and Wolf company (Endotorch, Wolf TM, Figs.10.1 and 10.11) [12, 13]. The Endotorch is a modified 20 cm long and 10 mm diameter laparoscope. Instead of a telescopic rod lens system, it has a central canal for the insertion of any 5 mm laparoscopic instrument (Figs. 10.1 and 10.11). The Endotorch gives maximum light at the tip of the light holding laparoscopic instrument thus automatically pointing to the center of the surgeon's dissection field (Fig. 10.1). This allows precise wide range tissue manipulation via mini-incisions within the extraperitoneal space. It may also be used for gasless laparoscopy and adhesiolysis. The circumferential dissection range in relation to the skin incision and recommended size of the rectangular retractors are given in Table 10.1. MILOS operations via 2 cm incisions are preferably performed with 3 mm laparoscopic instruments and a 5 mm, 30° laparoscope. Scar tissue formation, especially after previous operation(s) with mesh implantation, may reduce the maximum dissection range and warrant larger incisions [12, 13]. Via a 3–4 cm incision the Endotorch TM allows circumferential dissection of the extraperitoneal plane with a radius of at least 15 cm from the fascial border of the hernia gap.

Table 10.1 MILOS dissection range (cm) in relation to skin incision/minimal hernia defect size and recommended blade size of rectangular retractor pairs

Skin incision; minimal hernia defect size needed (cm) for transhernial dissection	Circumferential dissection range (cm)	Recommended pairs of rectangular retractors: blade size (mm) (Fig. 10.3)
2	6–10[a]	40 × 8; 60 × 8
3	10–15[a]	40 × 8; 60 × 10; 120 × 10
4	15–20[a]	40 × 8; 70 × 10; 120 × 10; 150 × 15; 200 × 20
5–6	15–25[a]	40 × 8; 70 × 10; 120 × 10; 150 × 15; 200 × 20

[a] Scar tissue may reduce the maximum dissection range and warrant larger incisions

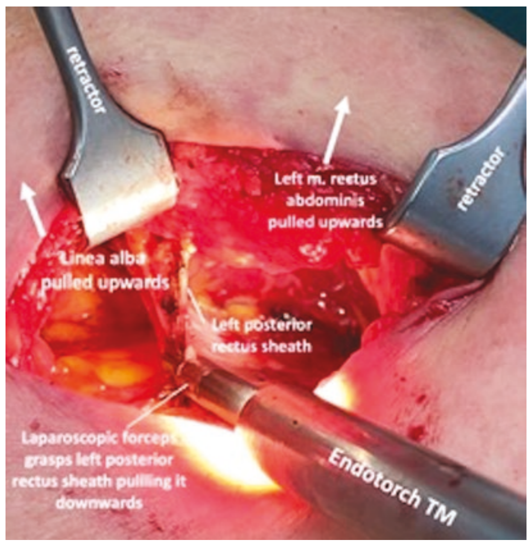

Fig. 10.12 The linea alba and posterior rectus sheath are pulled upward, the posterior rectus sheath downward

Step 8: In the midline, the peritoneum is separated from the linea alba (LA) (Fig. 10.12). The right and left posterior rectus sheath are extensively mobilized from the rectus muscle with laparoscopic instruments (Fig. 10.10).

Step 9: A transhernial longitudinal incision of the posterior rectus sheath (at the insertion of LA) is performed in all quadrants corresponding

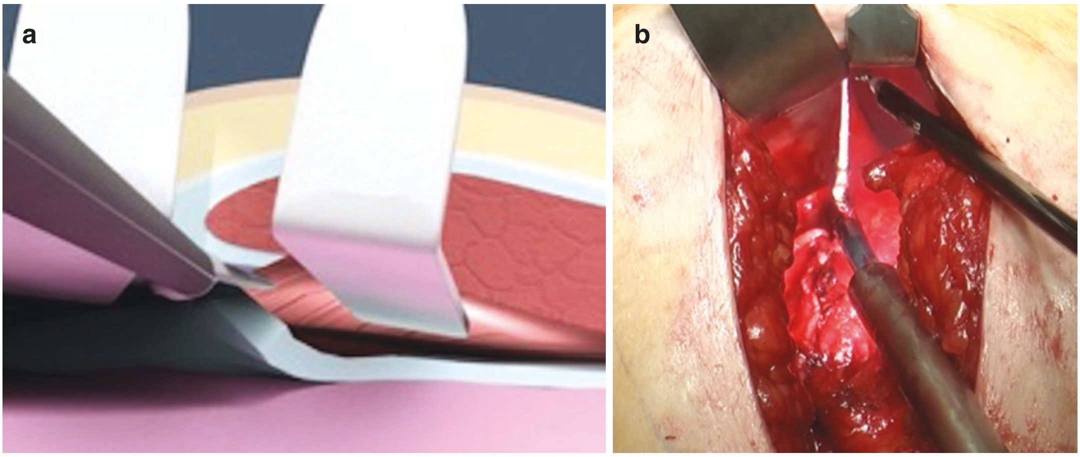

Fig. 10.13 (**a**) The posterior rectus sheath is incised longitudinally in all four quadrants. (**b**) The posterior rectus sheath is incised longitudinally in all four quadrants

to the size of the hernia defect and planned alloplastic mesh insertion (Fig. 10.13a, b).

10.6.3 Phase 3

After transhernial mini open dissection of the extraperitoneal space of at least 8 cm diameter, the operation can be continued endoscopically with capno-preperitoneum. The steps of EMILOS repair are described below.

Step 10: Closure of the abdominal cavity: the abdominal cavity is inspected to rule out visceral damage or bleeding. The PRS is closed only if this is possible with no or minimal tension. In most of our E/MILOS operations, the cut edges of both rectus sheaths are not apposed (Fig. 10.14). In all E/MILOS operations the peritoneum is closed meticulously thus preventing any contact between alloplastic material and the intestines (Fig. 10.14). Parts of the hernia sac may be very useful for complete tension-free closure of the peritoneum. If the posterior rectus sheath is not apposed, the mesh is placed in the right and left retromuscular position and dorsal to the LA in the preperitoneal plane (Fig. 10.14).

Step 11: Transhernial extraperitoneal implantation of standard large pore synthetic mesh, preferably polypropylene or polyvinylidenfluoride (PVDF). The mesh should posteriorly overlap the hernia defect by at least 5 cm in all directions. Prior to mesh insertion, we change gloves and perform skin disinfection.

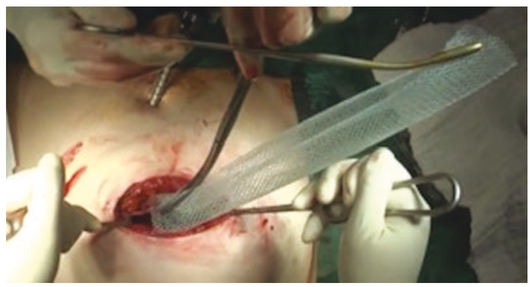

Fig. 10.14 Large standard mesh in retromuscular/preperitoneal plane. The posterior rectus sheath (PRS) is only closed if this is possible with low tension. The peritoneum between the cut edges of the PRS and the hernia defect are meticulously closed

The mesh is double rolled and inserted transhernially with two long curved clamps without skin contact (Fig. 10.15) and then unfolded with light-armed laparoscopic instruments or endoscopically (EMILOS technique, Fig. 10.16). The implantation of very large meshes is possible. In most cases, due to large mesh overlap, and complete anterior closure of the hernia defect, there is no need for mesh fixation. The intra-abdominal pressure prevents mesh dislocation and supports rapid mesh integration into the abdominal wall. In the case of subxiphoidal or suprapubic hernia defects, the mesh is secured with absorbable sutures to the paraxiphoidal fascia or Cooper's ligaments, respectively. In very large hernia defects when even after bilateral TAR maneuver a complete hernia defect closure is not possible, we perform a mesh bridging in sandwich technique: a second standard large pore mesh with 5 cm overlap is inserted in the sublay plane anterior to the first sublay mesh. The second mesh is fixated with a running 0 nonabsorbable suture to the fascial edge of the hernia gap. It is important that the fixating suture spares the first large mesh. Central sutures to the first large mesh may result in central mesh rupture, recurrence, and ileus. When bridging a hernia defect the mesh–defect size ratio should be at least 16:1. One suction Redon drain (8 Charr.) is inserted into the extraperitoneal space.

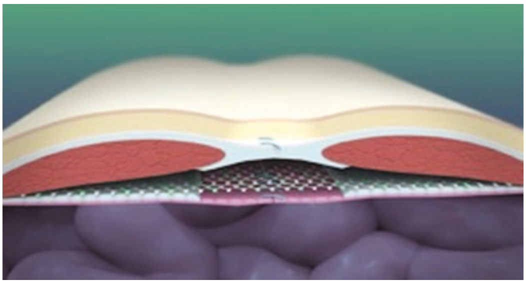

Fig. 10.15 Transhernial insertion of a large double-rolled standard alloplastic mesh

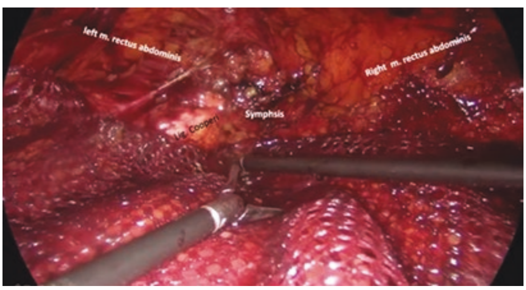

Fig. 10.16 EMILOS midline incisional hernia repair: endoscopic mesh insertion

Step 12. Additional hernia defects are closed transhernially using the MILOS or EMILOS technique. Satellite hernia defects and the main hernia gap are anatomically closed anterior to the mesh with a running nonabsorbable or long-term absorbable 0 suture in small-bite-small-stitch technique (Fig. 10.17a, b). Anatomical reconstruction of the abdominal wall is always the primary goal.

Step 13: Management of subcutaneous tissue and skin: Large hernia sacs are removed, meticulous subcutaneous electrocoagulation is performed and a subcutaneous 8 Char. Redon drain is inserted. If necessary, contracted scar tissue is mobilized and resected, and the umbilicus is reconstructed. The skin is closed with a running subcutaneous and intracutaneous suture. Figures 10.1 and 10.2 show two patients with small scars and corresponding mesh size after MILOS repair of incisional hernias (Fig. 10.18).

EMILOS repair (phase 3): After transhernial mini open dissection of the extraperitoneal space of at least 8 cm diameter, the operation can be continued endoscopically with capnopreperitoneum (Figs. 10.1 and 10.19). In analogy to TEP repair of the groin, EMILOS is an endoscopic total extraperitoneal ventral hernia repair (VTEP).

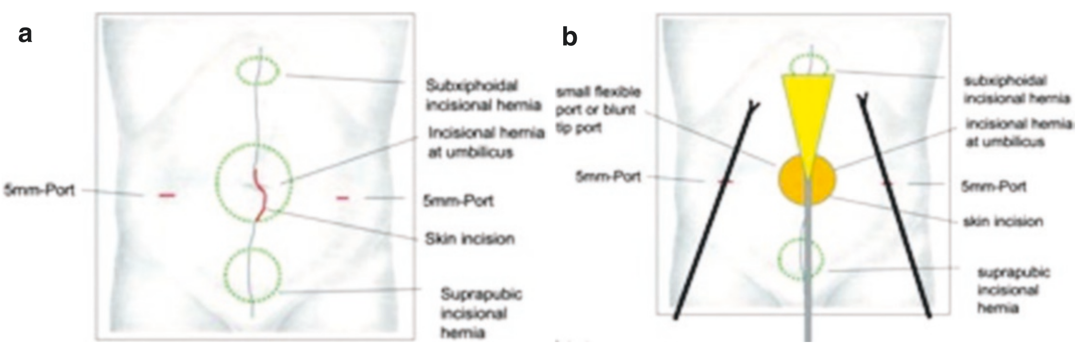

Fig. 10.17 (**a**, **b**) EMILOS repair: satellite hernia defects are endoscopically closed

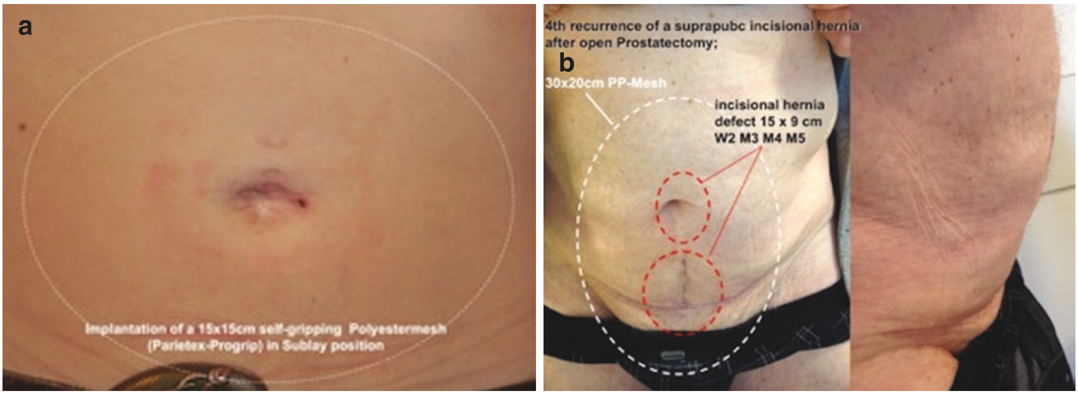

Fig. 10.18 (**a**) Young woman with 3 cm incisional hernia after umbilical hernia suture repair. MILOS operation with 3 mm instruments, 5 mm endoscope, and 2 cm incision. Implantation of a 15 × 15 cm PP mesh. (**b**) MILOS operation of the 4th recurrence of an incisional hernia after open prostatectomy

Fig. 10.19 EMILOS repair with transhernial flexible plastic sheet port (Alexis TM)

Fig. 10.20 EMILOS repair: Transhernial insertion of blunt tip port in incisions of up to 4 cm

EMILOS Step 1: gas-tight closure of the peritoneum to prevent CO_2 leakage into the abdominal cavity.

EMILOS Step 2: transhernial insertion of an optic port device that fits gas-tight into the skin incision to allow CO_2 insufflation without ambient leakage (Figs. 10.1 and 10.19). In skin incisions of up to 4 cm, standard blunt tip ports for TEP groin hernia repair may be used (e.g., Blunt tip port, Applied Medical) (Fig. 10.20). In incisions larger than 4 cm we use flexible plastic sheet ports (e.g., Alexis, Applied Medical) (Figs. 10.1 and 10.19). The port devices may be blocked at the level of the hernia defect or skin. The latter is recommended in larger hernia defects because it allows to keep the skin incision smaller than hernia defect diameter. To prevent subcutaneous emphysema the CO_2 pressure should be limited to 10 mmHg.

EMILOS Step 3: Optic port and working port placement. Our standard is the use of a transhernial 10 mm, 30° MIS laparoscope and two retromuscular 5 mm working ports at the horizontal level of the main hernia defect (Fig. 10.1) This allows 360° circumferential endoscopic dissection. The position of the optic and working ports may be adapted to the specific location and size of the hernia defect(s).

In patients with high cosmetic expectations, e.g., young women with smaller hernia defects combined with postpartum diastasis recti, E/

MILOS operations can be performed via a small transhernial skin incision (2 cm) with 3 mm laparoscopic instruments (Fig. 10.21a, b).

Our first EMILOS operations in 2009 were performed with transhernial single port technique (Fig. 10.2b) which is technically demanding due to the narrow parallel alignment of laparoscopic instruments and MIS optic port [8]. The use of standard ports allows better triangulation. Figure 10.22a, b show the cranial and caudal view of an EMILOS in a midline incisional hernia repair.

The E/MILOS technique allows a. exposure of the entire extraperitoneal retrorectus compartment from the retroxiphoid to the retropubic region, b. additional mini open or endoscopic-assisted posterior component separation transversus abdominis release (TAR), c. dissection of the complete lateral compartment, and d. closure of diastasis recti.

A modification of the EMILOS technique, the reversed TEP EMILOS operation for the surgical treatment of midline ventral hernias and concomitant diastasis recti was published by Schwarz et al. [10]. The initial steps of the reversed TEP EMILOS approach are identical to the E/MILOS technique: after transhernial mini open dissection and endoscopic preperitoneal retromuscular dissection like in a groin hernia TEP repair, the optic port is inserted in the suprapubic position. The endoscopic dissection is carried out in bottom-up direction [10].

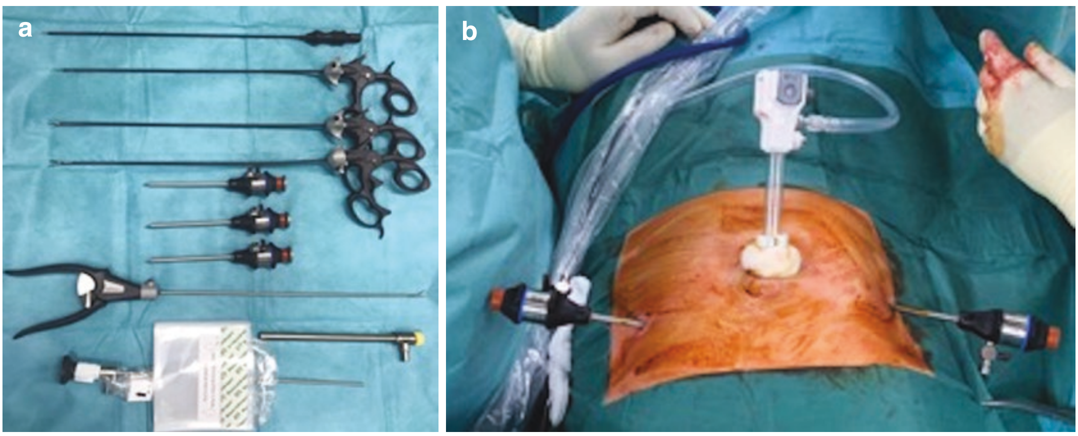

Fig. 10.21 (**a**) Set of 3 mm EMILOS instruments. (**b**) EMILOS ventral hernia repair with 3 mm instruments

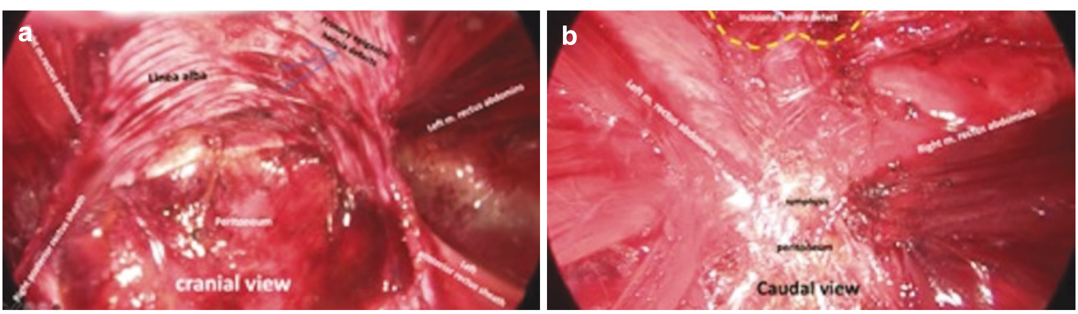

Fig. 10.22 (**a**) Cranial endoscopic view of an EMILOS midline incisional hernia repair. (**b**) Caudal endoscopic view of an EMILOS midline incisional hernia repair

10.7 E/MILOS Repair of Lateral Abdominal Wall Hernias

In primary and recurrent hernias of the lateral compartments, the transhernial dissection is performed in the preperitoneal plane. In order to obtain sufficient medial mesh overlap, the retrorectus space may require dissection by making an incision on the posterior rectus sheath. For the protection of segmental nerves and blood vessels the longitudinal incision should be performed at least 2 cm medial to the lateral border of the rectus compartment (reversed TAR procedure).

10.8 E/MILOS Operation of Ventral Hernias with Concomitant Diastasis Recti

The E/MILOS concept allows surgical repair of symptomatic diastasis recti (DR) with concomitant ventral hernias. Especially young women after childbirth often suffer from ventral hernias and concomitant symptomatic DR. The MILOS technique is used in operations with a maximum mesh size of 15 cm diameter. If larger meshes are implanted, we perform an EMILOS repair [13].

10.9 Treatment Algorithm

10.9.1 Mesh Augmentation of Diastasis Recti (DR)

Many obese patients, mostly men older than 45 years, present with umbilical or epigastric hernias with concomitant asymptomatic DR. DR is considered asymptomatic if it does not cause either pain, instability, or functional deficits. Many of these patients are often not aware of their DR which is a risk factor for hernia recurrence [15]. In those patients, we perform an E/MILOS repair with mesh augmentation of the fragile diastatic LA with circumferential mesh overlap of at least 5 cm. If the complete LA is fragile, mesh size is extended to 4 cm behind the xiphoid.

10.9.2 Mesh Augmentation with Plication of DR

In patients with a concomitant symptomatic DR, i.e., patients with functional deficit of the abdominal wall, instability, and/or pain, mesh augmentation with additional plication of the linea alba (LA) is indicated. In obese patients, an endoscopic posterior inverting suture of the LA is performed.

In slim and normal-weight patients, especially women with postpartum DR we prefer an EMILOS repair with additional subcutaneous (=epifascial) skin mobilization and anterior inverting plication of the LA. In those patients, a posterior inverting plication often leads to an ugly, symptomatic, and palpable vertical rim of the LA. The onlay dissection of the skin (Endoscopic mini or less open **onlay** dissection = E/MILOO) is performed via the same incisions and with the same instruments that are used for the transhernial retromuscular EMILOS dissection. Using the endoscopic mini open approach, onlay mesh repair is also possible. However, we are strongly in favor of sublay mesh repair. In women of childbearing age, the mesh should not be larger than 20 × 15 cm. We do not recommend E/MILOS ventral hernia and DR repair if further pregnancies are planned.

In all E/MILOS operations, the posterior rectus sheath is only closed if this is possible with low tension. To prevent an ugly cutaneous rim after suture repair of the DR, the subcutaneous tissue has to be detached from the LA and medial aspect of the anterior rectus sheath (2–5 cm on every side). The LA is anatomically reconstructed by an anterior inverting nonabsorbable running suture (0). The mesh is transhernially implanted in the sublay plane as described above.

10.10 E/MILOS TAR Options

In large hernias and non-midline primary or incisional ventral hernias, a transversus abdominis release (TAR) [16] can be performed using the E/MILOS technique (Fig. 10.23). The operation

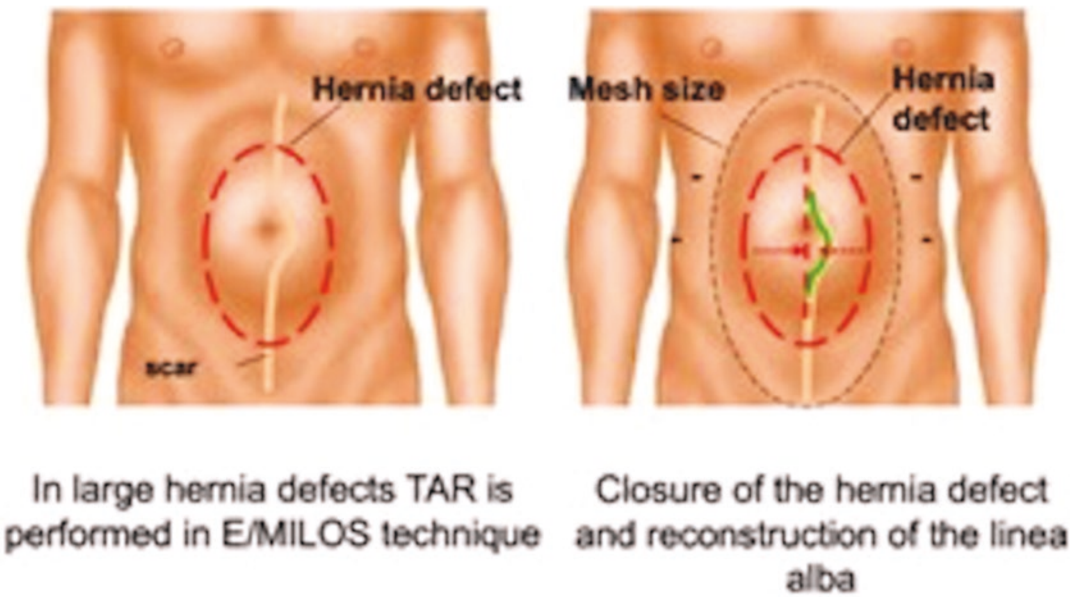

Fig. 10.23 Less open repair of large midline incisional hernia. If necessary E/MILOS TAR is performed

steps of the minimal invasive E/MILOS TAR procedure are identical to the procedure published by Novitsky et al. [16].

10.11 Results

From 2009 to March 2021 we carried out 1745 E/MILOS operations for incisional hernias and an approximately equal number of primary abdominal wall hernias. Data of all patients were prospectively documented in the German Hernia Registry “Herniamed.” The Mesh size used in these surgeries is given in Table 10.2. The results of our first 615 E/MILOS incisional hernia operations with 1-year questionnaire follow up were published in 2018 [12]. Propensity score matching of incisional hernia operations comparing the results of the E/MILOS operation with the laparoscopic intraperitoneal onlay mesh operation (IPOM) and open sublay repair from other German Hernia registry institutions was performed. Six hundred fifteen MILOS incisional hernia operations were included. Compared with laparoscopic IPOM incisional hernia operation, the MILOS repair is associated with significantly fewer postoperative surgical complications

Table 10.2 Size of mesh in incisional hernia operations (E/MILOS-OP; $n = 1745$)

Area (in cm^2)	0–50	50–100	100–200	>200
Number	0	21	182	1542

($P < 0.001$), general complications ($P < 0.004$), recurrences ($P < 0.001$), and less chronic pain ($P < 0.001$). Matched pair analysis with open sublay repair revealed significantly fewer postoperative complications ($P < 0.001$), reoperations ($P < 0.001$), infections ($P = 0.007$), general complications ($P < 0.001$), recurrences ($P = 0.017$), and less chronic pain ($P < 0.001$). The average operating time of E/MILOS incisional hernia repair was 102 min, 7 and 20 min longer than open sublay (95 min) and laparoscopic IPOM repair (82 min), respectively [12] (Table 10.3).

Complication rates after E/MILOS incisional hernia repair are very low (Tables 10.3 and 10.4). There were two small bowel enterotomies without spillage. They were closed with absorbable sutures. In these cases, MILOS mesh repair was performed without complications. Three superficial wound infections healed without mesh infection.

The results of our primary umbilical and epigastric hernia E/MILOS operations were recently published [13]. All primary ventral hernia E/

Table 10.3 E/MILOS incisional hernia repair at Gross Sand Hospital (n = 1745) vs. all incisional hernias documented in the German hernia Registry (99.516)

	E/MILOS incisional hernia operations % (n = 1745)	All incisional hernia operations in Herniamed Register (n = 99.516)
No complications	95.4	86.3
Total number of complications	4.6	13.7
Surgical complications:	3.1	9.6
Hemorrhage/postoperative haemorrhage	1.0	1.9
Enterotomy	0.2	0.5
Impaired wound healing	0.3	0.7
Seroma	0.9	4.1
Infection	0.3	1.2
Ileus	0.4	1.2
Reoperations	1.7	4.1
General complications	1.5	4.1
Mortality	0.1	0.3

Table 10.4 E/MILOS incisional hernia operations at Gross-Sand Hospital (n = 1745) vs. All incisional hernias operations documented in Herniamed Register (n = 88.866) with complete 1-year follow up

	E/MILOS incisional hernia surgeries (n = 1745)	All incisional hernia operations in Herniamed Registry (n = 88.866)
	%	%
Recurrence after 1 year	1.2	4.7
Pain at rest	3.8	8.6
Chronic pain at physical activities	7.4	15.6
Chronic pain requiring therapy	3.6	7.3

MILOS operations were prospectively documented in the German Hernia Registry "Herniamed." Five hundred and twenty primary umbilical and 554 epigastric E/MILOS operations with complete 1-year questionnaire follow up were included. Concomitant RD were treated in 18.3% and 14.1% of the umbilical and epigastric hernia cohort, respectively. Total perioperative complication rates and reoperation rates were 1.2% and 0.9% for both umbilical and epigastric hernias, respectively. Infection rates were 0.0% and 0.2% after umbilical and epigastric hernia operations, respectively. Recurrence rates 1 year after E/MILOS umbilical and epigastric hernia were 0.0% and 0.5%, respectively. One-year rates of chronic pain at rest, chronic pain during physical activities, and chronic pain requiring treatment after umbilical and epigastric hernia repair were 1.5% and 2.7%, 2.1% and 4.2%, and 0.6% and 1.8%, respectively [13]. Today we use the EMILOS technique in 65.5% of abdominal wall hernia operations. There is no difference in complication rates between the MILOS and EMILOS approach.

Postoperative consumption of analgesics was comparatively low. The standard postoperative pain medication was Metamizole 4 × 1 g p.o. Additional opioids were necessary in only 9.5% of the cases. Even in the case of large incisional hernias a peridural analgesic catheter is dispensable.

We have performed 117 E/MILOS TAR operations with low morbidity. There was one infection (mesh preserved), two hematomas with reoperation, one small bowel injury with immediate suture repair (uneventful course), and two recurrences at 1-year follow up. The chronic pain rate at 1-year follow up was 5.2%.

10.12 Discussion

To further improve abdominal wall hernia surgery and overcome the obvious disadvantages of the currently most widely used open sublay and laparoscopic IPOM repair, we have successfully developed the E/MILOS technique which is the first technique that allows the minimally invasive sublay mesh repair of almost all primary and recurrent abdominal wall hernias, except for giant eventrations. But even in extremely large primary ventral and incisional hernias the principles of E/MILOS repair help to reduce the surgical trauma to the abdominal wall.

10.13 Advantages of the E/MILOS Hybrid Concept

Our experience with 1745 E/MILOS incisional hernia operations and about the same number of primary ventral hernia E/MILOS repairs showed the following advantages of this novel technique:

1. The E/MILOS operation allows minimal invasive sublay repair of all ventral and incisional hernias except giant hernias.
2. E/MILOS operations were associated with significantly less perioperative complications, reoperations, general complications, and less recurrences and chronic pain after 1 year compared to open sublay and laparoscopic IPOM repair [12].
3. E/MILOS allows minimal invasive sublay repair of ventral hernias combined with rectus diastasis.
4. Easy and safe dissection of the hernia sac and incarcerated viscera (bowel, omentum).
5. Easy closure of hernia gaps and anatomical reconstruction of the abdominal wall. Protection of viable abdominal wall structures including nerves.
6. Option of laparoscopy or mini laparotomy is easy to perform.
7. Mini skin incision allows skin and scar corrections with good cosmetic results.
8. E/MILOS approach allows minimally invasive TAR.
9. Allows minimally invasive insertion of large standard meshes in sublay plane without traumatic fixation.
10. In comparison with laparoscopic IPOM operations, there is a saving of around 1.200 € in material costs per operation.
11. The E/MILOS repair combines the advantages and avoids disadvantages of laparoscopic IPOM repair and the open Rives Stoppa operation.

10.14 Conclusion

The novel E/MILOS technique allows the minimally invasive endoscopically assisted extraperitoneal repair of primary and incisional eventrations with very low perioperative morbidity, recurrences, and chronic pain after 1 year. The technique has the potential to revolutionize abdominal wall hernia repair if future studies of other working groups can reproduce our very promising results.

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11 Transabdominal Preperitoneal (TAPP) Repair of Ventral Hernia

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Optimal surgical management of primary ventral hernia and incisional hernia is still debatable. No single approach is suitable to repair all ventral/incisional hernias. In 1993, Le Blanc and Booth reported the application of intraperitoneal onlay mesh (IPOM) for ventral and incisional hernia [1]. This is a relatively straightforward procedure with decreased rates of SSI and mesh infection when compared to open repair [2–4]. However, the downsides are the increased cost of coated mesh and fixation devices, and the acute and chronic pain associated with it.

The endolaparoscopic groin hernia repair using synthetic mesh in TAPP or TEP are acceptable techniques today [5, 6]. Since there is extraperitoneal placement of synthetic mesh, these techniques are rarely associated with mesh induced-complications. Despite great progress in mesh technology, nearly all types of meshes have been found to produce a varying level of adhesions or tissue reaction, regardless of the material and coating used. Unpredictable mesh-related visceral complications may occur in some patients that may produce a severe reaction or major mesh-related adverse events [7].

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Various extraperitoneal techniques available for ventral hernia repair in literature are:

- Transabdominal preperitoneal repair (TAPP).
- Transabdominal Retromuscular repair (TARM).
- Transabdominal partially extraperitoneal repair (TAPE).
- Enhanced view totally extraperitoneal repair (eTEP).
- Endoscopic mini/less open sublay technique/repair (EMILOS).
- Robotic transabdominal preperitoneal repair (rTAPP).

TAPP refers to the laparoscopic ventral hernia and incisional hernia repair where the mesh is placed in the preperitoneal space, similar to TAPP and TEP for inguinal hernia repair. It involves the use of a transabdominal preperitoneal approach and can be used for midline and lateral hernias.

11.1 Indication of TAPP for Ventral Hernias

1. Primary Ventral Hernia (Periumbilical, Epigastric).
2. Primary Lumbar Hernia.
3. Lateral and Flank Hernias.

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https://doi.org/10.1007/978-981-19-5248-7_11

11.2 Contraindications

1. Recurrent incisional hernia.
2. Previous multiple abdominal surgeries.
3. Subcostal hernia.

11.3 Instruments and Energy Sources

- Monopolar diathermy.
- Ultrasonic shears (optional).

11.4 OT Setup

Figure 11.1 shows the OT setup used for TAPP of midline hernias.

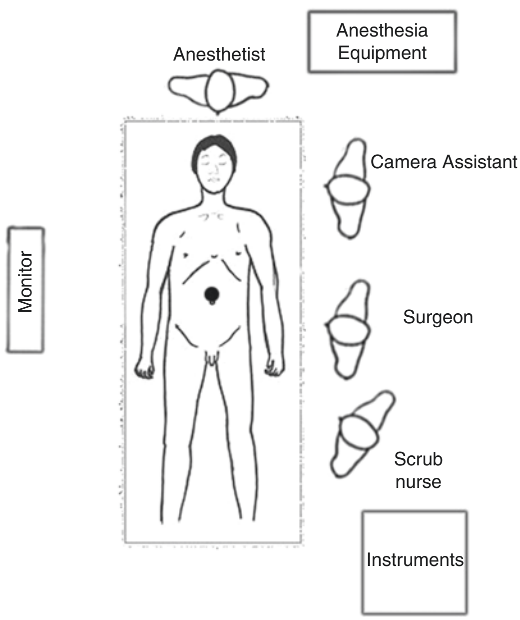

Fig. 11.1 OT setup

11.5 Operative Procedure

We position the camera and working ports as shown in the diagram (Fig. 11.2).

An important consideration is to create a peritoneal flap or pocket for mesh placement. The

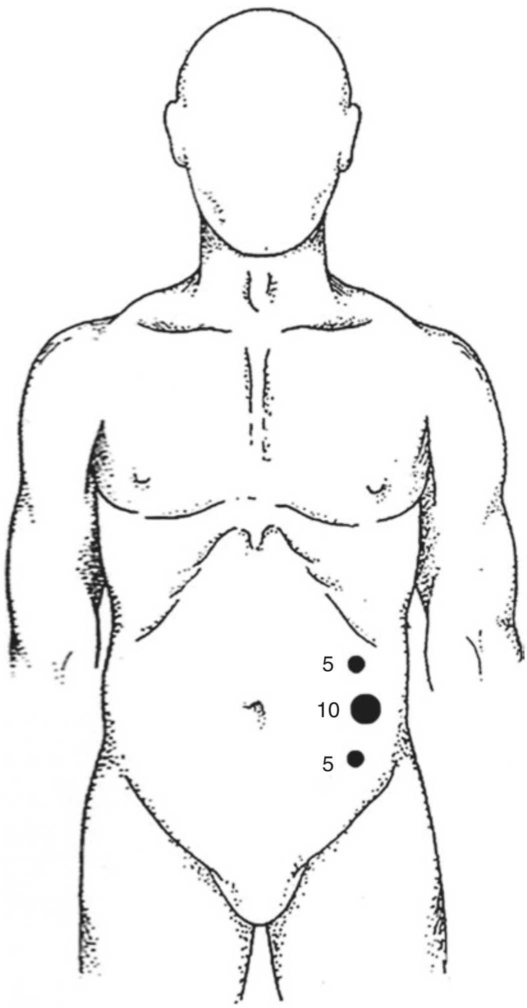

Fig. 11.2 Standard port placement for ventral hernia repair at the umbilicus

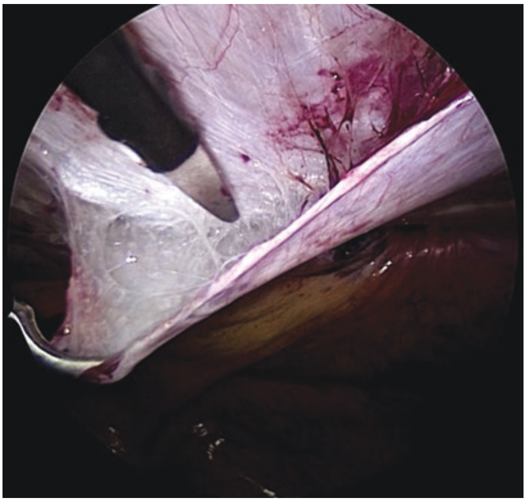

Fig. 11.3 Creation of peritoneal flap with sharp dissection

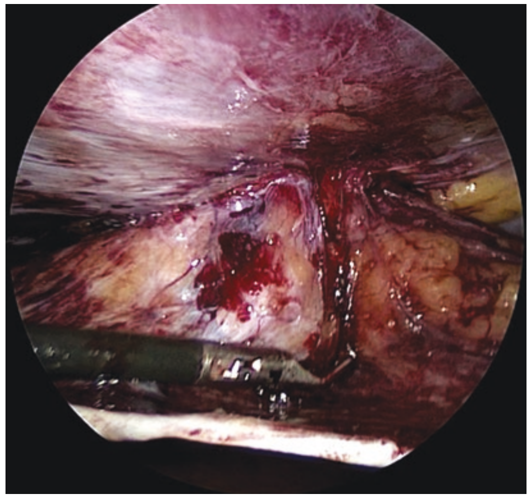

Fig. 11.4 Dissection of peritoneal flap

camera port and working port are placed at a distance of 4–5 cm from the planned peritoneal incision. A 30-degree scope is used. The peritoneum is incised and preperitoneal space is created with blunt and sharp dissection (Fig. 11.3). Due to the presence of preperitoneal fat, dissection of preperitoneal plane is technically easier in the medial compartment of the upper abdomen.

Damage to the skin is particularly avoided at the umbilical region, if there is just hernial sac and fat below the skin. The optimal ergonomics is facilitated by the positioning of the patient to have a contralateral downward tilt. The hernial sac may be dissected last after the peritoneal flap creation has been completed on both sides (Figs. 11.4 and 11.5). A polypropylene mesh is inserted and placed in preperitoneal space in such a way that the center of the mesh lies below the center of the hernia defect (Fig. 11.6). It is recommended to place two transabdominal sutures at 6'o clock and 12'o clock positions before inserting mesh into the peritoneal space (Fig. 11.6). The need for mesh fixation is lesser with this technique. Iatrogenic peritoneal defects are to be closed with absorbable sutures. The omentum is spread out over the surface of the bowel to function as a protective barrier. In comparison to IPOM, TAPP has less points of fixations therefore less penetrating trauma and hence less postoperative pain [8–10].

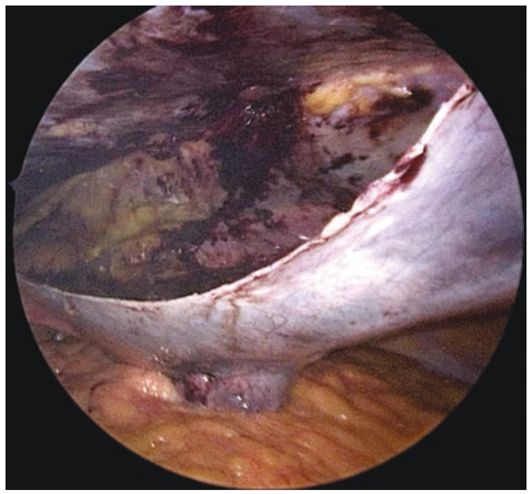

Fig. 11.5 Complete dissection of peritoneal flap showing the hernia defect

Drawbacks of TAPP for ventral hernia have been its technical difficulty, longer operative time, and poor reproducibility. The peritoneal dissection sometimes results in multiple peritoneal tears which may result in the bowel getting exposed to the underlying mesh.

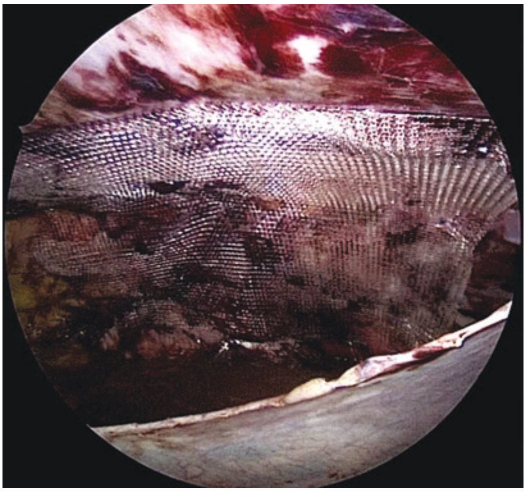

Fig. 11.6 Fixation of polypropylene mesh in the preperitoneal space

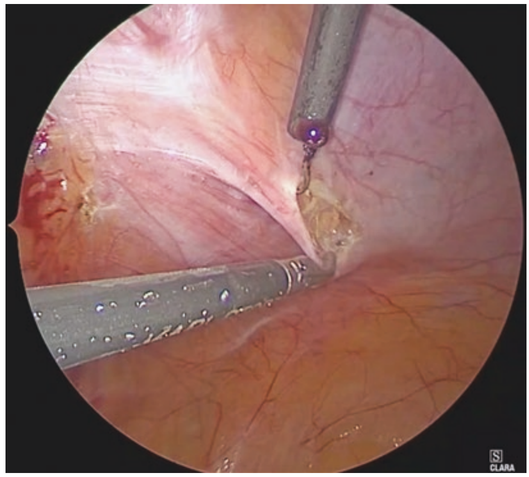

Fig. 11.7 Creation of peritoneal flap to expose the pubic arch in transabdominal partially extraperitoneal repair procedure

11.6 Transabdominal Partially Extraperitoneal (TAPE) Technique

This technique is suitable for hernias in suprapubic region located beneath the arcuate line. These hernias are common after low vertical or transverse incisions in urological, gynecological, or bowel-related surgeries [11]. The repair of suprapubic hernias is as such difficult due to absent posterior rectus sheath, proximity to the bladder, and important neurovascular structures [12].

- After urinary catheterization and creation of pneumoperitoneum the port placement is chosen on the basis of position and nature of the previous surgical scar.
- Ports are placed in the form of an arc of a circle in the upper abdomen.
- A horizontal peritoneal flap is created by dissection starting close to ASIS and is extended to the contralateral ASIS (Fig. 11.7).
- The inferior end of flap is dissected till the space of Retzius so that pubic arch and coopers ligaments on both the sides are completely exposed (Fig. 11.8).
- Medial dissection should be done carefully to avoid injury to the urinary bladder.

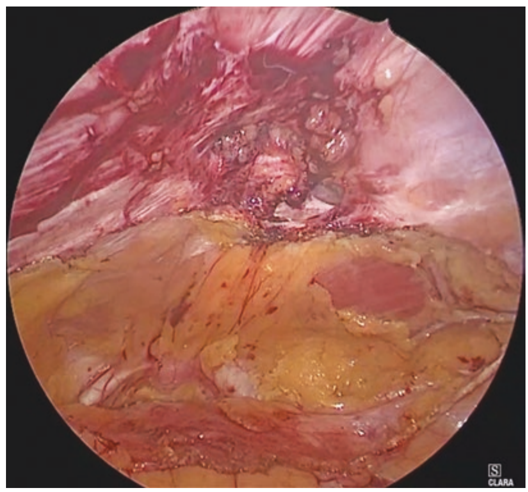

Fig. 11.8 Exposure of Pubic arch and Cooper's ligaments

- A composite mesh of appropriate size is chosen so that an overlap of at least 5 cm is achieved around the defect.
- The lower margin of the mesh must extend below the pubic arch by 1–2 cm and mesh fixation is to Cooper's ligaments bilaterally (Fig. 11.9).
- The mesh is passed through a 10 or 12 mm port and is positioned within the abdominal cavity so that the surface with adhesion barrier faces

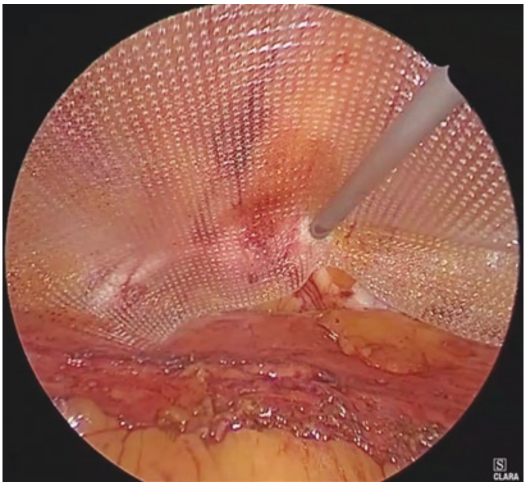

Fig. 11.9 Mesh positioned 2 cm beyond the pubic arch and fixed to Cooper's ligament bilaterally

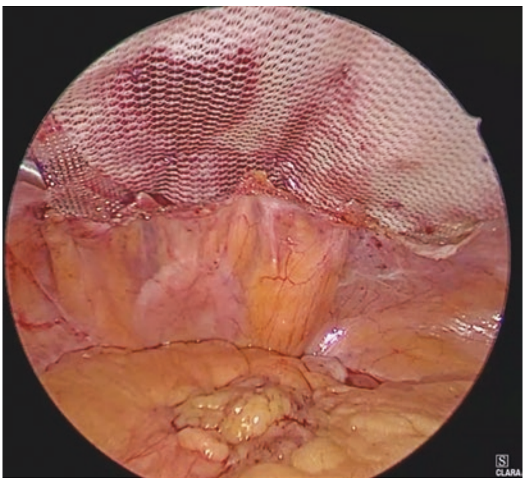

Fig. 11.10 Reperitonealization of part of Mesh

the abdominal viscera. The mesh is pulled up against the abdominal wall using three (lower one not required in TAPE) preplaced transabdominal sutures. Tacks are used to fix the mesh at two points on the Cooper's ligaments on both sides. Circumferential fixation is also performed at the mesh margins and around the margins of the hernial defect in the manner of double crowning.

– The peritoneal flap raised initially is reposited to reperitonealize the greater part of the mesh (Fig. 11.10).
– The main advantage of TAPE is appropriate mesh overlap of more than 5 cm from the distal margin of the hernial defect. The fixation of the lower mesh margin to Cooper's ligaments on either side increases the tensile strength of repair and decreases recurrence rates.

11.7 Tips and Tricks

The major problem with TAPP, especially when performed for umbilical hernia is making peritoneal holes while creating a pocket, since the peritoneum is densely adherent to the posterior sheath at this area. It is preferable to keep cautery at low settings. While crossing the linea alba, it is important to stay preperitoneal and not injure the linea alba. A good tip to remember is that if one sees yellow fat at the roof instead of the white criss-cross fibers of linea alba, the injury has occurred. In that event, it will need repair with a delayed absorbable or non-absorbable sutures. Another good tip is to cross over more cephalad where falciform ligament helps in forming a bulkier posterior layer. Finally, suturing the peritoneal incision is technically demanding because the camera is close to the target. This can be made ergonomically better by a contralateral tilt. sometimes, tacks, barbed sutures or transfascial sutures may be used to facilitate closure.

TAPE can also be used for the repair of lumbar and lateral abdominal wall hernias in a similar manner [13].

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12 Laparoscopic Transabdominal Retromuscular (TARM) Repair for Ventral Hernia

Ashwin A. Masurkar

12.1 Introduction

In recent years, surgeons have recognized small but finite risks of complications with the intraperitoneal location of mesh. This has encouraged them to devise a repair that can keep the mesh sandwiched between the layers of the abdominal wall. In the 1980s, Jean Rives and Rene Stoppa [1] described their technique of sublay mesh placement—open Rives-Stoppa (ORS) repair—which is a widely accepted procedure. Recent evidence has suggested that sublay mesh position with wide overlap and midline closure yields the best results with respect to restoration of biomechanics of the abdominal wall [2]. Laparoscopic sublay technique has been described by Schroeder et al. [3] but they had not included midline closure or posterior component separation in their procedure. Our technique of repair laparoscopic TARM [4] was developed since 2004, and was conceived in a rural private hospital setting, to serve as a low-cost and safe, minimally invasive alternative to laparoscopic intraperitoneal onlay mesh (IPOM) repair. The cost of composite mesh and fixation devices made the latter an unaffordable option for our patients. This paved a way for innovating a series of techniques to achieve sublay placement of a polypropylene mesh (PPM) like the ORS repair, along with midline closure and, the optional addition of posterior component separation by transversus abdominis release (TAR) [5]. Recent concerns of complications related to intraperitoneal location of mesh have made sublay placement a preferred option for many emerging laparo-endoscopic techniques like TARM, EMILOS [6], and eTEP [7].

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12.2 Contraindications

(a) Large hernias with loss of domain.
(b) Strangulated hernias.

Hernias with thinned-out redundant skin constitute a relative contraindication. This group may be better served by a hybrid technique of laparoscopic TARM and open abdominoplasty. The advantage of pursuing the minimal access approach is to reduce the size of incision and associated wound complications. The subsequent incision to trim off redundant skin can be minimized when the hernia repair is performed laparoscopically.

12.3 Indications and Case Selection

Uncomplicated small, medium, and selected large hernias are suitable for TARM. Ventral hernias with divarication of recti can also be treated with TARM. Irreducible hernias are best attempted by TARM due to the advantage of reduction of contents under direct visualization [8].

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12.4 Essential Equipment, Instruments, and Energy Sources

(a) Imaging system: High-definition camera system is desirable with monitors at or below eye level to allow favorable ergonomics.
(b) Energy sources: Monopolar cautery, bipolar electrosurgical unit and ultrasonic shears are desirable.
(c) OR table: Should be motorized with a feature of dropping to a low height. The lithotomy stirrups should be adjustable so that a modified lithotomy leg split position can be given. Additional table split/flex function is of great value for improving ergonomics.
(d) Anesthesia equipment: Workstation with long tubing enable surgeon and camera assistant to work at the head end.
(e) Laparoscopic hand instruments: autoclavable with dismantle feature, which allows a thorough cleaning prior to sterilization.

12.5 Team Setup, Anesthesia, and Patient Position (Figs. 12.1 and 12.3)

All patients are operated under general anesthesia (GA), in a modified lithotomy position. An indwelling urinary catheter and a nasogastric tube are passed soon after induction of GA. A high-definition endovision camera system and two 32″ monitors are used. These are positioned to the patient's right (Fig. 12.1).

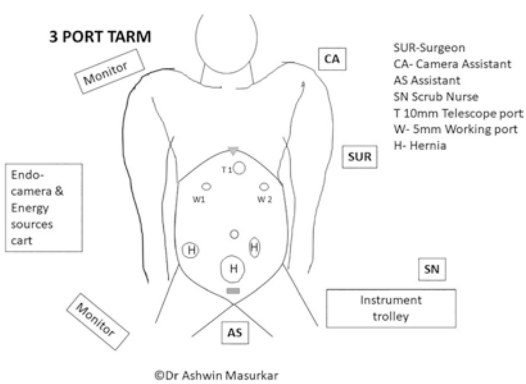

Fig. 12.1 3 Port TARM

12.6 Key Steps

(a) Patient positioning—An OR table with table split function is used. This allows for increase in the distance between the symphysis pubis and the xiphisternum, and consequently wider instrument manipulation angles. Modified lithotomy is used with the legs split and flexed at the hip to allow space while closing the midline and prevent the needle holders from colliding with the thighs of the patient. This position allows the surgeon to work with ergonomic comfort.
(b) Trocar placement—The first port is established using an open method and a Hasson trocar with a cone is placed. Figure of 8 sutures is placed on cut edges of the anterior sheath on each side with No 1 Polyglactin suture. This is looped around the Hasson's cone to secure the trocar as well as prevent gas leak. This stitch works as an anterior sheath closing suture at the end of the procedure.
(c) Diagnostic laparoscopy for evaluation of herniated contents is performed next.
(d) Adhesiolysis. Omental adhesions are lysed with ultrasonic shears or bipolar scissors, and bowel adhesions are taken care of using sharp dissection (cold scissors).
(e) Reduction of contents of the hernia sac: TARM being a transabdominal approach, this step can be carried out under direct vision and inspection of reduced contents adds to the safety.
(f) Defect assessment for size and number.
(g) Incision on the peritoneum-posterior rectus sheath (P-PRS): to access the retromuscular space. This is performed over the medial most extent of the rectus abdominis muscles (RA).

(h) Developing the retromuscular space: This involves lysing the P-PRS complex away from both the RA muscles and the linea alba (LA). Inferior limit is at least 8 cm distal to the defect and laterally till the linea semilunaris (LS) with careful preservation of the perforating neurovascular bundles.
(i) Defect closure: Is performed with running sutures of no 1-0 Polydiaxonone (PDS).
(j) Midline closure of defect: in the LA as well as the associated divarication is repaired using no 0 or 1 PDS.
(k) Measurement of the mesh bed: is done using a sterile measuring tape or umbilical tape with markings.
(l) Mesh placement: The mesh should extend from one linea semilunaris to the other with at least 5 cm overlap from the edges of hernia defect.
(m) Placement of suction drains over the mesh.
(n) Port closure: the 10 mm camera port is closed with no 1 Polygalactin910. Skin closure and 5 mm working ports are performed with subcuticular sutures of no 3-0 polyamide.
(o) External compression dressing is applied over the hernia site to prevent seroma formation.

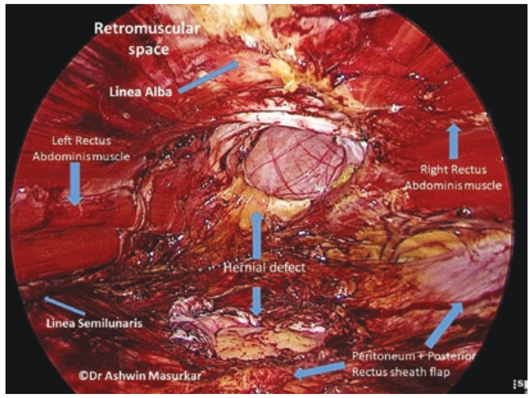

Fig. 12.2 Retromuscular space

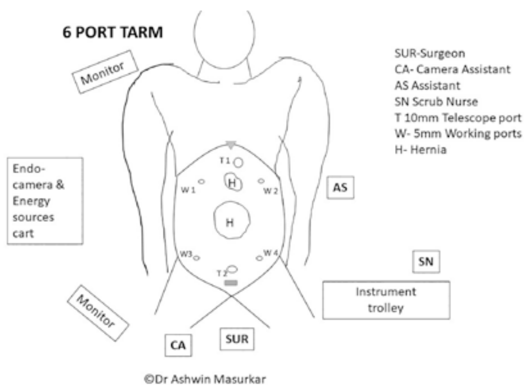

Fig. 12.3 6 Port TARM

12.7 Surgical Techniques and Variations

Based on location, size of hernia, and associated rectus abdominis divarication, three techniques were developed as follows:

12.7.1 Technique 1: 3 Port TARM/One P-PRS Flap (Figs. 12.1 and 12.2)

This technique was devised for epigastric, subxiphoidal, supra-pubic, infra-umbilical, and lateral hernias.

Three trocars are used; one 10 mm for telescope and two 5 mm trocars as working ports (Fig. 12.1; labeled T1, W1 and W2), placed in the upper abdomen for supra-pubic, infra-umbilical (M5, M4), and lateral (L2 and L3) hernias in a triangulated port geometry. For subxiphoidal and epigastric hernias (M1, M2), the ports are inserted in the lower abdomen (Fig. 12.3; labeled T2, W3 and W4). Working ports are placed medial to the linea semilunaris (LS). This can preoperatively marked by ultrasonography. LS may also be located intraoperatively by observing termination of the fibers of the transversus abdominis. Location may be derived from anatomic surface marking since the LS extends in a curvilinear direction at the lateral border of the recti muscles from the tip of the seventh costal cartilage to the pubic tubercle.

After adhesiolysis and reduction of the contents of the hernial sac, the defect is assessed. Using electrosurgery or ultrasonic shears, a 6–8 cm long transverse incision is made on the peritoneum (P) and posterior rectus sheath (PRS), underlying the rectus abdominis muscle; 6 cm proximal to the defect. The retromuscular space is developed by raising a flap of P-PRS, till 8 cm beyond the hernial defect; with careful preservation of epigastric vessels, neurovascular bundles at the LS laterally, and linea alba (LA) in the midline. The intra-abdominal pressure is then reduced to 8 mmHg. Defect closure [2] along with the LA is performed with a running suture of number 1 or 0 PDS passing through the medial edge of RA muscles, ARS and LA.

A medium-weight microporous PPM of adequate size, with wide overlap of 5 cm beyond the defect and extending from one LS to the other is placed into the retromuscular space. The hernial defect on P-PRS and initial transverse P-PRS incision are closed using No 0 PDS; followed by desufflation and port closure.

12.7.2 Technique 2: 6 Port TARM (Figs. 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 12.7, and 12.8)—Two P-PRS Flap Technique

This technique was devised for the repair of

(a) Large hernias regardless of location, particularly umbilical, para-umbilical
(b) Multiple defects
(c) Hernias associated with divarication of recti
(d) Large divarication of recti

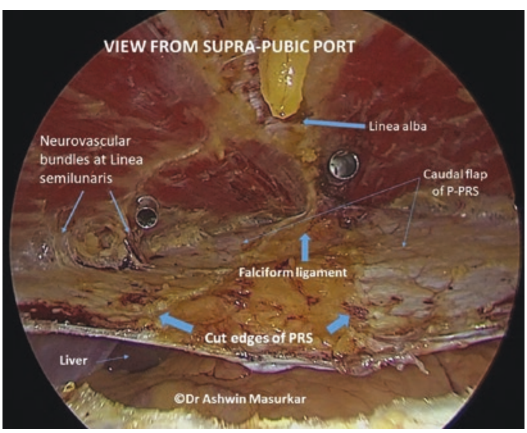

Fig. 12.4 6 Port TARM

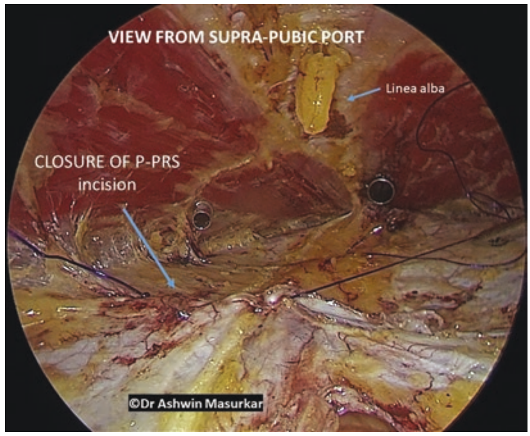

Fig. 12.5 P PRS closure

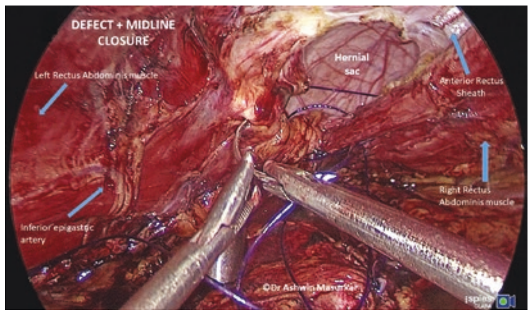

Fig. 12.6 Closure of hernial defect and rectus abdominis divarication

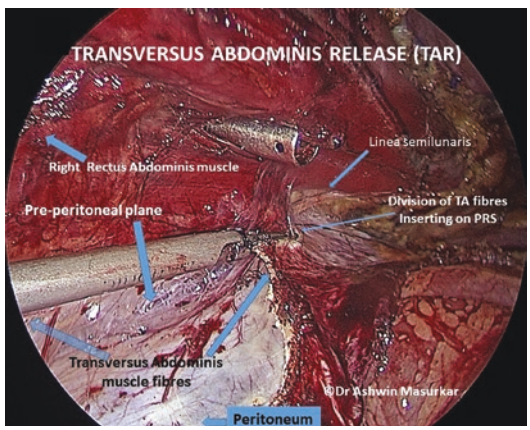

Fig. 12.7 Transversus abdominis release

In this variant, six ports are used to raise two P-PRS flaps. The first trocar is inserted in the epigastrium with two 5 mm working ports (Fig. 12.1 labeled T1, W1 and W2) medial to

Fig. 12.8 Mesh placement

LS. A transverse incision is made on the P-PRS, midway between the xiphisternum and symphysis pubis. The retro-rectus space is developed inferiorly till the symphysis pubis and laterally till the LS. Three more ports are inserted into the lower abdomen to lie in the retromuscular space (Fig. 12.3 labeled T2, W3 and W4). One 10 mm camera port in the supra-pubic area and two 5 mm working ports. The telescope is then shifted to the supra-pubic port. With the surgeon and camera assistant standing between the patient's legs, an upper flap of P-PRS is mobilized till the level of the xiphisternum. The initial three trocars inserted into the abdominal cavity are withdrawn into the retromuscular space. The intra-abdominal pressure is reduced to 8 mmHg, followed by the closure of hernial defects in P-PRS and the initial transverse incision on P-PRS (Fig. 12.5) with running suture of PDS. The defect in the anterior sheath; midline and divarication are approximated (Fig. 12.6). Finally, a PPM of adequate size (usually 15 × 30 cm or 20 × 30 cm) is inserted. It was spread out between one LS and the other and from xiphisternum to pubic symphysis (Fig. 12.7). No/minimal fixation is used as the mesh is sandwiched firmly between the P-PRS and the RA muscle. Fixation causes more postoperative pain and is therefore avoided. This procedure achieves complete reinforcement of the visceral sac-like ORS [1].

12.7.3 Technique 3: TARM-TAR

Includes the addition of transversus abdominis release (TAR) [5] to technique 1 or 2.

PCS by TAR is added to either of the previous techniques providing myofascial release for posterior flap closure.

This technique was used for the following indications during intraoperative assessment.

(a) Large hernias with wide divarication.
(b) Difficulty in P-PRS flap closure due to tension.
(c) In cases when midline closure was under tension.

Technique: The transversus abdominis (TA) muscle fibers are identified in the upper abdomen inserting into the PRS medial to the LS. The muscle is incised medial to the neurovascular bundles (Fig. 12.7); followed by dissection into preperitoneal space to provide reduced tension for midline closure. Next, a PPM (usually 20 × 30 or 30 × 30 cm size) is placed into the retromuscular space. A second mesh is placed in the lower abdomen in a diamond-shaped orientation to form a "home-plate" configuration.

I prefer to spray dilute gentamicin over the mesh to prevent mesh infection [9]. Suction drains are inserted and compression dressing is applied.

12.8 Tips and Tricks

- Positioning of the patient- supine position with leg split and table break at the level of the mid-abdomen. This increases the distance between the xiphisternum and the symphysis pubis.
- Initial trocar entry especially for six Port TARM should be made lateral to midline so that dissection can be performed beyond it and so that the trocar does not obstruct during the midline closure.

- Creation of P-PRS flap: lowering IAP to 8 mmHg allows for a posterior tug using a grasper on the P-PRS complex for space creation.
- Maintaining P-PRS flap integrity by setting the electrosurgical generator to minimum energy or keeping the active blade of the Harmonic scalpel laterally rather than posterior.
- While raising the P-PRS flap in the midline, the preperitoneal fat should be dissected off the LA and left on the peritoneum. This allows for a thicker mesh-bowel barrier and can prevent posterior disruption in the postoperative period.
- In case the peritoneal bridge between the cut edges of the PRS is thinned out, approximation of the cut edges of PRS should be performed to avoid postoperative disruption. In case this suture line is under tension, an incision may be taken on the TA for release and advancement of the posterior component.

12.9 Complications and Their Management

1. **Intraoperative**
   (a) **Linea alba injury**

   This can occur in the following situations (Fig. 12.9). (i) While taking a transverse incision on the P-PRS, it is recommended to take this incision over the area underlying the rectus abdominis muscle to allow direct access into the retrorectus space, one side at a time. If the incision is taken in the midline, where the LA is covered only by a layer of peritoneum and preperitoneal fat, it may be inadvertently divided. Further dissection of the P-PRS flap may end up detaching the LA from the anterior rectus sheath (ARS) and becoming a part of the P-PRS flap (Fig. 12.9). In this situation, one can see yellow subcutaneous fat between the rectus abdominis muscles, a situation which must be immediately remedied by reorienting oneself and correcting the plane of dissection. The correct plane is achieved when the criss-cross fibers of the LA inserting on the PRS of either side are divided carefully to leave a bridge of peritoneum and preperitoneal fat between the cut edges of PRS as shown in (Fig. 12.4). A pearly white LA should always be preserved between the two recti. If observed late, the cut edges of ARS and muscles should be carefully approximated during the midline closure. (ii) While connecting the two retrorectus spaces one may inadvertently divide the LA and end up including it in the P-PRS flap as described previously.

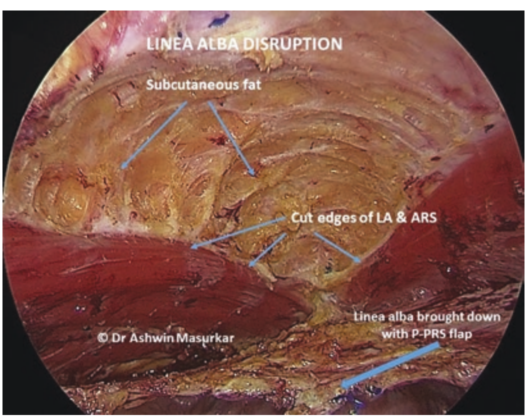

Fig. 12.9 Linea alba injury

   (b) **Hemorrhage**

   This occurs in two situations (i) During the P-PRS incision, the muscle may be inadvertently incised, especially while using electrocautery. (ii) While dissecting the P-PRS flap hemorrhage may occur from the avulsion of small vessels arising from the epigastric vessels. These vessels enter the PRS and should be carefully cauterized and divided close to the latter. (iii) Excessive posterior retraction of the P-PRS flap may avulse these small vessels from the main vessel causing rent and subsequent bleeding.

   (c) **Flap tears**

   These may occur due to adhesions or when the P-PRS is thinned out. These must be meticulously closed or may result in herniation of the bowel in the early postoperative period. If this closure is found to be under tension, incision of the TA can facilitate medialization of the posterior component to aid the flap closure.

2. **Postoperative**
   (a) **P-PRS suture line disruption:** may occur if (i) the flap or defect is closed under tension. (ii) The peritoneal bridge between the cut edges of the PRS is thin (iii) peritoneal tears during TAR. These situations may result in migration of bowel to lie in contact with the mesh and subsequent intestinal obstruction. To avoid these situations, one must ensure low tension during flap closure. Tension, if present, should be released by incision on the transversus abdominis alone without needing a full TAR.
   (b) **Seroma:** Suction drains were placed over the mesh, and compression dressing was applied to reduce seroma formation.
   (c) **Mesh infection:** This is a preventable complication. Preventive measures include (i) Preoperative skin preparation (ii) perioperative intravenous antibiotic (iii) autoclaved instruments and telescope; and gas sterilization of delicate components like camera head and fiber optic cables. (iv) Change of gloves by the surgical team prior to mesh insertion.

   Management of infected mesh specifically to TARM: The patient typically presents with a bulge over the hernia sac along with skin changes and often signs of sepsis. Diagnosis is by ultrasonography-guided aspiration followed by an incision over the previous hernia sac. In our experience, mesh conservation was possible in 80% of cases by antibiotics (both systemic and local), and negative pressure wound therapy (NPWT). Mesh removal was needed in one case which could be easily performed as the mesh fixation is not routinely performed in our center.

12.10 Specific Advantages of the TARM Technique

(a) Initial entry by laparoscopy allows excellent evaluation of the herniated contents as well as the defect.
(b) The larger working space and clearly demonstrable anatomy provide easy understanding and reproducibility.
(c) Adhesiolysis is performed first before flap mobilization, under direct laparoscopic vision adding safety to the procedure. This is of great help in irreducible hernias where it becomes necessary to assess bowel viability [8].
(d) Port positioning is like TAPP for inguinal hernia repair, which most surgeons are familiar with.
(e) There is an ergonomic advantage both while working on the upper as well as the lower abdomen. The six Port two P-PRS Flap technique allows reparative access for LA plication and divarication of recti from symphysis pubis to xiphisternum.
(f) The triangulated port geometry makes suturing easier.
(g) The technique for the creation of retromuscular space is similar to TAPP repair for inguinal hernia repair familiar to most hernia surgeons, and is done without needing balloon dissectors.
(h) Routine laparoscopic instruments and energy sources are adequate for performing TARM. Further cost reduction can be achieved by using electrocautery for flap dissection in place of Harmonic scalpel.
(i) The procedure avoids the need for Robotic arms; however, it may be easily adopted onto the robotic platform [10].
(j) Midline closure ensures restoration of biomechanics of the abdominal wall [2].
(k) PCS by TAR may be added within the same port positions, to aid myofascial medialization for low-tension closure whenever indicated. TARM can therefore achieve a comprehensive abdominal wall reconstruction.

(l) The mesh is well supported by the closed defect and approximated midline anteriorly, and the P-PRS posteriorly, avoiding the need for fixation. Similar to other endoscopic sublay procedures with no/minimal fixation, this can cause considerably less pain in the postoperative period.

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13 Laparoscopic Intracorporeal Rectus Aponeuroplasty (LIRA)

Salvador Morales-Conde, Andrea Balla, and Julio Gómez-Menchero

Abbreviations

CD	Closure of the Defect
LIRA	Laparoscopic Intraperitoneal Rectus Aponeuroplasty
LVHR	laparoscopic ventral hernia repair

13.1 Introduction

The initial development of laparoscopic ventral hernia repair (LVHR) [1, 2] by Leblanc in the early 90s added a new dimension to the treatment of ventral hernias, providing advantages over conventional open repair, especially related to a reduction of the morbidity associated to the surgical wound. This technique has been also known as IPOM (Intraperitoneal Onlay Mesh) technique since the mesh was placed intraperitoneally bridging the defect and fixed by transfascial suture or with a double crown of tackers [3]. The main criticisms of LVHR have been related to the consequences of bridging the defect and not performing an abdominal wall reconstruction, which is related to a so-called pseudo-recurrence due to the bulging effect of the repair [4].

An alternative to avoid the problems of IPOM and to increase the functionality of the abdominal wall, E Chelala et al. introduced the concept of performing the closure of the defect (CD) [5] by laparoscopy before placing the mesh. This is known as "IPOM-plus." The main drawback of this technique was the tension generated at the midline, that could result in pain and tears at the fascia and therefore long-term recurrences as it was suggested by Tandon et al. years later [6].

Since conventional LVHR without CD can potentially lead to pseudo-recurrence and bulging, and given that pain is the main drawback of CD together with a high bulging rate, we developed a completely new laparoscopic technique for the treatment of ventral hernia for defect width from 5 to 10 cm [7]. This technique was described under the acronym of LIRA, which stands for Laparoscopic Intraperitoneal Rectus Aponeuroplasty.

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This technique (LIRA) includes three main characteristics and advantages

(a) It is a minimally invasive technique.
(b) It is a reconstruction of the abdominal wall achieved by opposing the medial edge of the rectus sheaths, instead of just joining together the fibrous tissue of the edges of the defect. The latter technique does not result in proper healing to maintain together the rectus muscle in long term.
(c) It is a tension-free repair since the posterior rectus fascia is opened longitudinally along the area that needs to be repaired.

13.2 Indications, Case Selection, and Contraindications

Indications for the LIRA technique include:

- Midline primary and/or incisional hernia of the midline cranial to the arcuate line: M1, M2, M3, and M4 according to the EHS classification [8].
- Hernia with defect size with a width from 5 to 10 cm: W2 according to the EHS classification [8].
- Incisional hernias associated with weakness of the previous incision or primary ventral hernias associated with rectus diastasis.

Contraindications for the LIRA technique included:

- Absence of posterior aponeurosis integrity of both rectus muscles detected intraoperatively,
- Hernias larger than 10 cm: W3 according to the EHS classification.
- Lateral hernias.
- Suprapubic hernias: M5 according to the EHS classification.
- Those cases in which a laparoscopic approach is contraindicated.

13.3 Instruments and Energy Source

The instruments and energy devices needed to perform a LIRA technique are:

- Optic—10 or 5 mm 30° scope.
- Access—Verres needle or Hasson trocar.
- Trocars—one 12 mm trocars and two 5 mm trocars.
- Conventional laparoscopic instruments—one needle holder, two endograspers, one endodissector, and one endoshear.
- Energy—monopolar cautery.
- Suture—either a double-loop delayed absorbable suture number 1 or a permanent or delayed absorbable barbed suture number 1.
- Suture passer.
- Coated mesh to be placed intraperitoneally.
- Fixation device—tackers (permanent or absorbable fixation devices).

13.4 Team Setup, Anesthesia, and Position

Patient under general anesthesia is placed in supine position with both arms open and closer to the edge of the surgical table from where the surgeon performs most of the steps of the procedure. The surgeon and the assistant are usually to the left side of the patient where working trocars are placed most of the time, except in those cases where previous open left colonic or rectal resection or other surgical procedures have been performed in this area. The monitor and the scrub nurse are usually on the right side of the patient, opposite to the surgeon.

13.5 Key Steps of the Surgical Technique

13.5.1 Access and Pneumoperitoneum

Pneumoperitoneum is created at 12–14 mmHg by using a Veress needle in the left upper quadrant of the patient or using a Hasson trocar (Fig. 13.1).

13.5.2 Trocars

Three trocars are placed at the left mid-axillary line along a straight line: one 12 mm for the 30° camera to introduce the mesh and two 5 mm, cranial and caudal to the previous one (Fig. 13.2).

13.5.3 Adhesiolysis

Adhesions are released using a combination of cold scissors, electrocautery, and blunt dissection, ensuring that the posterior aponeurosis of both posterior rectus abdominal muscles is preserved intact during these maneuvers.

13.5.4 Measure of the Hernia Defect

Both axes of the defect (Fig. 13.3) are measured, the width and the length, by using transabdominal needles or with a ruler intraperitoneally, allowing to draw the area of the defect on the abdominal wall (Fig. 13.4).

Fig. 13.1 Pneumoperitoneum is created at 12–14 mmHg by using a Veress needle in the left upper quadrant of the patient

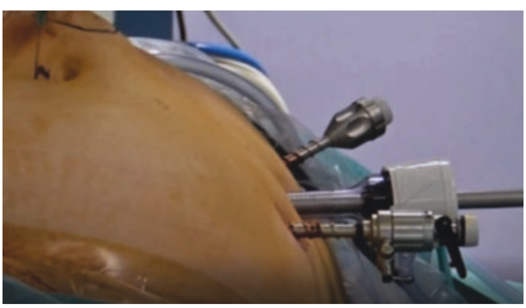

Fig. 13.2 Three trocars placed at the mid axillary line making a line: one 12 mm for the 30° camera and two 5 mm

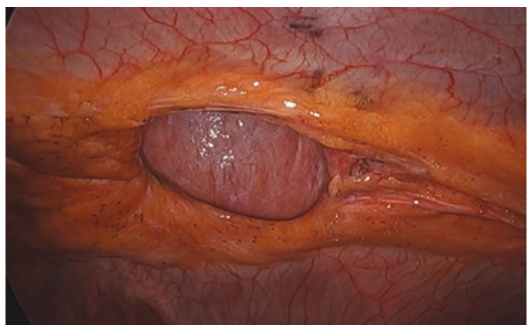

Fig. 13.3 Hernia defect

Fig. 13.4 Hernia defect and area of diastasis drawn on the skin of the patients after the adhesiolysis

13.5.5 Creating the Flap at the Posterior Fascia of the Rectus Muscle

The distance from the edge of the sac where the flap of the posterior aponeurosis is performed should be half of the width of the defect of the hernia (Figs. 13.5, 13.6, 13.7, and 13.8). For example, for a 6 cm width hernia, the incision on the fascia should be performed 3 cm from the edge of the defect. We should identify the lateral neurovascular bundles located at the lateral area of the rectus muscles to avoid injury to them during the dissection.

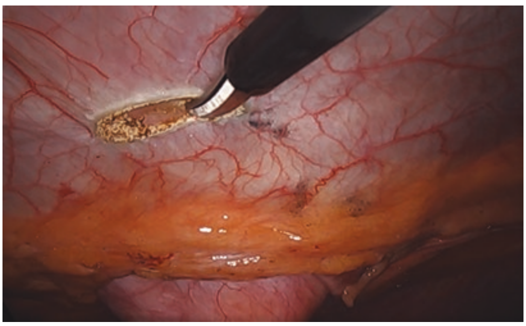

Fig. 13.5 The flap of the fascia is created approximately at half of the width of the defect of the hernia

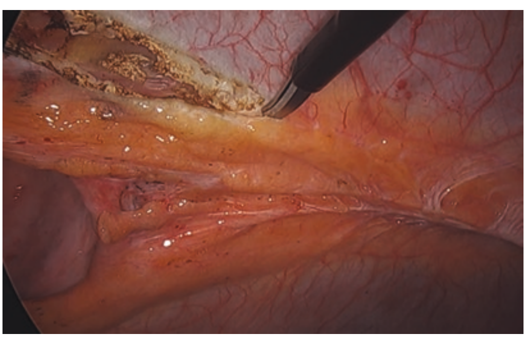

Fig. 13.6 The flap is continued cranially to the defect in order to include the whole incision, in case of an incisional hernia, or the diastasis, in case of primary ventral hernia

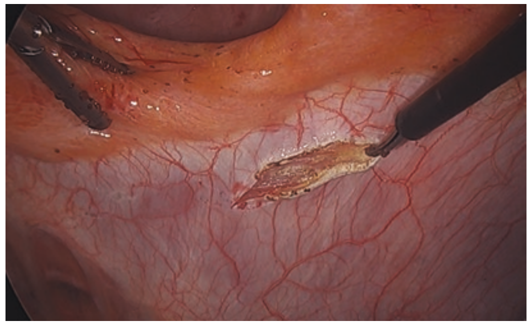

Fig. 13.7 The other flap is created in the contralateral side of the previous one

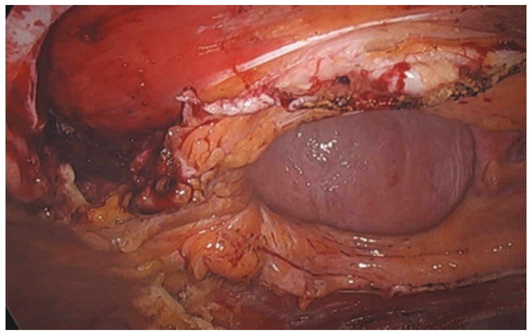

Fig. 13.8 Both flaps are created around the defect and the diastasis or including the whole previous incision

13.5.6 Suture of the Flap of the Posterior Fascia

Once both flaps are created, this step can be performed in two different types of continuous sutures, depending on one's preference:

(a) A double-loop delayed absorbable monofilament (MAXON™ loop 1, Medtronic, USA): the needle of the double-loop suture is introduced close to the caudal end of the opening of the fascia, maintaining the long threads outside the abdominal cavity, being introduced as needed (Fig. 13.9). After the first bite of tissue, the needle should go

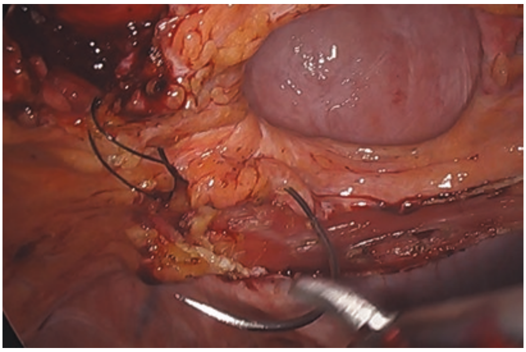

Fig. 13.9 Running suture of the posterior fascia of the rectus muscle using a doble-loop suture. The needle of the double-loop suture is introduced close to the caudal end of the opening of the fascia, maintaining the long threads outside the abdominal cavity

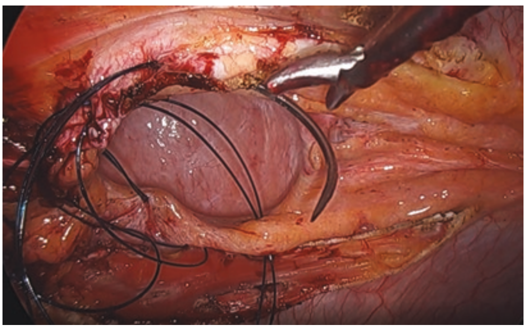

Fig. 13.10 The continuous suture of both flaps is performed completely intracorporeally by laparoscopy

across the two threads of the double loop, so it will lock by itself at the end when pulling off the whole suture, avoiding a knot at this end. The continuous suture of both flaps is performed completely intracorporeally by laparoscopy (Fig. 13.10). The suturing is finished cranially to the defect and both ends of the double-loop suture are knotted together in the subcutaneous tissue, after reducing the pneumoperitoneum to 8 mmHg, once the two threads have been exteriorized from the abdominal cavity through the same skin incision but a different incision of the fascia by using an endoclose or a suture passer (Figs. 13.11, 13.12, and 13.13).

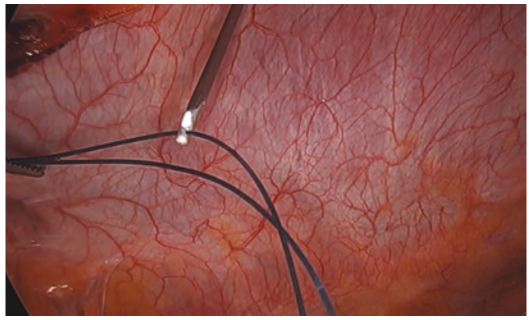

Fig. 13.11 The two threads are exteriorized from the abdominal cavity through the same skin incision but a different incision of the fascia by using an endoclose or a suture passer

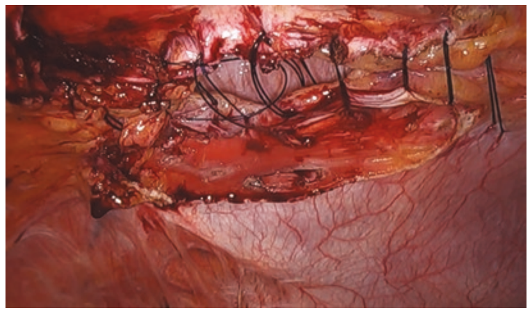

Fig. 13.12 Both ends of the double-loop suture are knotted together in the subcutaneous tissue, after reducing the pneumoperitoneum to 8 mmHg—before closing the middle line

Fig. 13.13 Both ends of the double-loop suture are knotted together in the subcutaneous tissue, after reducing the pneumoperitoneum to 8 mmHg—after closing the middle line

(b) Closure with barbed nonabsorbable monofilament suture (V-Loc™ Polybutester 1, Medtronic, Mansfield, MA, USA) (45 cm length number 1): the needle is introduced through the 12 mm trocar into the abdominal cavity and the whole thread is introduced to pass the needle through the small loop at the end of the thread. The suture is performed under low pneumoperitoneum to be able to maintain the tension, without the need to tie a knot at the end.

13.5.7 Size of the Mesh

Once the fascia is approximated at the linea alba and both rectus muscles have been joined together, the size of the mesh should be determined. Mesh should overlap 2 cm from the cranial, caudal, and lateral opening of the fascia to guarantee that the mesh is fixed to the posterior fascia (Fig. 13.14).

13.5.8 Fixation of the Mesh

Fixation starts at the cardinal point (Fig. 13.15), performing a double crown of fixation: the external one at the edge of the mesh, at the area of the intact fascia of the rectus muscles (Fig. 13.16); and the internal one at the rectus muscles, in order to guarantee that the mesh is in close contact with the muscles and therefore improving the integration. The final result show how the mesh mimics the posterior fascia of the muscle, the one that has been opened during the procedure (Fig. 13.17).

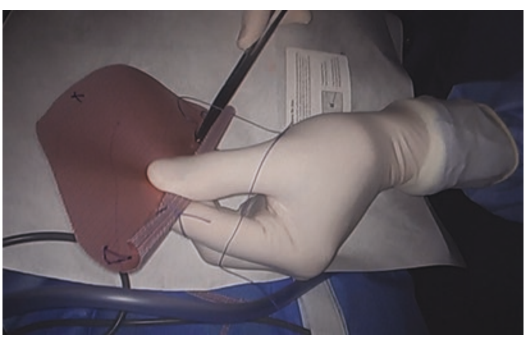

Fig. 13.14 It is recommended to roll half of the mesh following the vertical axis, with the visceral side toward the internal part, placing two stitches to maintain it in this way

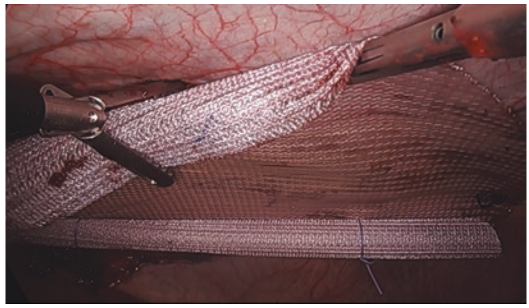

Fig. 13.15 Fixation starts at the cardinal point

Fig. 13.16 The external crown is performed at the edge of the mesh, at the area of the intact fascia of the rectus muscles with fixation every 2–3 cm

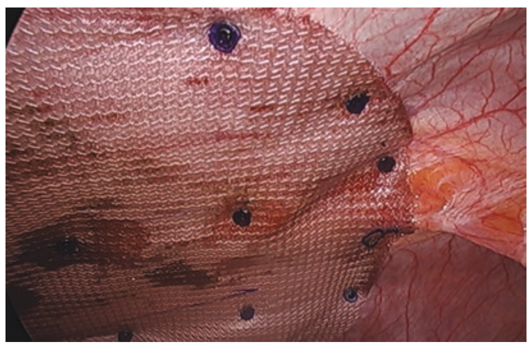

Fig. 13.17 The internal crown is performed at the rectus muscles, in order to guarantee that the mesh is in close contact with the muscles and therefore improving the integration

13.6 Tips and Tricks

13.6.1 Regarding Trocar Placement

In case the dissection of the posterior fascia or the fixation of the area close to the optic trocar is complex, a bilateral approach could be considered by adding under direct vision a contralateral 11 and 5 mm trocars, for the optic and one working channel, to perform a safer procedure.

13.6.2 Regarding Measure of the Defect

The length is measured including the whole incision, in case of an incisional hernia, or the rectus diastasis, in cases of a primary ventral hernia (Fig. 13.4). The width should include all defects in the same area and basically should be determined by the distance of the medial edge of the rectus muscles.

13.6.3 Regarding the Flap of Fascia

This flap of the aponeurosis is created using conventional cautery, either with a scissor or with a hook, paying special attention to the epigastric vessels and any bleeding from the muscular fibers. It is important at this point to consider creating first the flap at contralateral side of the trocars, what will be used as a guide to perform the flap of the rectus sheath in the area close to the optic. In case of difficulties at this point a bilateral approach should be performed by placing contralateral 11- and 5-mm trocars. It is important to have in mind that when opening the posterior fascia, the incision should factor in the diastasis, and we should continue cranially until both rectus muscles join to form a 2–3 cm at the linea alba.

13.6.4 Regarding Suturing the Flaps

Transfascial sutures are not recommended for this type of repair since the tension could be different at different zone of the linea alba creating an imbalance in this area. On the other hand, transfascial sutures are associated with more pain due to the amount of tissue that these sutures include.

13.6.5 Regarding Mesh Size and Introduction into the Cavity

The size is measured either by introducing a ruler intra-abdominally or using a needle drawing the edge at the skin. The mesh is trimmed to the exact size needed. Since the mesh is placed intraperitoneally, a coated mesh should be used.

It is recommended to roll half of the mesh following the vertical axis, with the visceral side toward the internal part, placing two stitches to maintain it in this way (Fig. 13.14). Then, the mesh is rolled completed and introduced through a 12-mm trocar. If the mesh is too thick when it has been rolled, it could be introduced through the trocar site after removing the trocar, being protected from the skin by using a plastic cover. Transfascial sutures at the cardinal point could be useful to position the mesh at the right place, although there is no need to tie them at the subcutaneous.

13.6.6 Regarding Fixation

Since this technique reduces the tension of the closure of the midline, we have moved into the use of absorbable fixation devices, such as Absorbatack, Optifix, or Securestarp, showing the same results after using permanent fixation devices. Nonabsorbable metal helicoidal sutures, Protack™ 5 mm (Covidien, Mansfield, Mass, USA), have been shown to induce dense adhesions; therefore, we avoid them. Mechanical fixation could be also reduced in number by adding glues.

13.6.7 Final Tips to Finish the Surgical Procedure

All 12-mm trocar should be closed at the end of the procedure under direct vision in order to include the entire muscle layers and the peritoneum. We also recommend to use compressive bandage during 7–10 days postoperative so as to improve patient comfort.

13.7 Final Remarks

LIRA allows a durable repair since the midline is reconstructed with the help of PRS from both sides and the mesh would mimic a new posterior fascia of the rectus muscles. The other reason for this solid repair is that the muscles are joined together with less tension after the opening of the posterior fascia. It can also lead to less postoperative pain.

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14 Robotic Transabdominal Retromuscular Umbilical Prosthetic Hernia Repair (rTARUP)

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14.1 Introduction

Umbilical hernias are among the more common abdominal wall hernias, accounting for 10% of primary hernias in adults. Umbilical hernias may occur spontaneously or at the site of a previous surgical access, such as those that may develop after laparoscopic port placement at the level of the umbilicus. For the repair of this type of hernia, the guidelines recommend the implantation of mesh in defects with a diameter greater than 1 cm [1]. Currently, the use of repairs with mesh placement in the extraperitoneal position is considered one of the best approaches for ventral hernias, since the mesh is excluded from the visceral content in addition to presenting favorable outcomes in terms of recurrence and surgical site infections [1]. With the appearance of the laparoscopic approach, lower rates of wound infection have been reported with similar recurrence rates compared to open surgery [2, 3]. In this context, in 2013 Schroeder et al. described a transabdominal laparoscopic ventral hernia repair technique using a lateral approach to access the retromuscular space combining the benefits of the minimally invasive approach avoiding the placement of the intraperitoneal mesh. However, the authors conclude that it is a technically very demanding technique [4]. More recently this same technique was described with the use of the Da Vinci platform with the name TARUP [5]. The advantage of this procedure is the extraperitoneal location of the mesh (Fig. 14.1) thereby avoiding the formation of adhesions with viscera. Further, this technique allows exploring the linea alba to detect and repair other asymptomatic defects that can occur in up to almost 40% of patients with umbilical hernia [6]. All this is facilitated by the robotic approach that allows suturing with greater comfort and better ergonomics for the surgeon [7].

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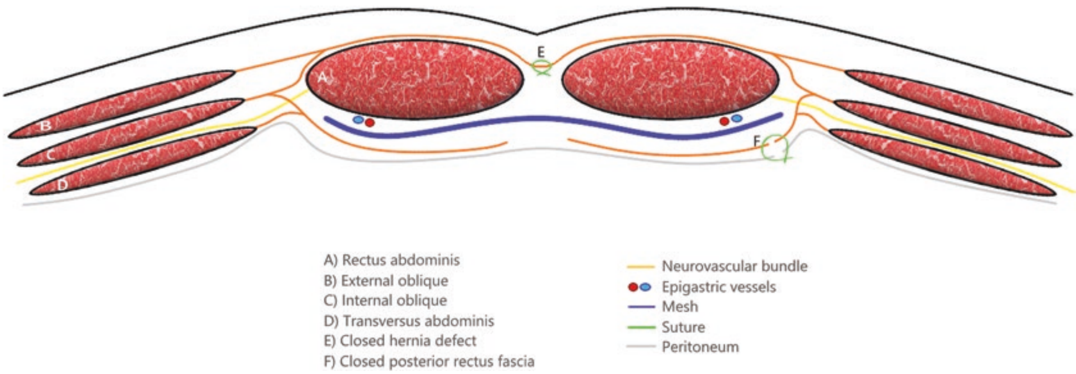

Fig. 14.1 Anatomical drawing of the technique of minimal invasive transabdominal retromuscular umbilical hernia repair (TARUP)

14.2 Indications and Case Selection

This technique is indicated in patients diagnosed with primary or incisional umbilical hernia with a recommended mean size of 4 cm in transverse diameter.

14.3 Contraindications

This technique is not useful for defects larger than 7 cm in transverse diameter, since they would require placing a mesh beyond the lateral borders of the rectus muscle. In the case of hernias with a width of more than 7 cm, a robotic transversus abdominis release (rTAR) may be indicated [6].

14.4 Instruments and Energy Source

Instrumentation consists of a ProGrasp™, monopolar scissors, and a suture needle driver. A 30-degree endoscope is used (all instruments from Intuitive Surgical Inc., Sunnyvale, CA, USA) (Fig. 14.2).

Fig. 14.2 Instrumentation

14.5 Team Setup, Anesthesia, and Position

Patients are placed in a supine position with both upper limbs close to the body; the robotic arm or boom was located to the right of the patient, and the trocars were arranged on the left side. The nursing staff stands on the left side of the patient along with the assistant surgeon.

14.6 Key Steps

14.6.1 Abdominal Access and Trocar Placement

To access the abdominal cavity safely, several methods have been described. We use the Veress needle at Palmer's point to create the pneumoperitoneum. Once access to the abdominal cavity has been achieved, the first 8 mm trocar is placed 2 cm below the costal margin in the left anterior axillary line. Subsequently, under direct vision, the other two trocars are placed in the same vertical line with a separation of 8 cm between them (Fig. 14.3).

14.6.2 Docking

Once proper trocar placement is achieved, the patient cart of the da Vinci surgical system (Model Xi, Intuitive Surgical Inc., Sunnyvale, CA, USA) is docked at the patient's right side. In the central trocar, the 30-degree camera is positioned pointed to the target anatomy and the system will automatically position the boom to ensure optimal arm configuration for the procedure. Instrumentation generally consists of ProGrasp™ forceps, monopolar scissors, and a suture cut needle driver (all instruments from Intuitive Surgical Inc., Sunnyvale, CA, USA).

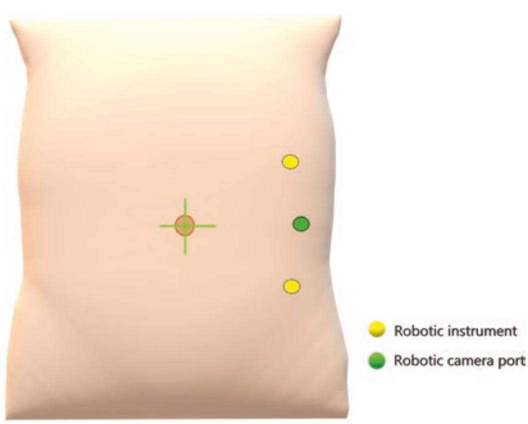

Fig. 14.3 Port placement

14.6.3 Adhesiolysis and Developing a Retromuscular Plane

Adhesiolysis of the abdominal wall to isolate the hernia defect must be performed meticulously to avoid injury to intraperitoneal viscera.

The posterior lamina of the left rectus sheath is incised 5 cm from the hernia defect to access the retromuscular space (Fig. 14.4). This incision is prolonged longitudinally following the direction of the muscle fibers as a reference. The retromuscular plane dissection is advanced towards the midline until the junction of the anterior and posterior laminae of the left rectus sheath is identified. At this point the crossover is performed, which is achieved by first dividing the posterior lamina of the rectus sheath before it fuses with the linea alba and gaining access to the preperitoneal plane behind the linea alba (Fig. 14.5). The contralateral rectus sheath divides just beyond the fusion with the linea alba. It is important not to divide and injure the linea alba here, as it will lead to the subcutaneous plane, and not to the contralateral retromuscular space. Once the contralateral posterior rectus sheath is divided, the retromuscular space is then developed up to the right linea semilunaris. The content of the hernia is reduced, trying to preserve the peritoneum intact (Fig. 14.6).

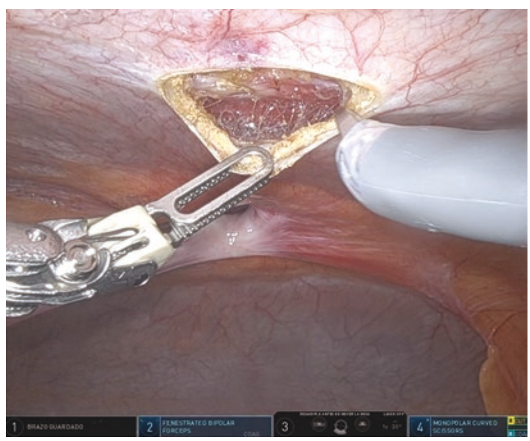

Fig. 14.4 Opening of the posterior lamina of the left rectus sheath

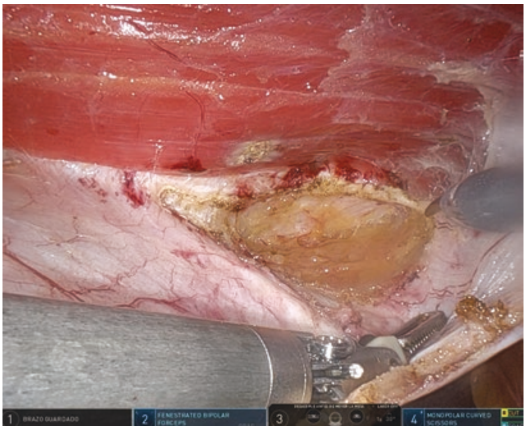

Fig. 14.5 Access to the preperitoneal space posterior to the midline (crossover)

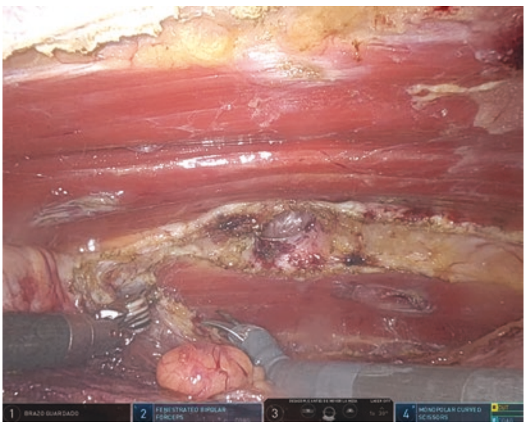

Fig. 14.6 Dissected retromuscular space and hernia defect

Fig. 14.7 Closure of the hernia defect

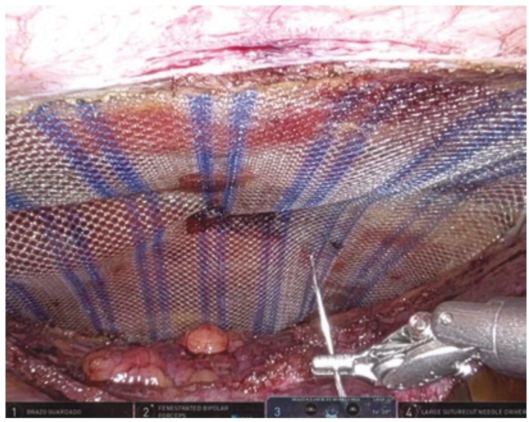

Fig. 14.8 Mesh placement

14.6.4 Primary Closure of the Defect

Closure of the hernia defect is performed to restore abdominal wall anatomy and function, as well as to prevent postoperative bulging. Primary closure of the hernia defect is performed by using a delayed absorbable barbed suture (Fig. 14.7).

14.6.5 Placement of Mesh with Minimal Fixation

Mesh is placed flat, against the rectus muscles. The size of the mesh must be adjusted to the retromuscular space created, which can be measured directly with a ruler placed intraperitoneally. The type of mesh used is medium-weight, macroporous polypropylene that can be fixed with four cardinal points of delayed absorbable suture. The use of self-gripping mesh or glue fixation may also be helpful (Fig. 14.8).

14.6.6 Closure of the Posterior Lamina of the Left Rectus Sheath

This is done using a continuous delayed absorbable barbed suture. No drains were placed (Fig. 14.9).

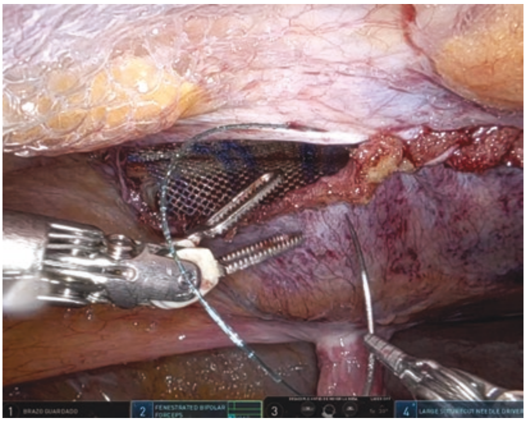

Fig. 14.9 Closure of the posterior lamina of the left rectus sheath

14.7 Complications and Management

Muysoms et al. reported two complications in their experience with 41 patients operated with TARUP technique both requiring surgical intervention. One for laparoscopic evacuation of retromuscular hematoma, and the other for drainage of periumbilical wound infection [5]. In addition, two seromas were also reported that were treated conservatively. More recently, Baur and coworkers presented a comparative study between r-TAPP and TARUP with a total of 118 patients, of which 30 were operated with TARUP technique. In this group, seven seromas (23.3%), three hematomas (10%), and one skin necrosis (3.3%) were reported. No details are given on the management of these complications [6]. Finally, in our recently published series with 10 patients who underwent this technique, five patients presented seroma and one patient an umbilical skin infection. All patients with seroma were treated conservatively and umbilical skin infection was treated with local wound care without reoperation [7].

Seromas are usually asymptomatic; however, some patients experience symptoms, such as pain and pressure. As for treatment, expectant management is reasonable since most seromas resolve spontaneously. Exceptionally, they require drainage or aspiration. The use of abdominal binder is recommended because it has shown to decrease the seroma formation [8].

Retromuscular hematomas usually manifest with pain, swelling, and ecchymosis. In the laboratory study, there may be a reduction in hematocrit. The definitive diagnosis is made with CT scan. Most patients can be treated conservatively because hematomas are usually self-limiting. Conservative treatment consists of rest, analgesia, management of predisposing factors, and, if necessary, reversal of anticoagulation. In the case of highly symptomatic, infected, and expansive hematomas, drainage may be indicated, which can be performed both by interventional radiology or by surgical approach. Meticulous hemostasis during dissection in the retromuscular planes seems important to avoid these bruises.

The diagnosis of ischemic necrosis of the umbilicus is based on clinical examination with the presence of erythema, induration, and signs of necrosis in the skin of the umbilicus. Laboratory tests and CT scan may be useful in detecting deeper infections. Treatment of ischemic necrosis of the umbilicus includes antibiotics and debridement of devitalized tissue. We recommend performing the dissection of the hernia sac very carefully. Damage to the layers of skin caused by electrocoagulation should be avoided.

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15 Enhanced View Totally Extraperitoneal (eTEP) Repair for Midline Hernia

Victor G. Radu

15.1 Introduction

The eTEP technique in laparoscopic ventral hernia repair was published 5 years ago by Dr. Igor Belyansky, as a paradigm-changing technique, that involved closing the defect, using uncoated mesh placed outside of the abdominal cavity, and minimizing the mesh fixation [1].

The underlying principle is to connect three spaces [2]—the preperitoneal space, the retrorectus spaces, and the pre-transversalis spaces crossing over the midline anterior to the falciform ligament or anterior to the umbilical ligament depending on hernia location. In this way, a large space is achieved for placing a retro-muscular mesh (Fig. 15.1).

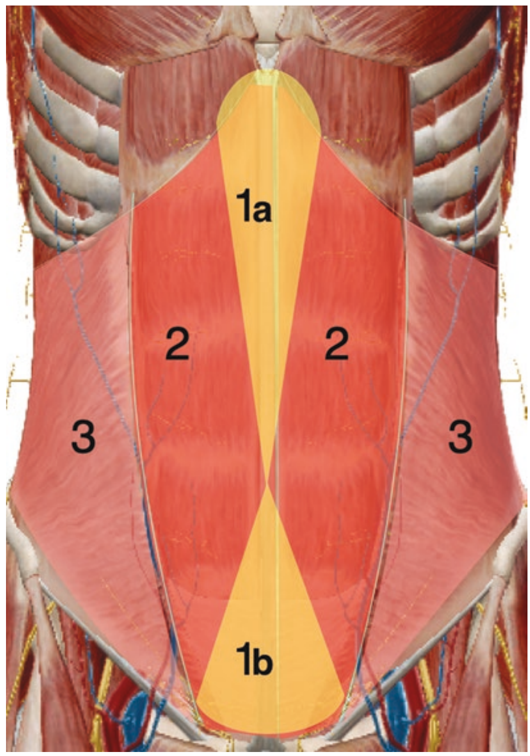

Fig. 15.1 Connection of the retro-muscular spaces: (1) preperitoneal space (1a—falciform ligament, 1b—umbilical ligament); (2) retrorectus spaces; (3) pre-transversalis spaces

Supplementary Information The online version contains supplementary material available at [https://doi.org/10.1007/978-981-19-5248-7_15].

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15.2 Indications and Contraindications

The indications for this procedure are: primary ventral hernias, incisional ventral hernias, and also complex incisional hernias with multiple site defects [3].

The eTEP is contraindicated in cases with mesh infection, entero-cutaneous fistula, loss of domain, and ulcerated skin [4]. A recurrence after a previous retro-muscular repair can also be considered a relative contraindication of this procedure.

The width of the defect is another subject of discussion regarding the contraindications. Depending on the compliance of the abdominal wall (with or without preoperative preparation with botulinum toxin), eTEP is efficient even in closing defects larger than 15 cm width [5].

Also, morbid obesity, uncontrolled diabetes mellitus, and active smoking are contraindications, in general [2].

15.2.1 Instruments

In the eTEP procedure, I use regular laparoscopic instruments (trocars 5 and 10 mm, 30-degree scope, graspers, hook monopolar cautery, scissors, needle-driver) and some specific instruments (balloon trocar or optic port, advanced energy devices as Harmonic or Ligasure grasper).

15.2.2 Position of the Patient

The bed is flexed up to 30 degrees. In this position, the distance between the iliac crest and the costal margin is increased allowing an optimal ports placement. Also, it avoids the conflict between the surgeon's hands and the patient's thighs (Fig. 15.2).

A Foley catheter can be useful, especially during a long time surgery and/or if the hernia is located in the inferior part of the abdomen (M4, M5).

The procedure is performed under general anesthesia with good muscular relaxation.

Fig. 15.2 Position of the patient

15.2.3 Team Setup

The right-handed surgeon sits on the left of the patient if the hernia is situated in the lower part of the abdomen, and on the right side of the patient if the hernia is located in the upper part of the abdomen respectively; conversely, the assistant sits on the opposite side to the surgeon.

15.2.4 Key Steps

15.2.4.1 For Hernias Located in the Lower Part of the Abdomen

The crossing over of linea alba is performed above the umbilicus, in front of the falciform ligament, connecting both retrorectus spaces in the epigastrium (Fig. 15.3).

The first step is the development of the left retrorectus space.

- An optic port is placed just below the left costal margin, penetrating the subcutaneous tissue, the anterior rectus sheath, and the rectus muscle to reach the retrorectus space. This space is dissected gently, using the scope; the insufflator is connected for the beginning, and the pressure of insufflation is set to 15 mmHg, high flow.

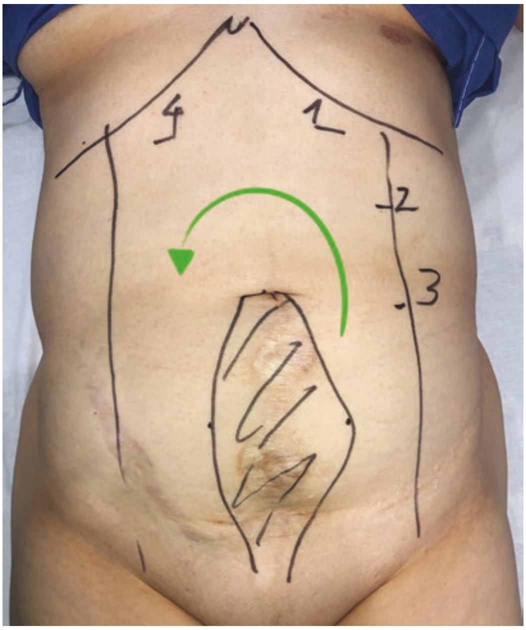


Fig. 15.3 Ports placement and planning to cross over the midline in hernia located in the lower part of the abdomen

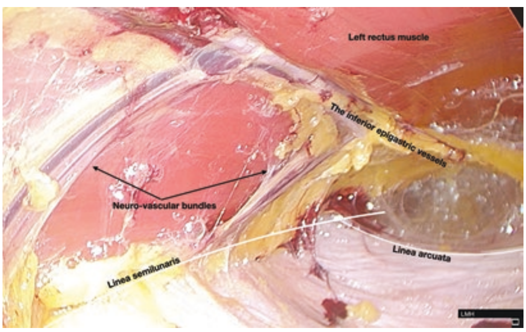


Fig. 15.4 Development of the left retrorectus space

It is necessary to identify and protect some anatomical structures: the inferior epigastric vessels, and the last six pairs of intercostal neurovascular bundles (Fig. 15.4).

– The second and the third ports are placed under direct vision, medially to the linea semilunaris.

The scope is moved to the left lower trocar, and a monopolar cautery hook is placed through the left upper trocar.

The next step is the incision of the medial aspect of the left posterior rectus sheath (PRS) (Fig. 15.5).

The crossing over of the midline is performed by dissecting the fatty tissue anterior to the falciform ligament (called the “fatty triangle”) without penetrating the peritoneal cavity. It is very important to identify the contralateral PRS, to maintain the integrity of linea alba.

– The contralateral (right) PRS is cut just lateral to the linea alba, and the right retrorectus space is dissected gently as wide as possible (Fig. 15.6).
– The fourth port (to be used for camera port subsequently) is placed just below the right costal margin.

At this point, the team setup is changed: the surgeon sits on the left of the patient, using the upper left trocars, and the assistant handles the camera placed on the right-side port.

– The retro-muscular dissection progresses from cranial to caudal, between the semilunar

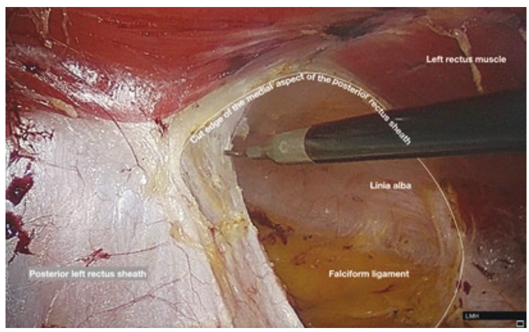


Fig. 15.5 Cutting the medial aspect of the posterior rectus sheath

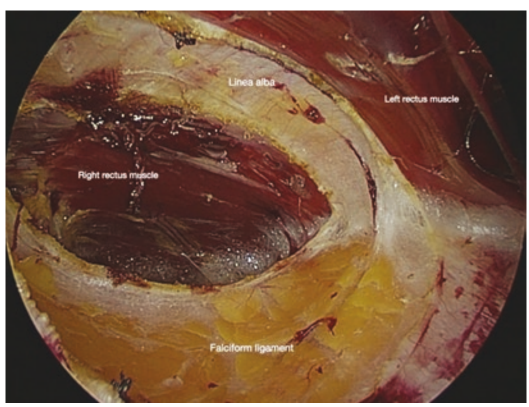


Fig. 15.6 Cross over the midline

lines. The connection of both retrorectus spaces, cutting the medial aspects of the PRSs, creates a common retro-muscular compartment [6] (Fig. 15.7).

– The medial aspects of the PRSs become the edges of the defect. While approaching the hernia neck, the PRS with the hernia sac resembles the edges of a volcano. The edges on both sides with the intervening yellow falciform ligament and hernia content resemble an erupting volcano—“volcano sign” (Fig. 15.8)

The contents of the hernia are gently reduced. In incarcerated hernias, it is necessary to cut the hernia ring. Often, this involves opening the peritoneal cavity with a small incision to check the contents of the hernia sac, reduce them, and perform adhesiolysis.

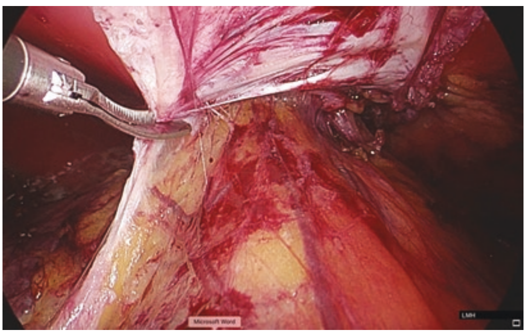


Fig. 15.7 Connection of retrorectus spaces cutting the medial edges of posterior rectus sheaths

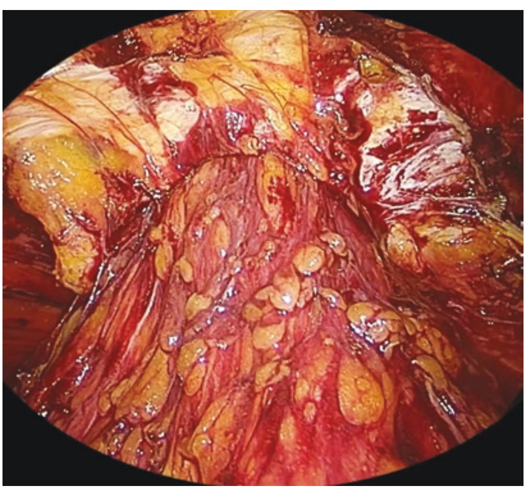


Fig. 15.8 Hernia neck—“volcano sign”

During this phase, the eTEP becomes a laparoscopic procedure. In incisional hernias, the penetration into the peritoneal cavity occurs more frequently due to the scar on the hernia neck. However, in my experience, the risk of bowel injury is not higher than in classical laparoscopic ventral hernia repair (IPOM). This is because there is always a small transparent area of the peritoneum that can be found to enter the abdominal cavity and check the content of the hernia sac and/or the adhesions, and perform adhesiolysis if necessary. Then, the hernia contents are reduced under direct vision.

– Measurement of the defect.

After the hernia content is reduced, it is necessary to measure the dimensions of the defect—the width and the length. This should be done at a lower intra-abdominal pressure of 6 mmHg. After measurement of the defect, we can decide the necessity of TAR using Carbonell’s algorithm:

“When the width of the defect closely approximates or exceeds two times the rectus widths, TAR is needed” [7] (Fig. 15.9).

15.2.4.2 For Hernias Located in the Upper Part of the Abdomen

Unlike the superior crossover in lower midline hernias, in upper midline hernias the crossing over of linea alba is performed below the umbilicus, anterior to the fat of the umbilical ligament [5] (Fig. 15.10).

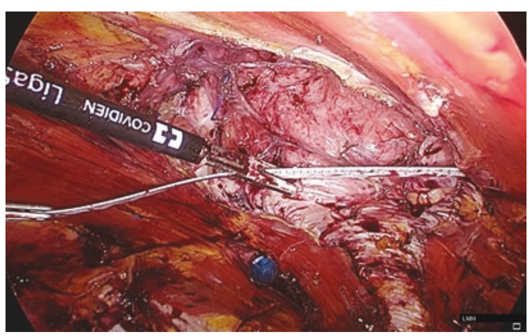


Fig. 15.9 Measurement of the defect

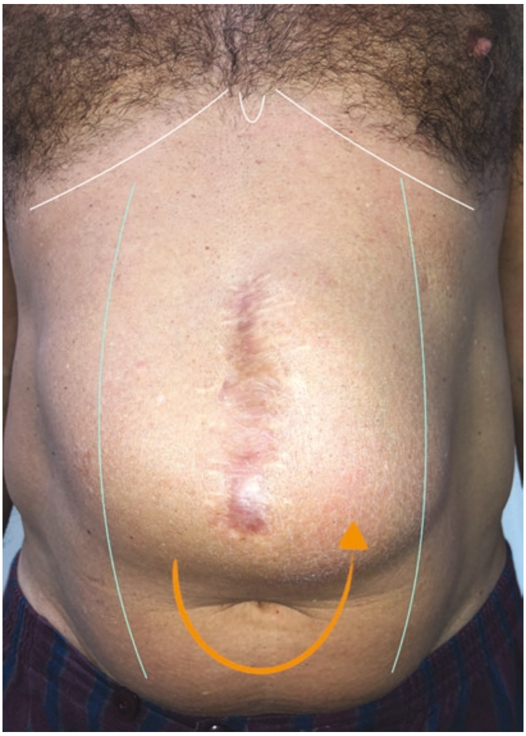


Fig. 15.10 Planning to cross over the midline in hernia located in the upper part of the abdomen

The first step is to develop the right retrorectus space. An optic port is placed through the right rectus muscle above the level of the umbilicus penetrating the subcutaneous tissue, the anterior rectus sheath, and the right rectus muscle into the retrorectus space. This space is dissected in the same manner as described on the left side.

– The second and the third ports are placed under direct vision, medial to the linea semilunaris at the level of linea arcuate (Fig. 15.11).

  The dissection progresses caudally, toward the Retzius space, and medially, crossing over the midline, anterior to the umbilical ligament. The fourth port—for the scope—is placed in the left lower quadrant
– Connection of both retrorectus spaces is realized by cutting the medial aspects of the posterior rectus sheaths and the retro-muscular dissection progresses from caudal to cranial, between both semilunaris lines, and creating a common retro-muscular compartment as described before (Fig. 15.12).

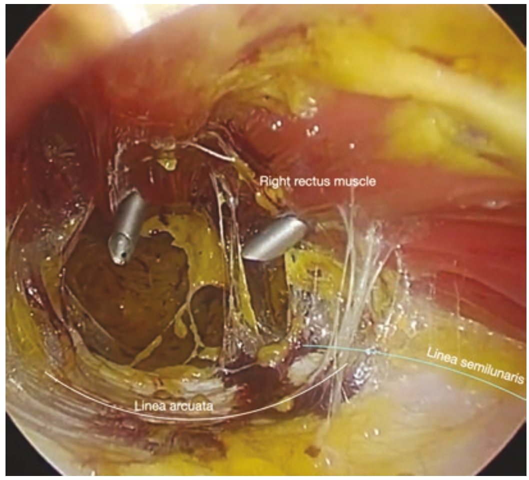


Fig. 15.11 Ports placement to cross over the midline in hernia located in the upper part of the abdomen

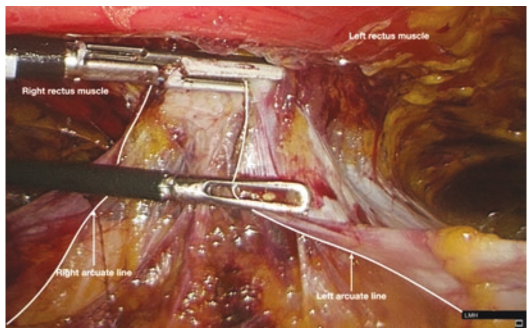
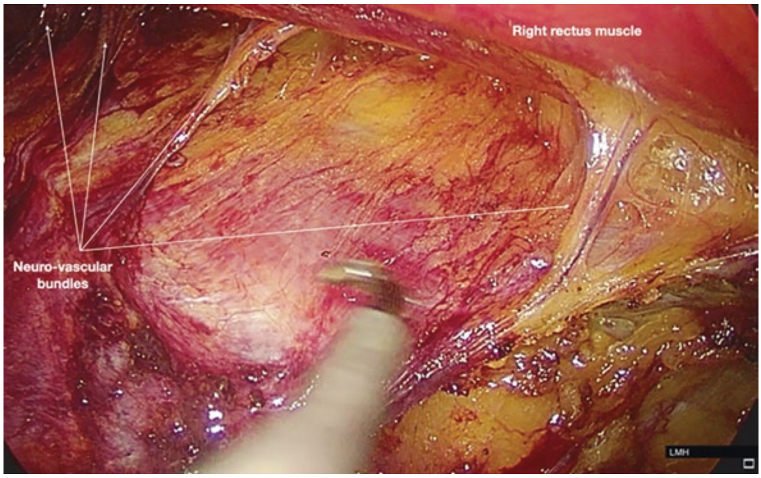


Fig. 15.12 Connection of the retrorectus spaces from caudal to cranial

15.3 Transversus Abdominis Release (TAR)

One of the advantages of the eTEP approach is that the retro-muscular dissection can be enlarged laterally to the linea semilunaris by performing TAR. This decision can be done during the surgery, without any preoperative preparation.

Fig. 15.13 Landmarks of right TAR



Before describing how the TAR is performed laparoscopically, it is necessary to highlight some anatomical details/landmarks. The neurovascular bundles must be recognized and protected. The incision for the TAR on the PRS will be placed medially to the linea semilunaris, at least 5 mm medially to the nerves. For the right-handed surgeon, it is easier to perform TAR on the right side from cranial to caudal (Novitsky way) [2] (Fig. 15.13).

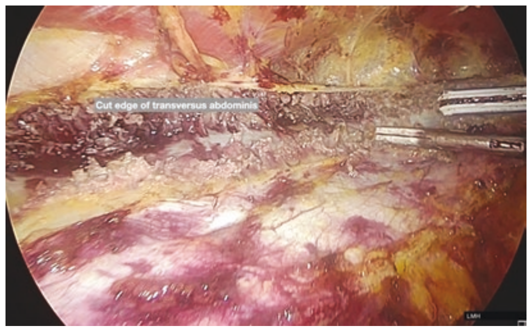


Fig. 15.14 Right TAR

15.4 Division of the Transversus Abdominis

After the posterior lamella of the internal oblique muscle is incised, the transversus abdominis muscle belly is visible which is then cut. Then the release is carried down caudally till the arcuate line is reached. This gives a good release of the fascial flap (Fig. 15.14).

15.5 Development of the Pre-transversalis/ Retro-Muscular Space

The pretransversalis space is developed as lateral as possible and also as cranial as necessary to obtain a large overlap of the defect, depending on the hernia location.

It is important to be sure that the dissection progresses in the correct anatomical plane. One way of being sure of this is to ensure that there are no muscular fibers on the "floor." Also, it is important to know that the diaphragm is located in the same anatomical plane as the transversus abdominis; the bundery between them is represented by a thin fatty tissue—the "yellow line," a constant landmark. In this anatomical plane, the dissection can be enlarged cranially up to the central tendon of the diaphragm, when a subxiphoid hernia is repaired (Fig. 15.15).

TAR on the left side is performed starting from caudal to cranial (bottom-up).

First, the landmarks—linea semilunaris and the neurovascular bundles—are identified.

The TAR begins from the arcuate line, by incising the posterior lamella of the internal oblique and then the transversus abdominis. The retro-muscular dissection is performed similarly as described on the right side (Figs. 15.16 and 15.17).

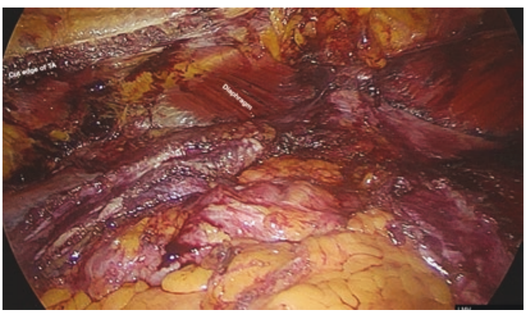


Fig. 15.15 TAR. Retro-muscular dissection

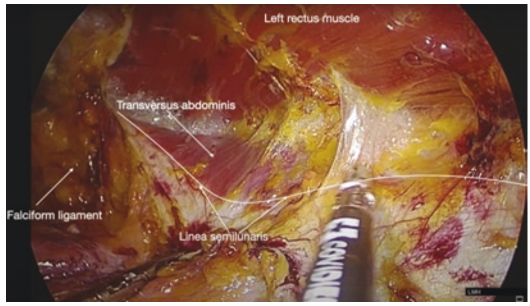


Fig. 15.16 Landmarks for the left TAR

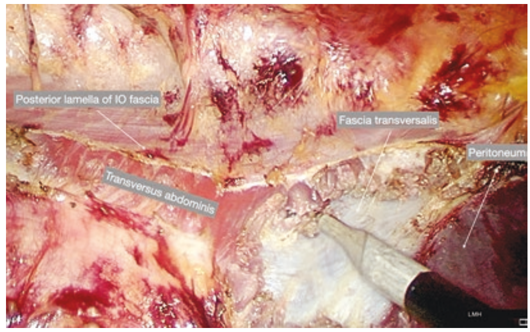


Fig. 15.17 Left TAR

15.6 Closure of the Posterior Layer

This is performed using an absorbable barbed suture 2/0.

The Achilles heel of this procedure is the tension in the suture line of the posterior layer. If this closure is under tension, it may result in a rupture and occurrence of a postoperative intraparietal hernia [8] (Fig. 15.18). Therefore, achieving a tension-free closure of the posterior fascia is crucial to a successful procedure.

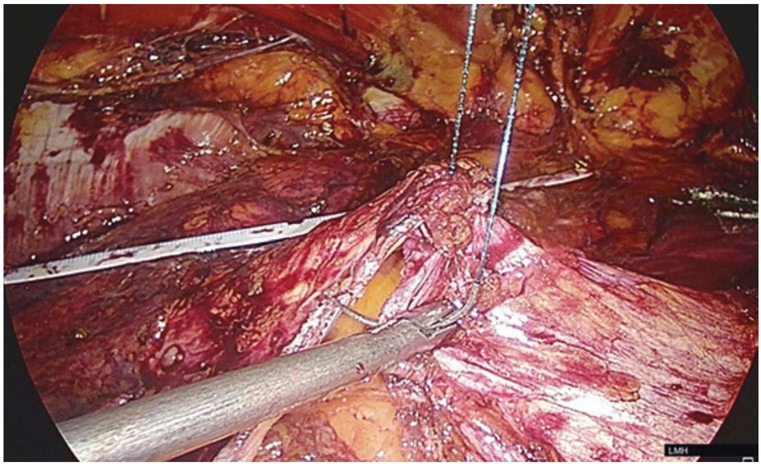


Fig. 15.18 Closing of the posterior layer

15.7 Restoration of the Linea Alba

This is performed next using a nonabsorbable barbed suture 0 or 1/0. This suture should also incorporate bites on the pseudosac so as to avoid a dead space that might lead to postoperative seroma formation (Fig. 15.19).

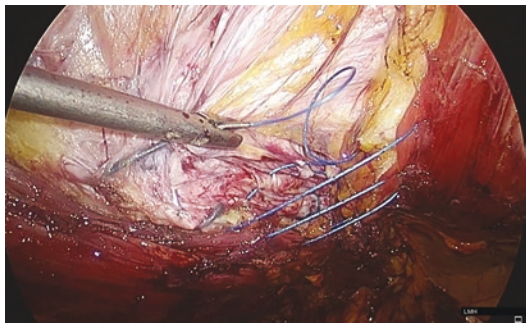


Fig. 15.19 Restoration of the linea alba

15.8 Mesh Placement

A medium-weight, macroporous polypropylene mesh is placed into the retro-muscular space, tailored to the entire dissected area after its measurement. If the defect is correctly closed and the landing zone for the mesh is large enough to ensure a correct overlapping of the defect, it is not necessary to fix the mesh (Fig. 15.20).

The hemostasis must be as perfect as possible. Even at the expense of spending some extra time, the operative field should be clean and dry. It is not necessary to place drains if meticulous hemostasis has been obtained.

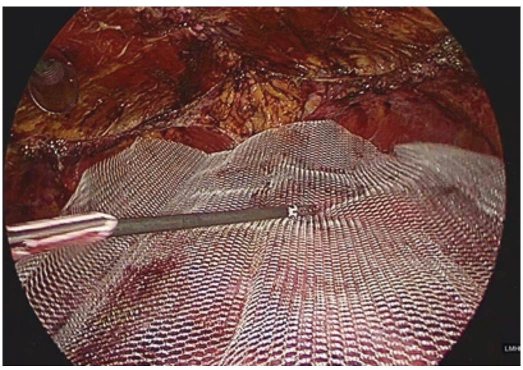


Fig. 15.20 Mesh placement

15.9 Complications and Management

– Injury of linea alba may happen during the crossing over. This should be detected intraoperatively, sutured, and/or covered with the mesh. Failure to do this entails a high risk of recurrence.
– Postoperative intraparietal hernia is due to the rupture of the posterior layer. It occurs when the posterior layer is sutured under tension. Once this occurs in the postoperative period, patients usually present with features of intestinal obstruction. It is managed frequently with redo laparoscopic surgery.
– Retro-muscular hematoma. The Rives-Stoppa space is very well vascularised and hematomas can be a side effect. Meticulous hemostasis is the key to prevention, and treatment may involve reexploration.

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16 Enhanced View Totally Extraperitoneal (eTEP) Repair for Iliac Fossa and Lumbar Hernias

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16.1 Introduction

Laparoscopic repair of ventral hernia has gained widespread acceptance among surgeons as well as patients worldwide for the various benefits it has to offer. Intraperitoneal onlay mesh repair is the most commonly performed laparoscopic ventral hernia repair with good long-term outcomes [1]. However, placing the mesh within the peritoneal cavity predisposes to troublesome adhesion formation which has not been eliminated despite the use of composite meshes. Also, it is evident from studies that retrorectus placement of mesh has biomechanical advantages of distributing the intra-abdominal pressure on the mesh and tightly securing it thereby preventing mesh migration and hernia recurrence [2].

The enhanced view totally extraperitoneal (eTEP) repair of ventral hernia is the endoscopic adaptation of Rives-Stoppa technique of retrorectus mesh placement. This technique was initially described for repairing large inguinal hernias and was later utilized for repairing midline ventral hernias [3, 4]. With growing experience in performing endoscopic component separation, surgeons have extended the indications of eTEP for tackling more complex and atypical hernias including iliac fossa and lumbar hernias. In this chapter, we will discuss our technique of eTEP for iliac fossa and lumbar hernias.

16.2 Preoperative Preparation

A thorough preoperative evaluation is needed for successfully managing atypical hernias. CT scan of the abdomen and pelvis is a useful tool to define the anatomy of the hernia, its contents, and relationship to surrounding structures. As with the repair of any incisional hernias, patients who smoke should be encouraged to stop smoking for at least 4 weeks before the planned procedure. Cigarette smoking decreases tissue oxygenation and impairs wound healing [5]. Strict glycemic control is another important component of preoperative preparation. Ideally, the HbA1c levels should be below 7% in the preoperative period and perioperative blood glucose levels should be tightly regulated to minimize surgical site infections (SSI). A systematic review of surgical repairs of incisional hernia identified wound infection as the most important cause of hernia recurrence [6]. For elective hernia repairs, obese patients should be encouraged to lose weight as morbid obesity is a risk factor for recurrence.

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16.3 eTEP with TAR for Iliac Fossa Hernias

16.3.1 Patient Position and Team Setup

Patient is placed in supine position with both arms tucked. The monitor is placed at the foot end of the patient. The surgeon initially stands on the side opposite to the hernia.

16.3.2 Operative Procedure

A 12 mm incision is placed about 2.5 cm above and lateral to the umbilicus on the side opposite to the hernia. Using optical trocar (ENDOPATH XCEL® Trocars with OPTIVIEW®, Ethicon) and 10 mm zero-degree telescope the retrorectus space is entered. Carbon dioxide insufflation is started at an insufflation pressure of 12 mmHg once the trocar is in the retrorectus plane (Fig. 16.1). The retrorectus space is dissected by telescopic dissection to facilitate the placement of working ports (Figs. 16.2 and 16.3). A 10 mm port is placed 5 cm below the camera port at the level of semilunar line. Further dissection is carried out using monopolar electrocautery with a hook or scissors. The dissection is carried out as inferiorly as possible and a 5 mm port is placed about 5 cm below the 10 mm port (Figs. 16.4 and 16.5). The camera is then shifted to the 10 mm port and the other two ports are used as working ports. The posterior rec-

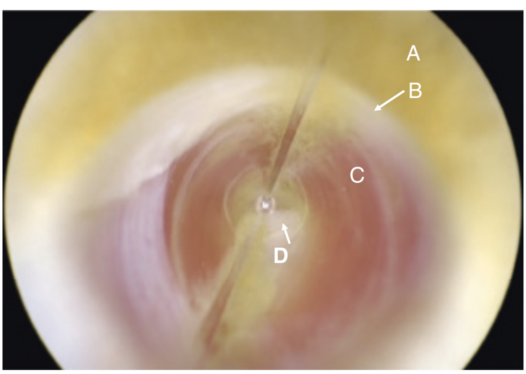

Fig. 16.1 Entry into the retrorectus plane with optiview trocar using 0 degree telescope. (A) Subcutaneous tissue. (B) Anterior rectus sheath. (C) Rectus muscle. (D) Posterior rectus sheath

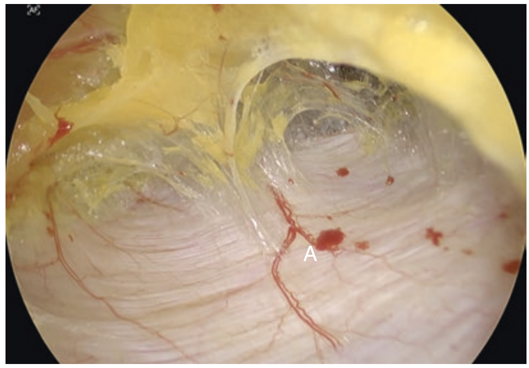

Fig. 16.2 Creation of retrorectus plane under vision by telescopic dissection. (A) Posterior rectus sheath

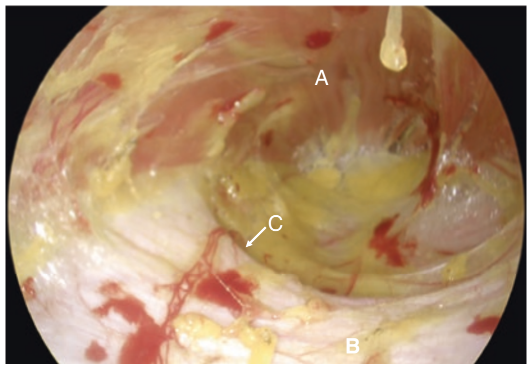

Fig. 16.3 Left retrorectus plane is created. (A) Posterior rectus sheath. (B) Rectus muscle. (C) Arcuate line

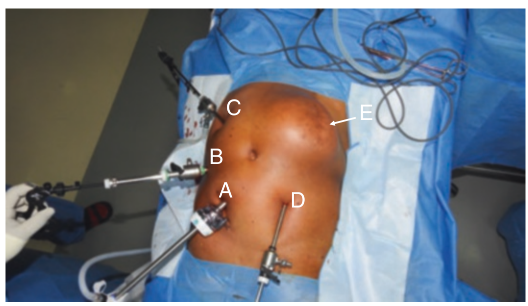

Fig. 16.4 Port position. (A) 10 mm port in the left of midline for camera and working. (B) 10 mm port in the left lumbar region for camera and working. (C) 5 mm port in the left iliac fossa for working. (D) 5 mm port in right subcostal region for working. (E) Right iliac fossa hernia

tus sheath (PRS) is incised about 5–7 mm below its medial attachment to the linea alba on the cranial side. This exposes the falciform ligament which is separated from the linea alba by blunt dissection (Fig. 16.6). Care should be taken to avoid injuring the linea alba. The opposite side PRS is identified by the color change due to the underlying rectus abdominis muscle and incision is made on it to enter the contralateral retrorectus space (Fig. 16.7). An additional 5 mm working port is placed in the subcostal region on the opposite side. The camera is then shifted to the optical trocar and utilizing the 10 mm port and the 5 mm subcostal port as the working ports, retrorectus space is created on the opposite side as well. The surgeon stands at the head end of the patient for infra umbilical retrorectus dissection [7] (Fig. 16.8).

A survey of the hernial defect can be done through the midline opening in the PRS. Adhesiolysis can be done and hernial contents can be reduced through the opening (Figs. 16.9, 16.10, and 16.11) and sac excision/division is done (Figs. 16.12, 16.13, and 16.14).

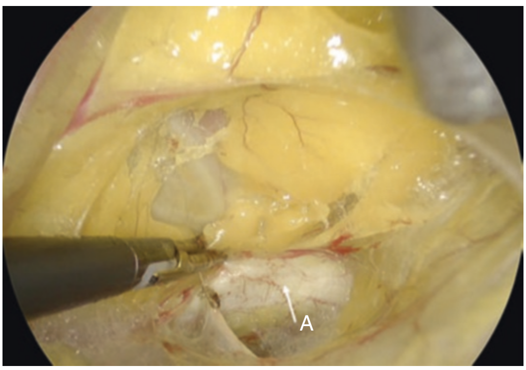

Fig. 16.5 Dissection in the space of Retzius, pubic bone exposed. (A) Symphysis pubis

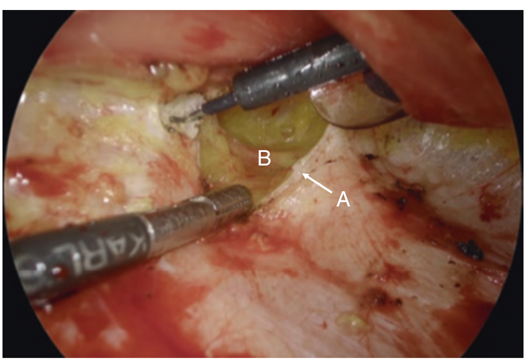

Fig. 16.6 Midline crossover by division of left posterior rectus sheath attachment from linea alba. (A) Left posterior rectus sheath. (B) Falciform ligament

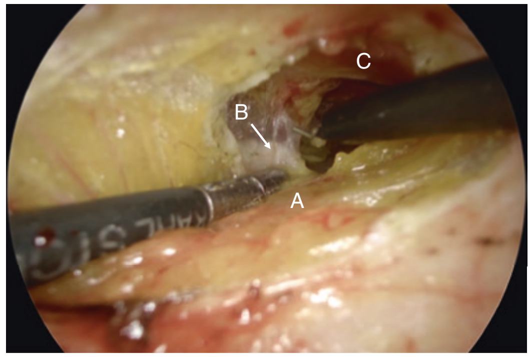

Fig. 16.7 Entry into the right retrorectus plane by division of right posterior rectus sheath. (A) Falciform ligament. (B) Right posterior rectus sheath. (C) Right rectus muscle

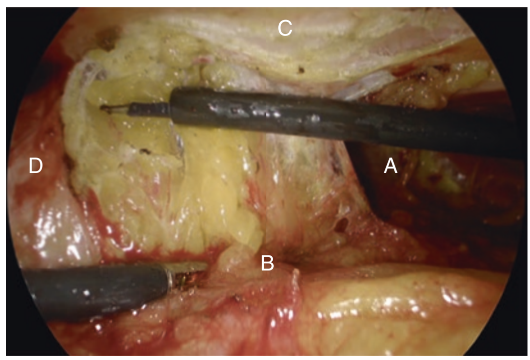

Fig. 16.8 Midline dissection. (A) Right retrorectus space. (B) Falciform ligament. (C) Linea alba. (D) Left posterior rectus sheath

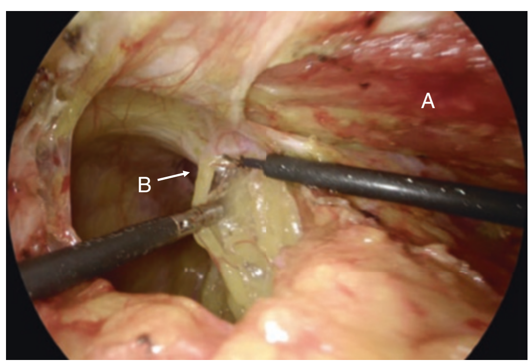

Fig. 16.9 Adhesilolysis of omentum from the defect transabdominally. (A) Right rectus sheath. (B) Defect

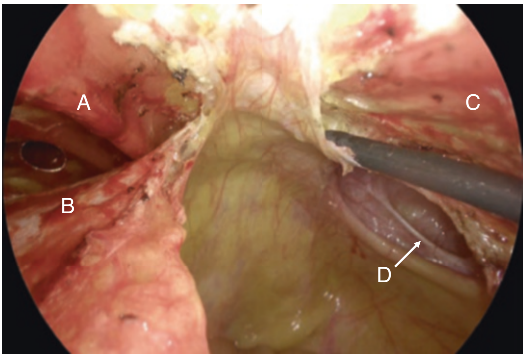

Fig. 16.10 Retrorectus plane created till the level of defect on the right side. (A) Left rectus muscle. (B) Left posterior rectus sheath. (C) Right rectus muscle. (D) Defect

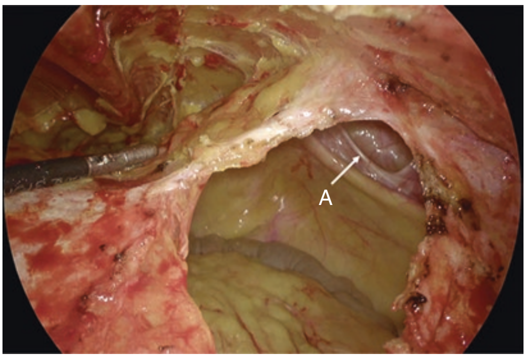

Fig. 16.11 Retrorectus space created all around the defect. (A) Defect

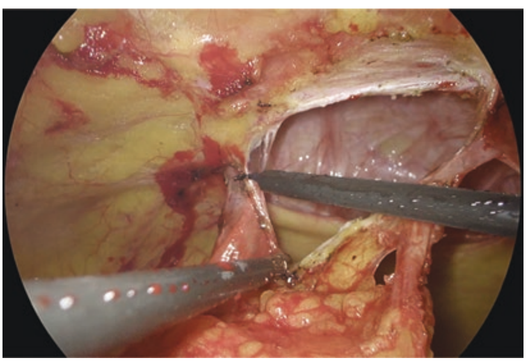

Fig. 16.12 Dissection of posterior layer of transversals fascia and the peritoneum from the defect

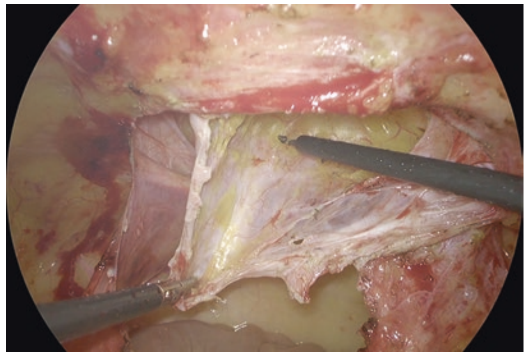

Fig. 16.13 Dissection of sac

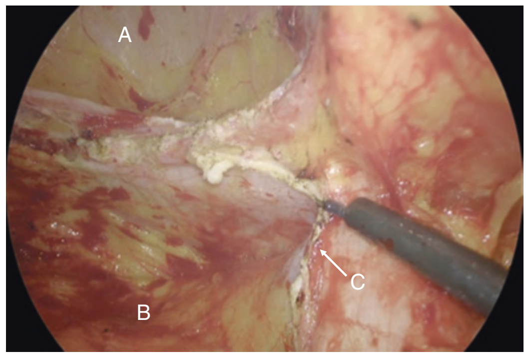

Fig. 16.14 Completion of dissection, peritoneum is mobilized well below the defect. (A) Defect. (B) Posterior layer of transversalis fascia. (C) Arcuate line

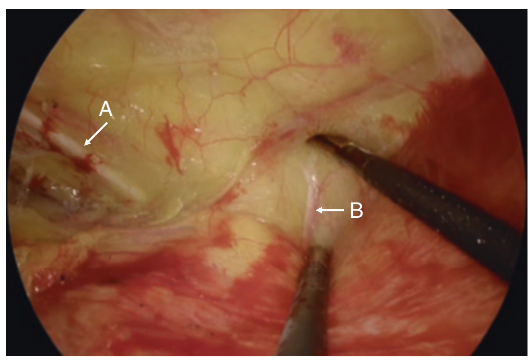

Fig. 16.15 Right Bogras space is being dissected. (A) Right pubic bone. (B) Round ligament

The focus is again shifted to the extraperitoneal space. Inferiorly the preperitoneal spaces of Retzius and Bogros are dissected (Fig. 16.15). The spermatic cord structures are parietalized in male patients while the round ligament can be divided in female patients. TAR is done by incising the posterior lamella of internal oblique and then the transversus abdominis muscle to enter

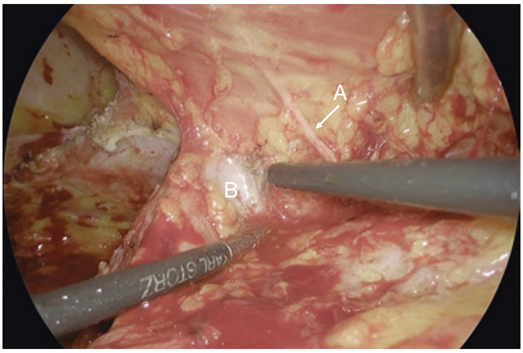

Fig. 16.16 Release of posterior rectus sheath from the linea semilunaris. (A) Neurovascular bundle. (B) Posterior rectus sheath

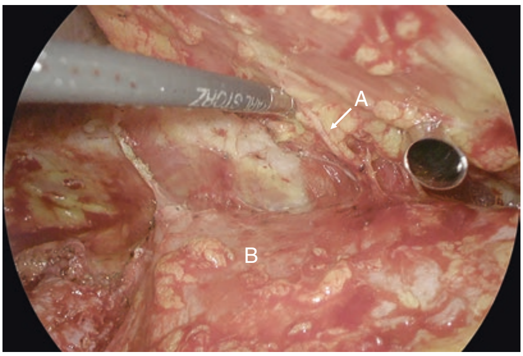

Fig. 16.17 Posterior rectus sheath is released from the linea semilunaris. (A) Neurovascular bundle. (B) Posterior rectus sheath

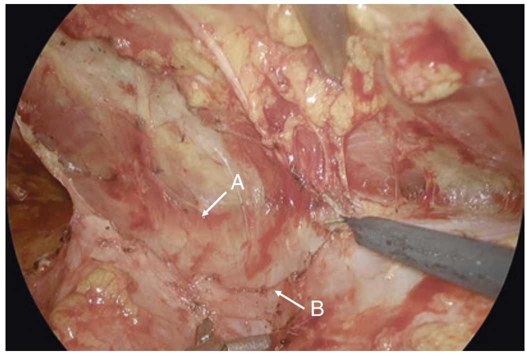

Fig. 16.18 TA muscle is exposed after PRS release. (A) TA Muscle. (B) PRS release site

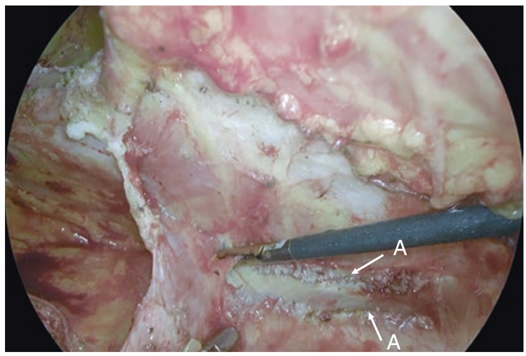

Fig. 16.19 TAR is being done using Alan vessel sealing device. (A) Divided edge of TA muscle

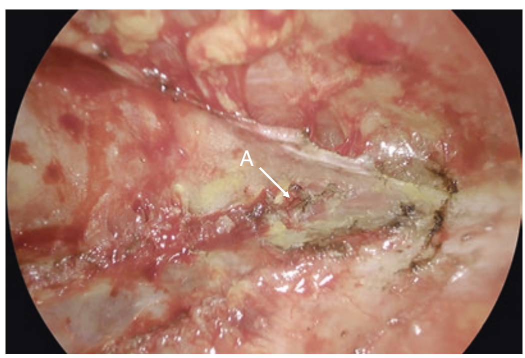

Fig. 16.20 TAR is extended cranially. (A) Divided TA muscle

the pre-transversalis plane, safeguarding the neurovascular bundles. Initially, TAR is done near the hernial defect and then continued cranially (Figs. 16.14, 16.16, 16.17, and 16.18). Lateral to the linea semilunaris, the hernial defect is identified and delineated. The hernia sac is dissected but preserved to bridge any gaps in the PRS or peritoneum. Further dissection is done all around the defect area to create a wide space for placement of the mesh.

Transversus abdominis release (TAR) is an integral component of eTEP repair for all iliac fossa hernias. Transversus abdominis muscle can easily be identified by the transversely oriented fibers just lateral to linea semilunaris. TAR is done by dividing the transversus abdominis muscle along its entire length using monopolar electrocautery or harmonic shears in cranial to caudal direction (Figs. 16.19 and 16.20). This is facilitated by creating space between the transversus abdominis muscle and transversalis fascia by blunt dissection.

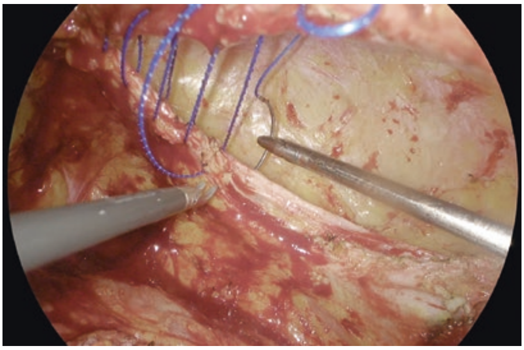

Fig. 16.21 Suturing of the defect using Vloc PBT

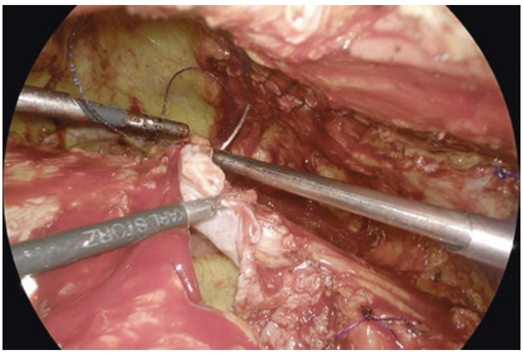

Fig. 16.22 PRS closure using 0 VLoc PDS

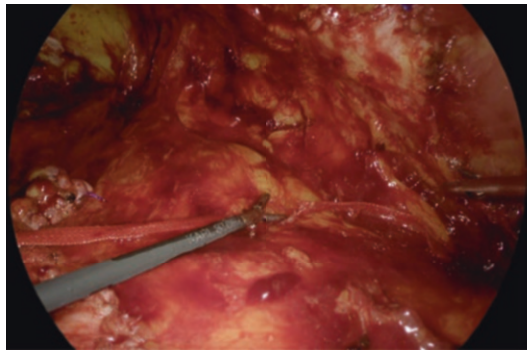

Fig. 16.23 Cotton tape is being used to measure the dissected area

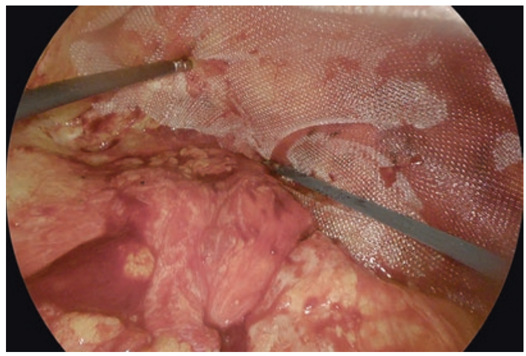

Fig. 16.24 Polypropylene mesh is placed to cover the dissected area

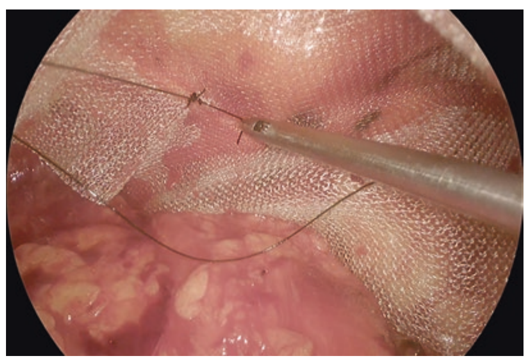

Fig. 16.25 Mesh is fixed to the right cooper's ligament

The hernial defect is closed using V-Loc™ PBT nonabsorbable wound closure device No. 1 (Covidien™) (Fig. 16.21). The posterior rectus sheath is closed with V-Loc™ PDS 0 absorbable wound closure device (Covidien™) (Fig. 16.22). The hernial sac which was preserved can be utilized to bridge any defects in the PRS or peritoneum. The linea alba is reconstituted using V-Loc™ PBT nonabsorbable wound closure device No. 1 (Covidien™). The dissected space is measured using an umbilical cotton tape (Fig. 16.23) and an appropriate sized medium weight macroporous polypropylene mesh is placed. The mesh is fixed to the Cooper's ligament and the parietal wall anteriorly, laterally as well as posteriorly using polypropylene 0 sutures (Figs. 16.24 and 16.25). A vacuum suction drain can be selectively placed if the dissected space is very large. Pneumo is then deflated under vision. All ports 10 mm and wider are closed with transfascial sutures (Fig. 16.26). The port sites are closed using Vicryl 3-0 subcuticular sutures.

16.4 Unique Features of eTEP for Iliac Fossa Hernias

- Creation of retrorectus space is fairly straightforward in case of iliac fossa hernias. The hernial defect is only visible after releasing the PRS from linea semilunaris.
- The preperitoneal space of Retzius and Bogros are routinely dissected for iliac fossa hernias to ensure adequate mesh coverage of the defect.
- TAR is invariably required for the repair of iliac fossa hernias. So competence in doing TAR is a prerequisite for eTEP repair of iliac fossa hernias.
- Unlike eTEP for midline hernias where the mesh is placed on the floor of the dissected space, for iliac fossa hernias, the mesh is fixed to the Cooper's ligament and to the anterior, lateral, and posterior aspect of roof of the dissected space.

16.5 Flank Hernias

Lumbar hernia lie between iliac crest and costal margin. They can be congenital or acquired. Congenital lumbar hernias present during early childhood and are much less common than the acquired variant. Acquired lumbar hernias can be primary or secondary. Secondary lumbar hernias occur following trauma or surgeries on the flank.

Congenital lumbar hernias can occur through superior or inferior lumbar triangles, two potential sites of weakness in the flank. The superior lumbar triangle (Grynfeltt) is bounded superiorly by the 12th rib, medially by quadratus lumborum, and laterally by the posterior border of the internal oblique muscle. The floor is formed by transversalis fascia [8]. The inferior lumbar triangle (Petit) is bounded by iliac crest inferiorly, latissimus dorsi posteriorly, and external oblique anteriorly. The floor of the triangle is formed by internal oblique muscle [8].

Lumbar hernia repairs are technically challenging due to the anatomical constraints of the region. The presence of bones both superiorly and inferiorly pose difficulties with proper mesh overlap and fixation. The repair can further be complicated by nerve injuries with resultant chronic pain and sensory disturbances.

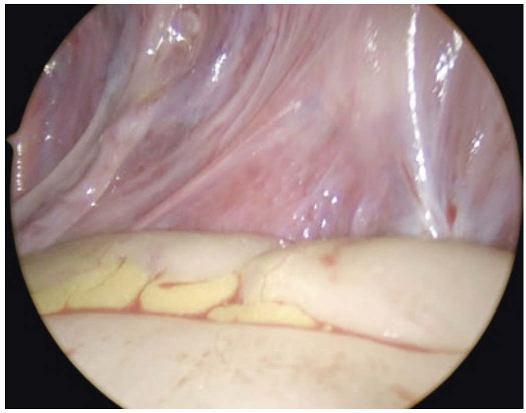

Fig. 16.26 Transabdominal view at the end of the procedure

16.6 eTEP for Lumbar Hernias

16.6.1 Patient Position and Team Setup

Patient is placed in supine position with both arms tucked. The monitor is placed on the side of the hernia. The surgeon stands on the side opposite to the hernia.

16.6.2 Operative Procedure

For acquired lumbar hernias the ports are placed close to the midline on the same side of the hernia. The retrorectus space is created only on the side of the hernia. The PRS is released close to the linea semilunaris as described for eTEP for iliac fossa hernias. TAR is performed in a cranial to caudal direction as described previously. This is followed by posterior component separation which involves gentle swiping of the transversalis fascia away from the transversus abdominis muscle towards the peritoneum taking care to avoid rents in the peritoneum. The dissection is continued laterally and posteriorly delineating the hernial defect. The dissection is carried further posteriorly as far as the psoas major muscle to ensure adequate mesh overlap all around the hernial defect. The hernial sac is then excised followed by the closure of the defect using V-Loc™ PBT nonabsorbable wound closure device No. 1 (Covidien™). Any defects in the peritoneum are also closed using PDS 3-0 sutures to prevent direct contact of bowel with the mesh. The dissected space is measured using umbilical cotton tape and an appropriate-sized medium weight macroporous polypropylene mesh is placed. A vacuum suction drain can be placed if the dissected space is very large. Pneumo is then deflated under vision. The port sites are closed using Vicryl 3-0 subcuticular sutures (Figs. 16.27, 16.28, 16.29, 16.30, 16.31, 16.32, and 16.33).

For primary lumbar hernias, the technique can be modified by placing the optical view trocar

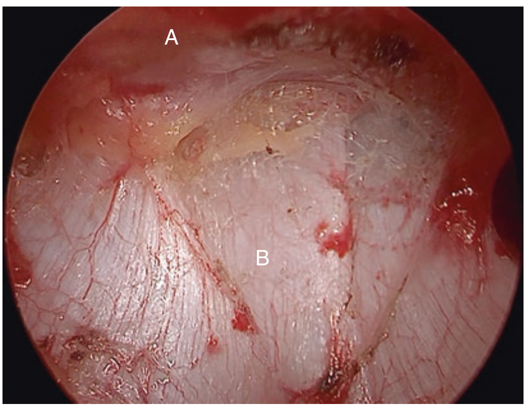

Fig. 16.27 Retrorectus space created on the side of hernia. (A) Rectus muscle. (B) PRS

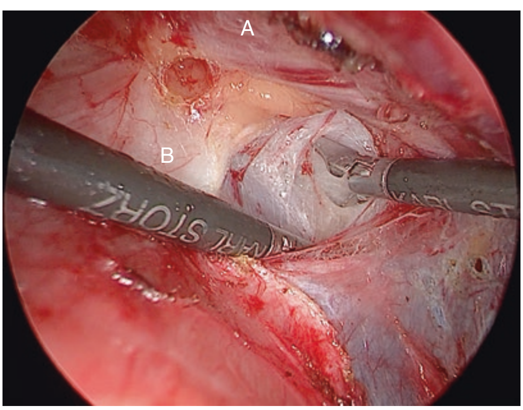

Fig. 16.28 PRS is released and lateral space entered. (A) Rectus muscle. (B) PRS

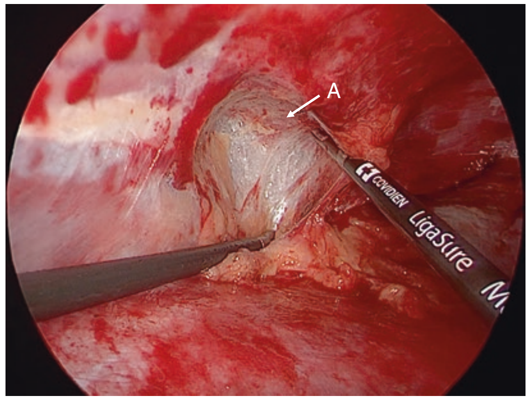

Fig. 16.29 Lateral dissection is continued and defect is reached. (A) Area of the defect

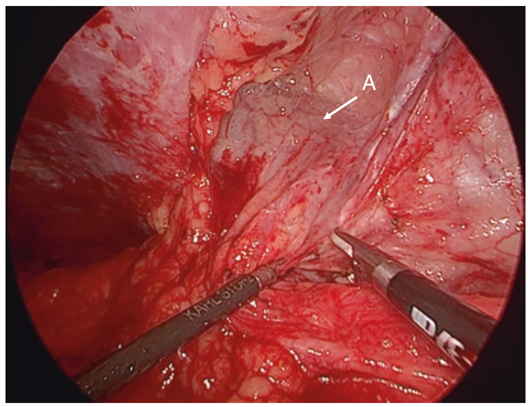

Fig. 16.30 Content and sac is mobilized. (A) Sac

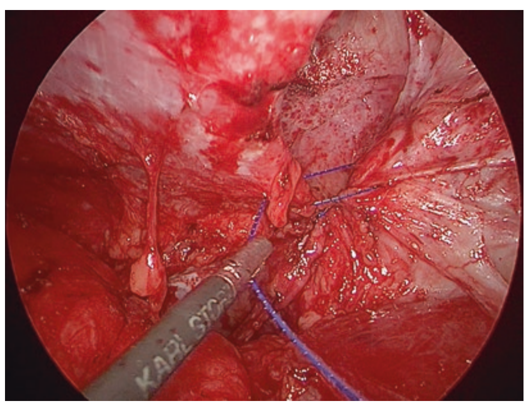

Fig. 16.31 Defect is closed using Vloc PBT

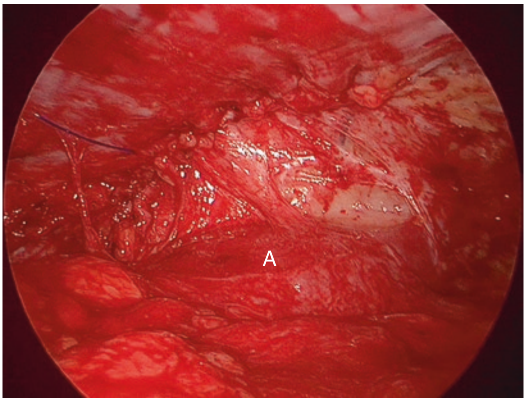

Fig. 16.32 Completion of defect closure. (A) Psoas muscle

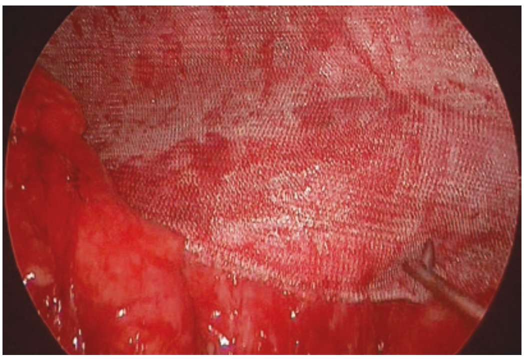

Fig. 16.33 Polypropylene mesh is placed

directly between transversus abdominis muscle and transversalis fascia lateral to the semilunar line. Subsequent steps are similar to that described previously for acquired lumbar hernia.

16.7 Discussion

Iliac fossa and lumbar hernias pose unique challenges to the hernia surgeon. To tackle these hernias, a sound knowledge of the anatomy of the lateral and posterior parietal wall is essential. The presence of bony structures on both the superior and inferior aspects can cause difficulties in mesh placement. For very large hernial defects, it may be necessary to dissect the space well above the costal margin to all the way below up to the pubic bone. Similarly, the dissection may have to be extended beyond the psoas major muscle posteriorly to facilitate tension-free closure of the hernial defect. Despite such extensive mobilizations it may at times still not be possible to close the defect. In such instances, the defect can be bridged with the help of a mesh. Such difficulties should be anticipated by preoperative imaging to avoid any intraoperative surprises.

Iliac fossa and lumbar hernias are relatively rare. Most of the reports in the available literature are case reports and case series that have adopted an open method of repair [9, 10]. Laparoscopic intraperitoneal mesh repair is the commonly reported minimal access technique for iliac fossa and lumbar hernias [11, 12]. Some surgeons have also utilized laparoscopic preperitoneal mesh repair for tackling such hernias [13, 14]. With only a small number of patients and retrospective nature of these studies it is difficult to derive definitive conclusions. With paucity of literature evidence, it is vital to adopt a pragmatic approach based on the individual patient characteristics for managing these complex hernias.

16.8 Conclusion

Iliac fossa and lumbar hernias can be successfully managed by eTEP approach. Proficiency in TAR and posterior component separation is essential for eTEP repair of iliac fossa and lumbar hernias. For obtaining optimum results such hernias should be repaired by experienced surgeons in high-volume centers.

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17 Enhanced View Totally Extraperitoneal (eTEP) Repair for Subxiphoid and Subcostal Hernias

Jenny Lee, Michael Sung, Teri Nguyen, and Rockson Liu

17.1 Introduction

Subxiphoid and subcostal hernias are considered atypical hernias. Both hernias are predominantly incisional hernias. Subxiphoid hernias are a specific type of hernia resulting from median sternotomies, with an incidence of 4.2% [1]. Subcostal hernias result from surgery to access the upper quadrants, mostly for hepatobiliary surgery, with an incidence between 4% and 20% [2]. Subxiphoid and subcostal hernias have in common location along the periphery of the abdominal wall, which presents challenges not typically found in more central abdominal incisional hernias.

These hernias have been challenging to repair with traditional laparoscopic and open techniques due to several factors. Recurrence rates for subxiphoid hernia repairs have been reported to be 80% with primary repair and between 2.2% and 30% with prosthetic reinforcement [3]. The recurrence rates for subcostal hernia repairs are not clear as recurrence rates for these hernias are frequently reported with other incisional hernias. Their location adjacent to bony prominences, such as the xiphoid process and ribs, as well as proximity to vital structures, including the diaphragm, pleura, and pericardium make mesh fixation difficult [4]. These factors have created difficulty in completing an optimal repair that achieves the fundamental principles of tension-free repair with well-fixated, well-overlapping sublay prosthetic reinforcement [1, 5]. The potential for a defect in the diaphragm—involving sternal and/or costal fibers—can lead to additional repair challenges, including pericardial and myocardial injuries.

Robot-assisted laparoscopic enhanced view Totally Extraperitoneal (eTEP) and Rives-Stoppa (RS) repair techniques combined with limited Transversus Abdominis Release (TAR) can help surmount these challenges [4–6].

The robotic platform provides surgeons the ability to work on the ceiling and at odd angles with improved ergonomics. The dexterity of the robot also allows more precise and efficient anterior defect closure. Magnification and fine instrument control allow for more precise dissection and application of hemostasis during dissection of the preperitoneal and retrorectus planes. The ability to develop large extraperitoneal pockets allows for the placement of larger pieces of mesh with wide mesh overlap and minimal need for fixation. This overcomes the traditional challenges of poor mesh overlap and poor fixation.

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One of the principal advantages of robotic hernia repair is the ease of opening multiple abdominal wall compartments to facilitate wide dissection and mesh overlap. Here we have schematically represented the abdominal compartments that can be developed and connected (Fig. 17.1). Thinking about the spaces that can be developed and connected is a good starting point when beginning to create an operative plan for atypical hernias with the robotic eTEP techniques.

This chapter describes our approach to repairing subxiphoid and subcostal hernias with a focus on robotic-assisted techniques with mesh placement in the retromuscular position. We will use the EHS hernia classification to describe these hernias. This chapter will focus heavily on anatomy and operative technique.

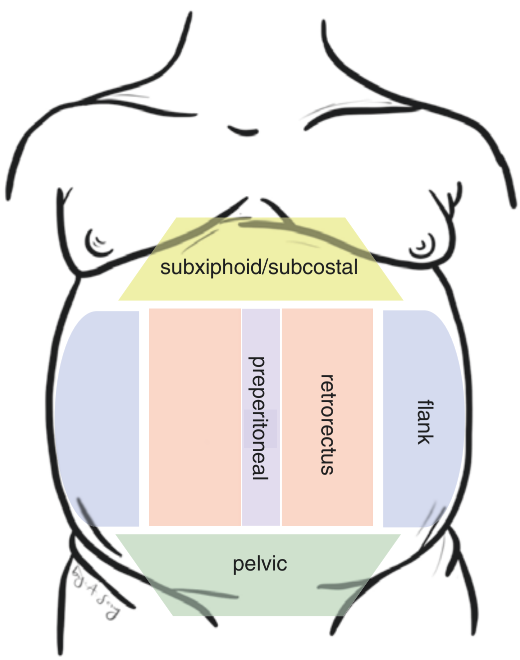

Fig. 17.1 Dissection planes accessible via robotic ventral hernia repair

More importantly, it will focus on a general framework on how to successfully approach these challenging hernias. This chapter focuses on hernias in the M1 (subxiphoid) and L1 (subcostal) locations.

17.2 European Hernia Society Hernia Classification System

We utilize the European Hernia Society abdominal wall hernia classification system in order to describe the length, width, and location of the hernia in a standardized fashion. Below is the classification schema.

- European Hernia Society midline abdominal wall hernia classification (Fig. 17.2a)
  - M1: subxiphoidal (from the xiphoid till 3 cm caudally)
  - M2: epigastric (from 3 cm below the xiphoid till 3 cm above the umbilicus)
  - M3: umbilical (from 3 cm above till 3 cm below the umbilicus)
  - M4: infraumbilical (from 3 cm below the umbilicus till 3 cm above the pubis)
  - M5: suprapubic (from pubic bone till 3 cm cranially)
- European Hernia Society lateral abdominal wall hernia classification (Fig. 17.2b)
  - L1: subcostal (between the costal margin and a horizontal line 3 cm above the umbilicus)
  - L2: flank (lateral to the rectus sheath in the area 3 cm above and below the umbilicus)
  - L3: iliac (between a horizontal line 3 cm below the umbilicus and the inguinal region)
  - L4: lumbar (laterodorsal of the anterior axillary line)

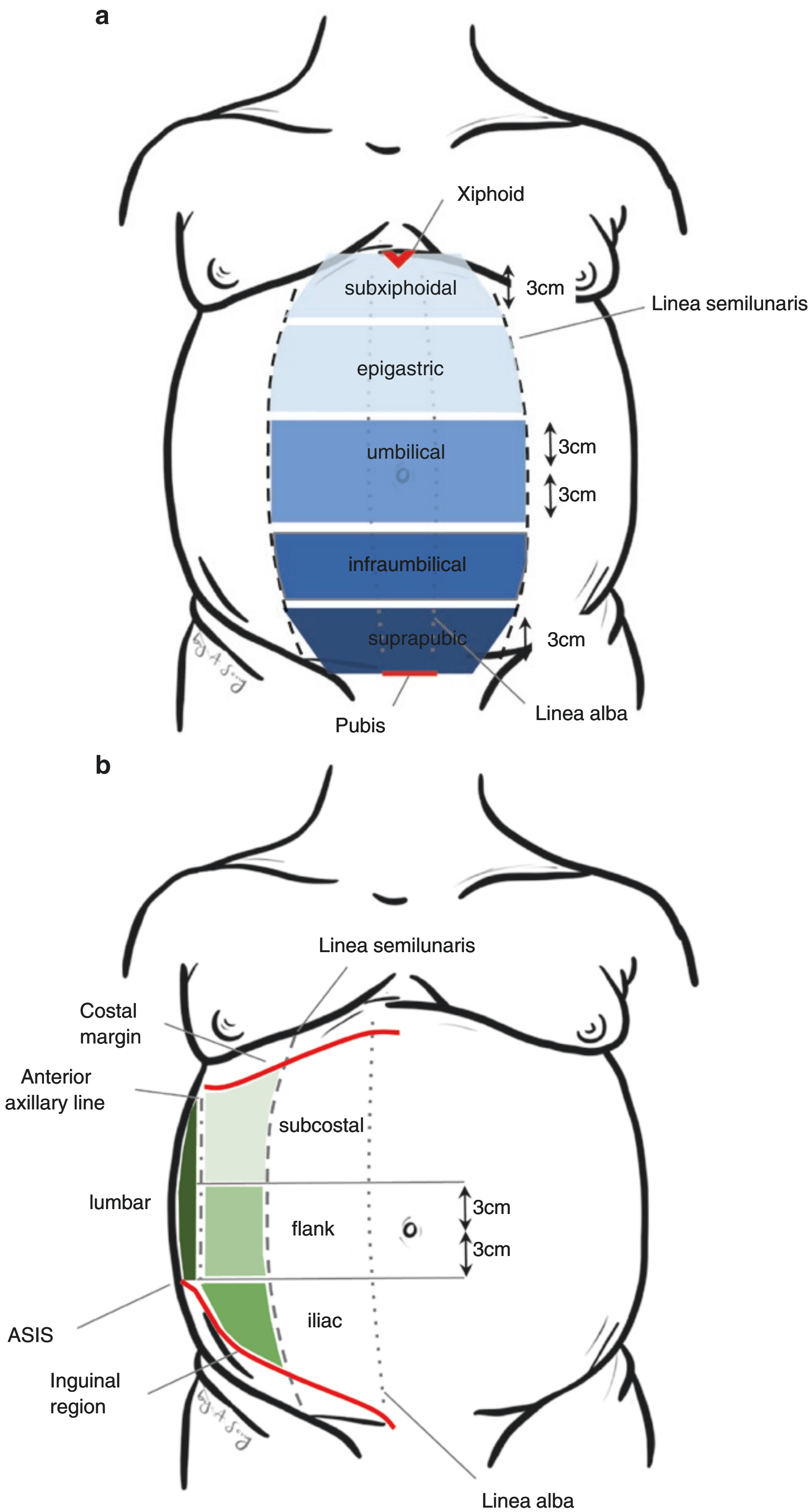

Fig. 17.2 (**a**) European Hernia Society midline abdominal wall hernia classification. (**b**) European Hernia Society lateral abdominal wall hernia classification

17.3 Indications and Case Selection

Subxiphoid and subcostal hernias often occur after prior incisions such as median sternotomy or subcostal incisions [4]. Patients may present with bulging and discomfort but rarely present with symptoms of incarceration, likely due to the presence of the liver [5, 6].

Preoperative imaging with a CT scan helps the surgeon in many ways. The width of the rectus muscle, a surrogate for the amount of retrorectus space available for port placement, can be accurately measured. The exact size of the defect can be measured. Once the hernia defects are evaluated and the amount of mesh overlap is determined, the dissection planes and spaces needed to be combined to fit the appropriately sized mesh can be identified. For example, a right subcostal hernia via an eTEP RS approach may require combining the right retrorectus space, right flank space, and right subdiaphragmatic space; it may require the opening of the left retrorectus space as well.

The authors use eTEP RS access for medium to large defects with potential for TAR. It is especially advantageous in patients with multiple prior abdominal operations to operate outside of the peritoneal cavity.

17.3.1 Contraindications

Absolute contraindications to eTEP and other minimally invasive hernia approaches are active mesh infection, loss of domain, and the presence of a fistula. Absolute contraindications specific to eTEP RS is a lack of available retrorectus space for port placement, such as after prior retrorectus mesh reconstruction. Relative contraindications to eTEP repair are patients who have incisions that extend from xiphoid to pubis as crossover to the contralateral space may be difficult, although in experienced hands this is not a contraindication [7].

17.3.2 Instruments and Energy Source

- Ultrasound to identify abdominal wall landmarks for entry.
- Zero-degree laparoscope for optical entry with an optical port that allows insufflation while the scope and obturator are still in the port.
- Xi Robot. Three 8 mm trocars.
- Left-hand instrument: Fenestrated bipolar or force bipolar grasper.
- Right-hand instrument: Monopolar curved scissor. Later a mega-suture cut needle driver is exchanged in the right hand.
- A 30-degree robot scope.

17.3.3 Team Setup, Anesthesia, and Position

- Team setup: Surgeon, assistant, OR nurse, scrub tech, and anesthesia team.
- Anesthesia: General anesthetic with ET tube.
- DVT Prophylaxis: Bilateral lower extremity sequential compression devices.
- Patient Position: Supine with appropriate padding. The arm on the port side is tucked. In patients with a short torso, the bed can be flexed to increase the length of the abdominal wall and avoid collision between robot ports and avoid instrument collision with the patient's thigh.
- Bed Position: Slight reverse Trendelenburg. For subcostal hernias, the bed should be tilted away from the side of the hernia to facilitate access to the posterolateral diaphragm and retroperitoneum.

17.3.4 Key Steps

- Ultrasound identification of landmarks including the linea semilunaris and linea alba.
- Bilateral TAP block under ultrasound guidance.

- Port placement and development of the retrorectus space with care not to enter the peritoneal cavity. Additional port placement and docking of the robot.
- Ipsilateral retrorectus dissection, crossover, and dissection of the preperitoneal space.
- Entry into the contralateral retrorectus space with transversus abdominis release if needed for wide mesh overlap.
- Reduction of the hernia sac and continuing dissection into both retrorectus spaces and preperitoneal space with division of the posterior rectus sheath at the costal margin to open the subdiaphragmatic space.
- Careful dissection of the transversalis fascia and peritoneum off the diaphragm.
- The extent of dissection should allow for mesh overlap of about 5 cm in all directions around the unclosed defect.
- Reconstruction with closure of anterior fascial defects and posterior peritoneal defects.
- Measurement of the extraperitoneal space and finally mesh placement.

17.3.5 Surgical Techniques/Variations

- Ultrasound identification of anatomic landmarks
  - Ultrasound is used to delineate the boundaries of the retrorectus space. Specifically, the linea semilunaris and linea alba are identified. A line is drawn with the skin marker to mark these landmarks externally for later identification. A bilateral TAP block is then performed. An echogenic needle and an Exparel solution consisting of 20 mL of Exparel, 30 mL of ¼% Marcaine, and 30 mL of saline are used to perform the TAP block. 20 mL of this solution is injected into each TAP plane between the internal oblique and the transversus abdominis muscle lateral to the linea semilunaris. A rectus sheath block is performed in the subcostal area with 15 mL of the Exparel solution on the contralateral side. The ipsilateral side is not injected as the Exparel solution can make optical entry difficult. The ipsilateral side is injected under direct vision along the linea semilunaris when the 5 mm optical trocar is being upsized to 8 mm.
- Port placement
  - The authors prefer to enter the left upper quadrant of the left retrorectus space in eTEP RS surgery. A point about two fingerbreadths below the costal margin and 1 cm medial to the linea semilunaris (as previously identified by ultrasound) has been an area that provides more consistent and reliable entry into the retrorectus space. For subxiphoid hernias, this entry point can be more caudal. The posterior rectus sheath (PRS) contains more muscular transversus abdominus (TA) in this location, which is more forgiving in the situation where the tip of the trocar obturator is accidentally driven too deep. Accidental entry into the peritoneal cavity during this portion of the operation can make the subsequent step difficult if not impossible.
  - An 8 mm horizontal incision is made through the skin. Local anesthetic is not injected at this time as the anesthetic can enter the port obturator and obscure visualization of the tissue. An Applied Medical Kii Fios trocar with a 0-degree 5 mm laparoscope is used to dilate through the tissue. The advantage of this specific port is the ability to insufflate while the scope and obturator are still in the port. Using a back-and-forth twisting motion, the port is slowly advanced through the subcutaneous tissue. Next, the white anterior fascia will be dilated and the rectus muscle, which is red, will be entered (Fig. 17.3). Once the tip of the obturator is in the retrorectus space, dissection is temporarily stopped. Care must be taken not to advance beyond the PRS.
  - High flow insufflation is initiated at 15 mmHg pressure and 40 L/min. The surgeon should be patient at this point and allow the CO_2 to slowly expand the retrorectus space. The PRS will slowly separate

from the rectus muscle with CO_2 insufflation. Once an adequate amount of space has been created by the CO_2 insufflation, the port and obturator are carefully advanced into the retrorectus space in the caudal direction. A side-to-side sweeping motion with the obturator is used to lift the fibroareolar tissue off the PRS. The obturator should remain in the plane directly on the PRS. This plane of dissection will prevent injury to the epigastric vessels and the major neurovascular bundles. Enough retrorectus space should be developed to allow placement of a second 8 mm robotic port 6–7 cm away from the first port. This is usually the camera port, so the positioning of this port site must be deliberate and well planned to ensure adequate visualization of the operative field. Once the second port is inserted, an instrument with energy (i.e., Maryland or Ligasure) can be used to divide larger vessels in order to develop the rest of the retrorectus space. The second 8 mm robotic port is then inserted under direct vision 6–7 cm away from the second port. Finally, the initial 5 mm port is upsized to a third 8 mm robotic port. The three ports are placed in an oblique fashion directed towards the xiphoid region or subcostal hernia site (Fig. 17.4).

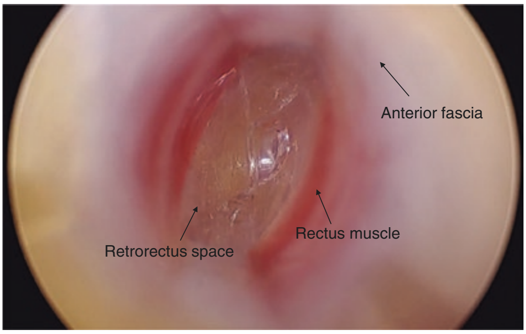

Fig. 17.3 Visualization of optical view entry as the anterior sheath and rectus muscle are entered. This is the critical point to stop and start insufflation to open the retrorectus space

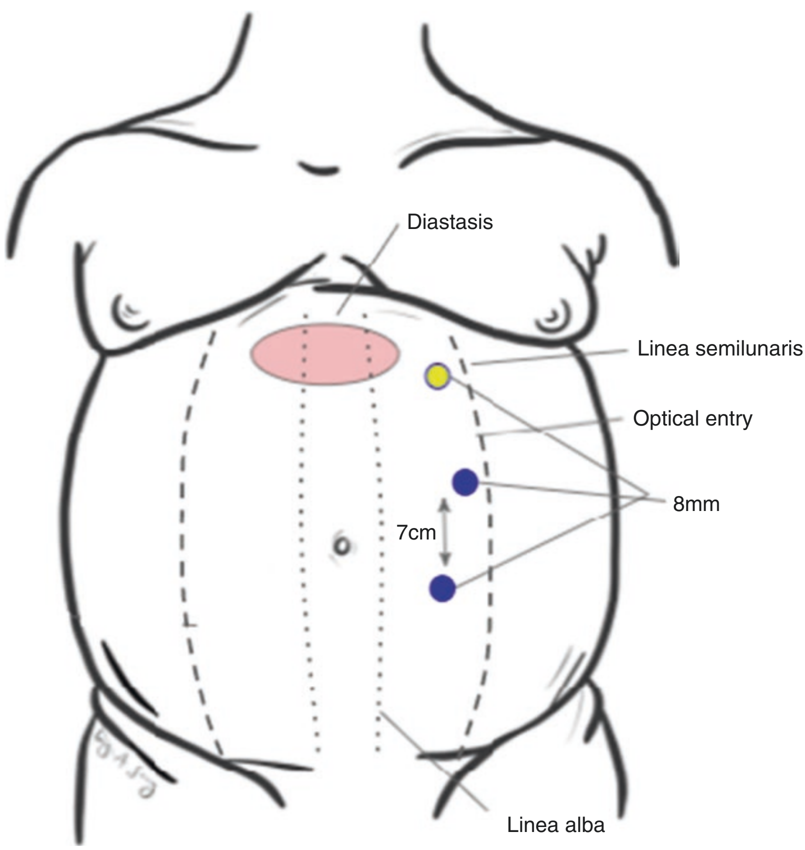

Fig. 17.4 Subxiphoid hernia: extended totally extraperitoneal repair (eTEP) port placement

  - Extreme care should be taken to avoid penetrating the PRS and peritoneum during initial entry or port insertion. If at any point the PRS and peritoneum are violated, CO_2 will escape into the abdominal cavity. When the pressure equalizes, there may not be enough retrorectus working space to insert additional ports. To reestablish adequate working space, a 5 mm port will need to be inserted into the contralateral abdominal cavity to desufflate the peritoneal cavity.
  - The robot can now be docked. Automatic targeting with the DaVinci Xi robot can be performed at this point. However, manual targeting is preferred since atypical hernias are not a programmed setting in the robot. Manual docking involves manually rotating the boom until the green crosshair on the camera port is lined up with the target anatomy (i.e., middle of the hernia). The boom is then lowered or raised to ensure the arms will have enough vertical play to retract or extend as needed during the operation. The left-hand instrument is usually a fenestrated bipolar or a force bipolar grasper. The right-hand instrument is a monopolar curved scissor. A 30-degree scope is used, starting in the "up" position.
- Ipsilateral retrorectus dissection
  - The ipsilateral retrorectus space is dissected and the remaining fibroareolar tissue is cleared off the PRS. This will allow definitive identification of the linea alba to avoid injury to this important structure during the crossover. Moreover, the CO_2 is usually still contained at this point, which allows the surgeon to dissect the space with ease and minimize injury to the inferior epigastric vessels, neurovascular bundles, and the important linea. The amount of the retrorectus space to develop is dictated by the size of the mesh that needs to be placed.
- Crossover and dissection of the preperitoneal space
  - Once the ipsilateral retrorectus space has been cleared, the crossover into the preperitoneal space is performed. For subxiphoid and subcostal hernias, completion of the crossover will require entering the contralateral retrorectus space. Crossover is initiated caudal to the hernia in the upper abdomen. The falciform preperitoneal fat is usually abundant, but keep in mind that previous upper abdominal surgery may have disrupted the falciform and preperitoneal fat in the upper abdomen. The crossover begins by cutting the PRS about 1 cm lateral to the linea alba. The PRS should not be cut too close to the linea alba to avoid weakening or injuring the linea alba, which will result in an iatrogenic hernia.
  - Cautery should not be used when initiating the crossover in case there is bowel on the other side of the PRS. Once preperitoneal fat is visible, cautery may be used more liberally, but judiciously. The PRS incision should be continued cephalad and caudally. The preperitoneal fat should be dissected off the midline. When the hernia sac has been encountered the entire hernia sac should be reduced. At this point, it is common to accidentally incise the hernia sac or peritoneum and enter the abdominal cavity. This should not be considered a failure. It is an opportunity to see within the abdominal cavity and determine the contents of the hernia sac. If extensive adhesions are noted, this is an opportunity to fully enter the abdominal cavity and lyse adhesions to make the sac take-down safer. Alternatively, one could avoid lysis of adhesions and continue sac mobilization knowing that intra-abdominal contents are adherent to the sac. Occasionally, the sac will reduce very easily negating the need for extensive adhesiolysis. Once the preperitoneal space has been developed and the hernia sac has been reduced, the contralateral retrorectus space is entered.
- Entry into the contralateral retrorectus space
  - In general, crossover to the contralateral retrorectus space is safer at the arcuate line. It is easier to identify the rectus muscle below the arcuate line where the PRS is very attenuated. However, it is usually

unnecessary to dissect down to the arcuate line in subxiphoid and subcostal hernias. If the exact location of the linea alba and the medial edge of the rectus muscle are not obvious, the bedside assistant is asked to insert a needle through the ultrasound-marked contralateral linea alba to facilitate identification of the linea alba intra-abdominally. Monopolar energy can be applied to the visible fascia to activate rectus muscle contraction to identify its medial edge. These maneuvers will help the surgeon avoid inadvertently cutting medial to the linea alba and cause an iatrogenic midline hernia.

- The contralateral PRS should be incised about 1 cm lateral to the linea alba. The amount of PRS is determined by the pocket necessary for adequate mesh overlap. Once the PRS has been divided, the PRS is separated from the rectus muscle. The retrorectus fibroareolar tissue again should be lifted off the PRS to avoid injury to the inferior epigastric vessels and neurovascular bundles.

• Subdiaphragmatic dissection and Transversus Abdominus Release (TAR)
  - Entry into the subdiaphragmatic space to ensure adequate cephalad mesh overlap will require transection of the PRS along the costal margin (aka “upper” TAR) (Fig. 17.5). The “upper” TAR should start in the midline near the xiphoid. A potential space within the retro-xiphoid fat can usually be identified. This is a good space to aid the surgeon in finding the proper plane when the dissection proceeds laterally. The full thickness of the PRS is then divided along a path that parallels the costal margin. The PRS consists of the posterior lamella of the internal oblique (PLIO) and the Transversus Abdominus (TA). Medially, near the xiphoid, there is usually contribution from the diaphragm to the PRS. Therefore, the surgeon will need to divide not just the PLIO and TA, but also this diaphragm contribution. Otherwise, an iatrogenic Morgagni-type hernia can be created (Fig. 17.6a).
  - Once the TAR is initiated and the surgeon has confirmed that the diaphragm fibers have not been separated from the ceiling/chest, the surgeon should stay in the areolar plane against the diaphragm muscle. This plane is between the transversalis fascia (and peritoneum) and diaphragm muscle (Fig. 17.6b). There are numerous small vessels in this space entering the diaphragm, so cautery should be used liberally. Laterally, the subdiaphragmatic space will be connected to the space behind (deep to) the TA. There is usually a strip of fat directly posterior to the costal margin, which is a landmark signaling the area where the diaphragm and TA converge at the costal margin.
  - Both subdiaphragmatic spaces need to be connected for subxiphoid hernias (Fig. 17.6c). Therefore, bilateral upper PRS division will need to be performed. Once the spaces are connected, the sternal fibers and bilateral costal fibers of the diaphragm should be visible. Dissection can be continued in this retromuscular plane and the central tendon can be exposed if necessary for extensive cephalad mesh overlap.
  - For subxiphoid hernias, the PRS division (TAR) only needs to be carried to the linea semilunaris and no further. For subcostal hernias, the TAR will need to continue along the linea semilunaris. The division of the PLIO and TA should be done about 1–2 cm medial to the linea semilunaris. Care should be taken to preserve the larger neurovascular bundles. The caudal extent of the TAR will depend on the space needed for adequate mesh overlap.
  - Since there will be scarring along the costal margin and possible disruption of the upper linea semilunaris in a subcostal hernia, the surgeon should initiate the TAR in virgin tissue. This may mean having to start inferolateral to the hernia with a “bottoms-up”

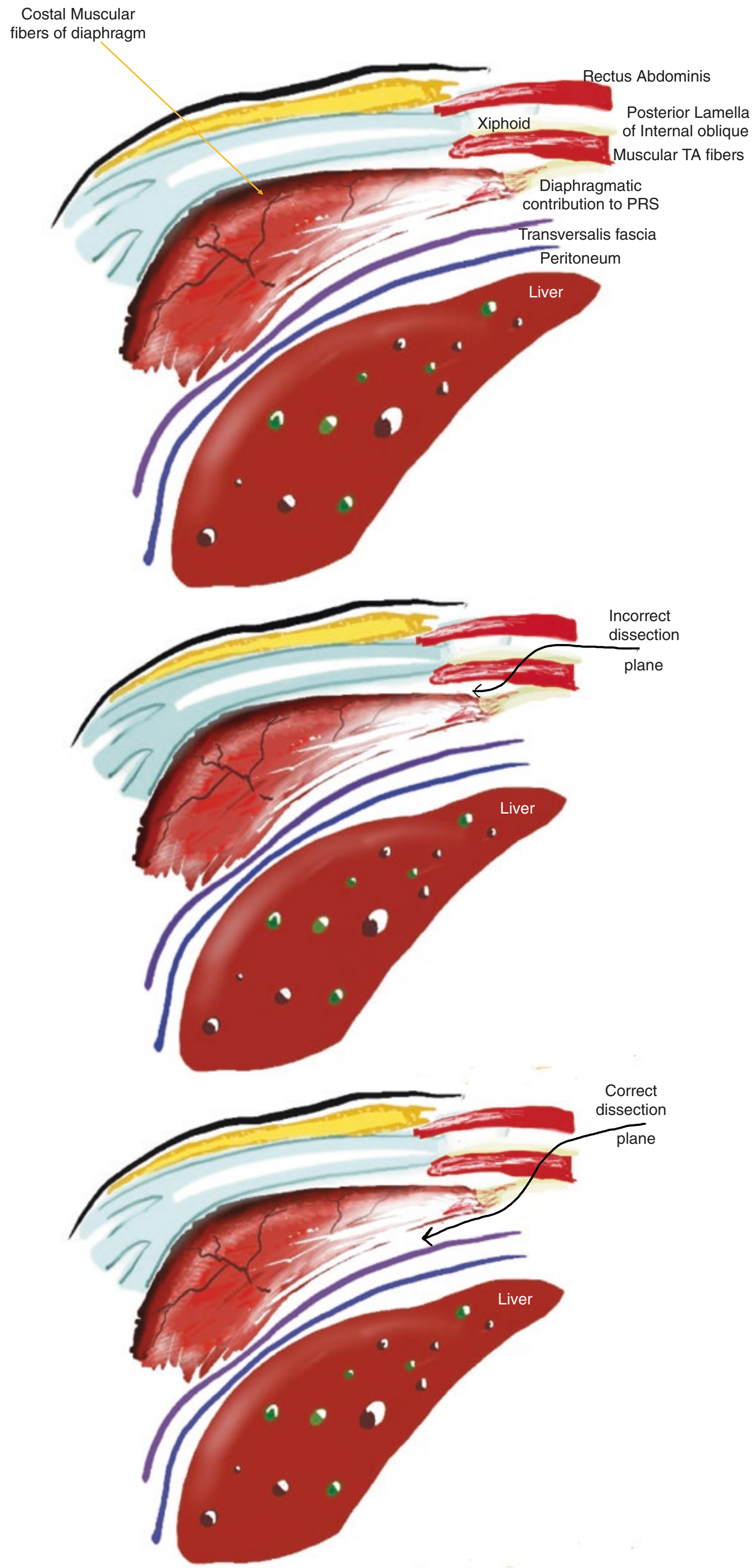

Fig. 17.5 Division of the posterior rectus sheath at the costal margin opens the subdiaphragmatic space. It is important to remember to keep the fibers of the diaphragm up to prevent creation of Morgagni hernia

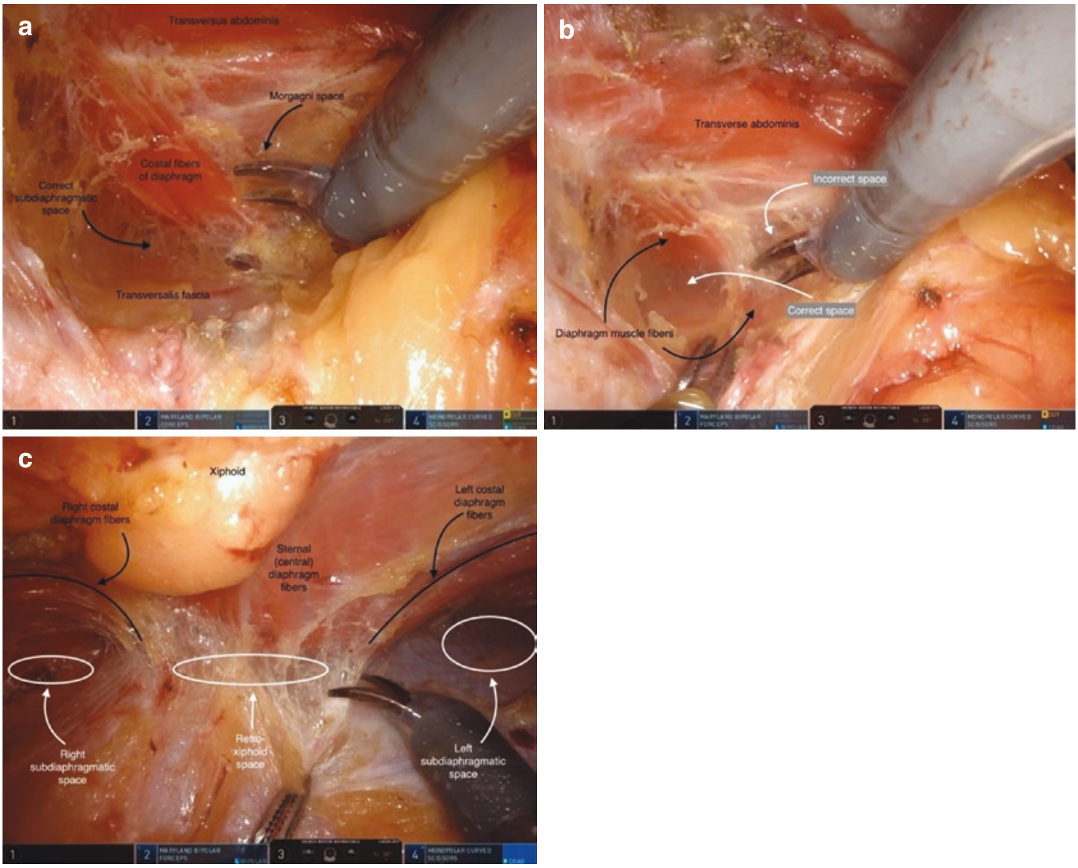

Fig. 17.6 (**a**) To prevent creation of iatrogenic Morgagni type hernia the diaphragm contribution to the posterior rectus sheath must be divided in addition to the transversus abdominus and the posterior lamella of the internal oblique. (**b**) Plane between the transversalis fascia (and peritoneum) and diaphragm muscle. (**c**) Dissection in the correct plane will expose the sternal and costal muscle fibers of the diaphragm

TAR, rather than starting medially by the xiphoid.

- – Again the extent of dissection under the diaphragm and laterally behind the TA into the flank will depend on the amount of mesh overlap desired. These spaces can usually easily accommodate 10 cm of overlap beyond the costal margin.

- Reconstruction
  - – Posterior peritoneal defects: If there are any small defects larger than 5 mm in the peritoneum they should be closed with figure-of-eight 3-0 polyglactin sutures. If the defects are large, a 3-0 absorbable barbed suture is used for the repair in a running fashion. Reapproximating the posterior rectus sheath without a component separation is not recommended as there will be too much tension. This tension can lead to postoperative suture line disruption and an intraparietal hernia.
  - – Anterior defects: the anterior defect is repaired with a 0-long absorbable barbed suture. For most defects larger than a few centimeters, a suturing technique similar to tying a Corset with a long suture (usually 12″ or 18″) is used by the authors. Sutures should be placed without tightening as they advance. Once most of the sutures have been used up, the authors return to the start of the suture line and begin pulling the suture tight to slowly close the defect.

Distributing the tension along a long length of the defect makes it easier to close wider defects without breaking the suture or tearing tissue. After the defect is closed, the barbed suture is run back at least two throws to lock the suture.

- Mesh Placement
  - Once the posterior and anterior defects are closed, the mesh is inserted. Medium-weight macroporous polypropylene mesh is routinely used by the authors. The floor dimensions are measured with a single craniocaudal measurement and a single transverse measurement at the widest level. The mesh corners are trimmed to fit the space. The mesh should overlap the craniocaudal direction by at least 5 cm for most hernias. If the anterior defect cannot be closed and a bridging repair is performed, heavy-weight mesh should be used.
  - The mesh is laid on the floor of the space. The mesh is usually not sutured in place, since the retrorectus space is a confined space and the mesh should not shift much. Furthermore, macroporous polypropylene mesh should integrate fairly rapidly in the retromuscular space.
  - The retrorectus space is desufflated under direct visualization to ensure the mesh is not overly redundant and does not shift. The robotic instruments are then removed and the robot is undocked. The ports are removed. Since the mesh covers the port sites, the fascia does not need to be closed. The skin is reapproximated with interrupted subcuticular 4-0 Monocryl sutures. Skin glue is applied. An abdominal binder is placed around the abdomen.

17.4 Tips and Tricks

- The left hand is crucial to achieving the correct amount of tension during dissection and identifying the correct planes.
- Flipping the camera between 30 degrees up and down allows for easier dissection throughout the abdomen as well as easier suturing of the anterior and posterior defects.
- When closing the anterior defect, small bites are taken of the hernia sac to decrease dead space and decrease the likelihood of large seroma formation. Care must be taken not to go too superficial into the overlying skin.
- Collisions of the robot arms and instruments can be alleviated by the adjustment of the flex joints.

17.5 Complications and Management

Most patients are admitted for observation for 1 day and discharged home on postoperative day 1 with minimal narcotic use. The most common complications encountered after an eTEP repair include wound infection and seroma formation.

- Wound infection: while rare, wound or mesh infections are possible and should be treated with antibiotics and close observation. Any infected fluid collection should be drained.
- Seroma: by taking bites of the hernia sac during closure of the anterior defects, seroma formation is significantly decreased in size and can usually be observed.

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18 Robotic Transversus Abdominis Release (RoboTAR) for Ventral Hernia Repairs

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18.1 Introduction

Robotic transversus abdominis release (roboTAR) is a minimally invasive surgical technique which follows the principles set forth by Rives and Stoppa, who pioneered the retromuscular preperitoneal approach for hernia repair. The retromuscular approach allows for mesh placement within a well-vascularized space separated from the visceral space [1]. Novitsky et al. first described the open transversus abdominis release (TAR) as a form of posterior component separation for abdominal wall reconstruction with avoidance of division of the neurovascular bundles at the semilunaris. This is accomplished by medializing the rectus muscle via division of the transversus abdominis along its entire length allowing for a large extraperitoneal plane to be developed; thereby, allowing for giant prosthetic mesh reinforcement [2]. TAR traditionally has been exclusive to open surgery; however, with the advent of robotic surgery, TAR can now be performed with a minimally invasive technique.

Advantages of performing a roboTAR, in comparison to an open approach include shorter length of hospital stay, reduced wound morbidity, reduced postoperative pain, and expedited return to work and activities of daily living [3]. Carbonell et al. demonstrated a significantly shorter duration of hospitalization in the robotic group when compared to open ventral hernia repair (2 vs. 3 days, $P < 0.001$) [4]. Overall, it appears that the minimally invasive approach improves clinical outcomes when compared to the open approach by significantly decreasing the length of hospital stay and surgical site complications.

18.2 Indications and Case Selection

The indications for a robotic TAR versus open TAR are relatively the same. Factors to consider when choosing to perform a TAR, in general, include the following: large ventral hernias with greater than 10–12 cm defects, prior ostomy sites, and lateral wall defects [5, 6]. Patients with complex or large soft tissue or skin defects that will require resection or revision at the time of operation may not be suitable for a roboTAR.

A comprehensive history and physical exam are crucial to obtain when developing an operative plan. Comorbidities such as diabetes, obesity, smoking, and collagen vascular disease may profoundly affect the operative plan. We recommend that patients attempt to lose weight, optimize their blood glucose level (ideally a HbA1C <7), and quit smoking at least 4 weeks prior to surgery. All patients undergoing a large

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abdominal wall reconstruction require a preoperative CT to map out the entire abdominal wall and cavity. This allows the provider to evaluate the defect, prior mesh positioning in the setting of recurrence, incarcerated abdominal contents, and the existence of other concurrent hernias. The Carbonell equation can be used to assess if a patient is a good candidate for a roboTAR [7, 8]. This equation states that if the sum of the width of the recti is twice the size of the defect, a Rives-Stoppa repair will suffice. However, if the ratio is less than two, posterior component separation by TAR should be considered.

18.3 Contraindications

Contraindications to roboTAR are similar to those of other laparoscopic surgeries. Patients who cannot tolerate pneumoperitoneum, and with extensive adhesions and "frozen" abdomen should not undergo roboTAR. Patients with extensive loss of domain secondary to large abdominal wall hernias, defects that extend from flank to flank, and poor skin integrity/ulceration should not undergo roboTAR as well. We recommend performing roboTAR only in clean cases; however, this is not an absolute contraindication.

18.3.1 Operative Techniques

There are three ways to perform a roboTAR, and they are as follows—bottoms-up TAR, Novitsky method, and top-down TAR. All three ways can be used to initiate the TAR and proceed with dissection. The top-down and bottoms-up TAR will eventually coalesce with the prior Novitsky dissection, and all three planes can be joined. The key to performing a successful TAR is obtaining a critical view of TAR. This is achieved when the cut edge of transversus abdominis (TA) is demonstrated on the lateral abdominal wall medial to the preserved neurovascular bundles and linea semilunaris, and the other cut edge of TA is observed on the posterior sheath with no muscular elements on the posterior elements. The three ways to TAR may be employed based on surgeon comfort and knowledge. However, certain patient factors such as scarring from prior hernia repair or underlying viscera may dictate which approach is primarily used. A combination of the three approaches is usually employed together.

18.3.1.1 Gaining Entry into the Abdomen: Patient Positioning, Trocar Placement, and Docking

The patient should be placed supine with the arms tucked and all pressure points adequately padded. Intra-abdominal access is achieved under direct visualization in the left upper quadrant, lateral to Palmer's point. Other access points are also an option if necessary due to prior surgical history. Eight millimeter robotic trocars are placed in the left upper quadrant, left lateral mid-abdomen, and left lower quadrant (Fig. 18.1). In patients with shorter torsos, bed flexion can be used to create more space between the costal margin and iliac crest to adequately space out the trocars; however, the extent of bed flexion must be monitored carefully to avoid causing back pain or trauma. The robot is docked over the contralateral abdomen.

18.3.1.2 Division of Posterior Rectus Sheath and Subsequent Mobilization to the Linea Semilunaris

After safe entry is gained into the abdomen, the entirety of the anterior abdominal wall is evaluated (Fig. 18.2). Adhesiolysis, as well as reduction of the hernia content, is performed with care

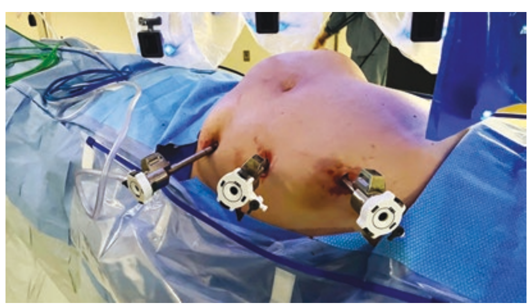

Fig. 18.1 Initial robotic port placement

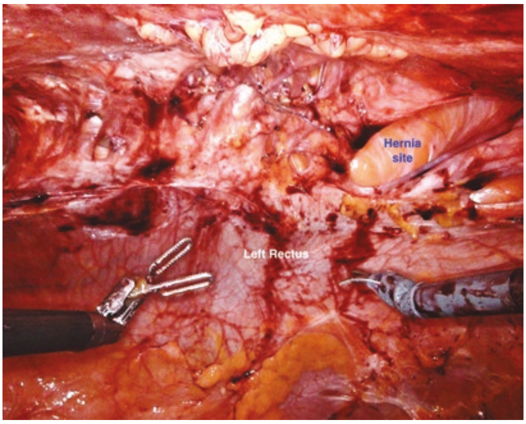

Fig. 18.2 The entirety of the abdominal wall is evaluated. All adhesions are cleared off the entire abdominal wall. Here you see the prior ostomy site now with a hernia defect and the bilateral rectus abdominis muscle

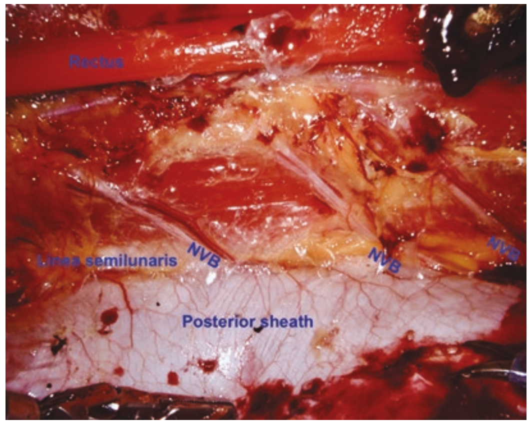

Fig. 18.4 The dissection continues laterally until the semilunar line is reached. It is critically important to identify the neurovascular bundles to avoid denervation to the rectus abdominis muscle

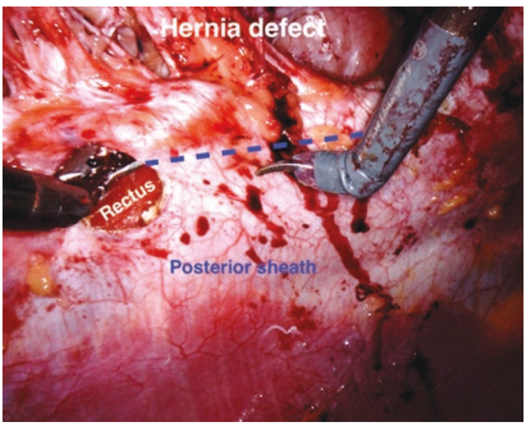

Fig. 18.3 The transverse fibers of the rectus abdominis muscle must be recognized after incision of the posterior sheath to ensure that the correct space is entered. The dissection is continued along the dotted line to release the posterior sheath from its contribution to the linea alba

taken to avoid injuring the viscera. The patient may have concomitant inguinal hernias, and therefore complete abdominal wall clearance is needed for full evaluation. Retromuscular access is obtained by incising the posterior sheath 1–2 cm lateral to the linea alba and mobilizing the posterior rectus sheath laterally until the neurovascular bundles are visualized (Fig. 18.3).

Muscle fibers of the rectus must be visualized to verify the correct space. To ensure the dissection is in the correct plane, the rectus abdominis muscle should be kept anteriorly against the abdominal wall, and the posterior elements (posterior rectus sheath, transversalis fascia, and peritoneum) should be mobilized to the "floor" posteriorly. This may be difficult to distinguish in those with atrophic recti or when this plane has previously been accessed. The dissection is continued laterally until the neurovascular bundles (NVBs) are identified, signifying that the linea semilunaris has been reached at the lateral border of the rectus (Fig. 18.4). The NVBs must be preserved to avoid devascularization and denervation of the rectus muscle.

The retrorectus dissection is continued cephalad until the epigastric crossover is performed. This is performed cephalad to the hernia defect in the preperitoneal plane typically at the level of the falciform ligament, which is mobilized posteriorly with the flap (Fig. 18.5). To ensure the flap is continuous with the posterior rectus sheath, care is taken to dissect all preperitoneal fat posteriorly and away from the linea alba. Caudally, the retrorectus dissection is continued below the arcuate line and the suprapubic crossover is performed to create a preperitoneal flap that is continuous with the posterior rectus sheath (Fig. 18.6). The suprapubic crossover results in a preperitoneal flap creation down to the level of the space of Retzius. In this location, the preperi-

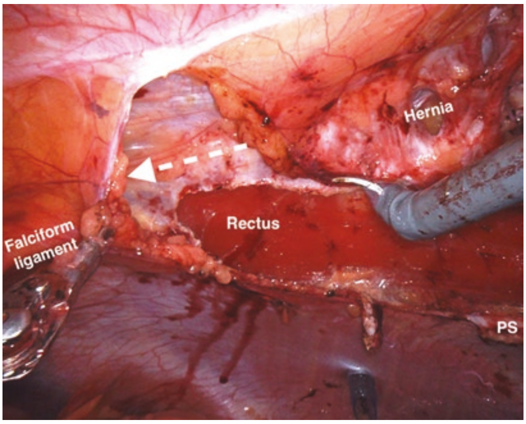

Fig. 18.5 Performing the epigastric crossover. The arrow demonstrates the plane of dissection. The falciform ligament is brought down

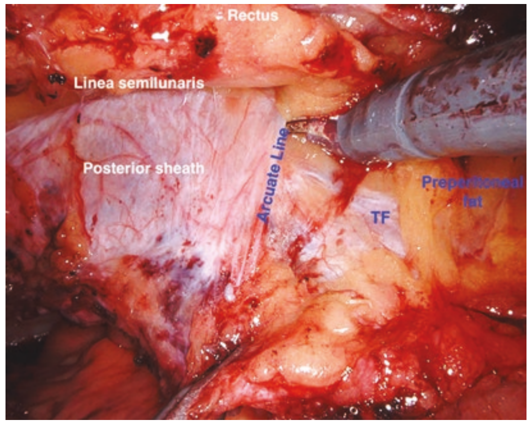

Fig. 18.7 Dissecting more laterally and caudal reveals the arcuate line at the linea semilunaris. The preperitoneal fat is more prominent in the lower abdomen to facilitate mobilization of the posterior elements

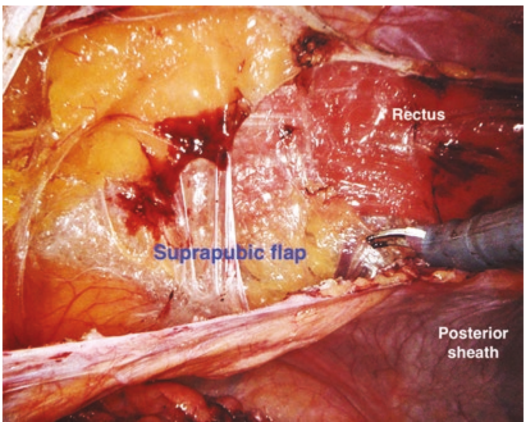

Fig. 18.6 Dissection is continued further caudal in the preperitoneal space by bringing the suprapubic flap down

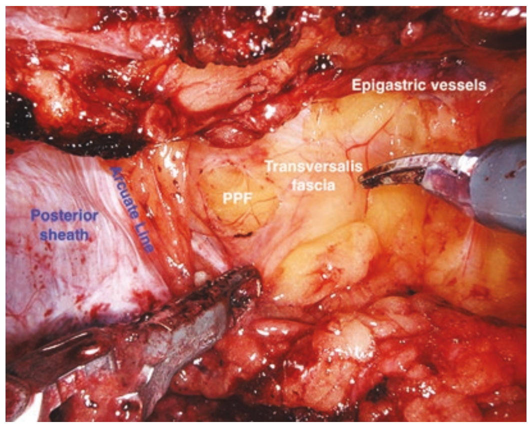

Fig. 18.8 The transversalis fascia is incised to reach the preperitoneal fat and the preperitoneal plane

toneal fat is more prominent in the lower abdomen, which helps facilitate the mobilization of the posterior sheath. The dissection is carried out laterally until the arcuate line is delineated at the level of the linea semilunaris (Fig. 18.7). At this location, inferior to the junction between the arcuate line and linea semilunaris, the transversalis fascia is incised to enter the preperitoneal plane (Fig. 18.8).

The preperitoneal fat is swept downwards, and dissection is continued laterally until the transversus abdominis muscle is visualized along the lateral abdominal wall, which will facilitate dissection of the Space of Bogros. The space of Bogros is bounded anteriorly by the superficial transverse fascia, medially by the inferior epigastric vessels, laterally by the pelvic wall, and posteriorly by the psoas muscle, external iliac, and the femoral nerve. Dissection is continued laterally and posterior to the inferior epigastric vessels until the TA muscle is identified on the lateral abdominal wall. Cooper's ligament should be visualized and any inguinal, obturator, and femoral hernias identified are reduced at this time (Fig. 18.9). The inferior epigastric vessel is a good landmark for the suprapubic crossover, as well as the myopectineal orifice. This space signifies the starting location for the bottoms-up TAR.

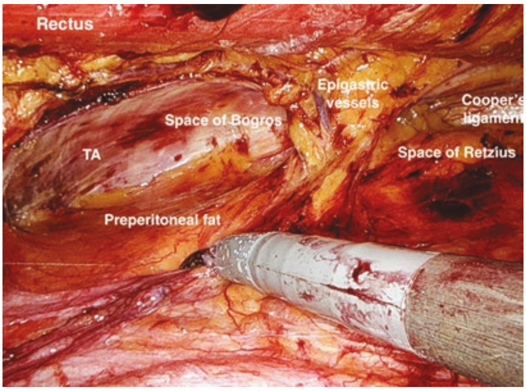

Fig. 18.9 Caudal dissection must be performed to the level of Cooper's ligament in the space of Retzius. Concurrent inguinal hernias are repaired at this time

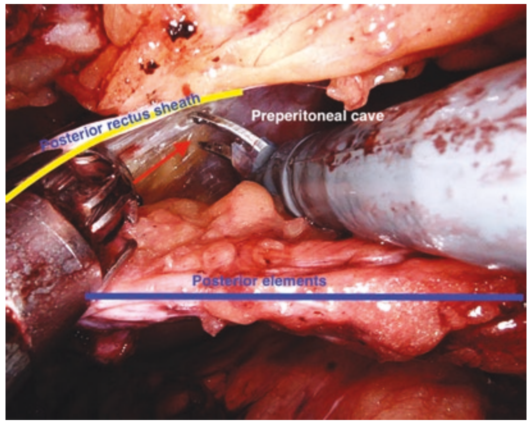

Fig. 18.10 The goal of bottoms-up TAR is to separate the posterior elements from the posterior sheath. The posterior elements here represent the peritoneum along with the preperitoneal fat. As the layers are further separated, a preperitoneal cave is created making the shape of a "V"

18.3.1.3 Three Ways to TAR

Bottoms-Up Technique

Although there are three ways to initiate a TAR, the authors of this chapter believe that the division of the transversus abdominis (TA) muscle is facilitated by executing the procedure in a caudal to cephalad direction. The bottoms-up dissection begins in the Space of Bogros when the TA muscle is in view. The posterior elements (i.e., peritoneum, transversalis fascia, and preperitoneal fat) must be separated from the overlying TA muscle and lateral posterior sheath. This facilitates subsequent division of the aponeurotic TA in the lower abdomen, and the muscular TA in the mid to upper abdomen (Fig. 18.10).

With continued separation of the layers, a preperitoneal cave is developed. In the lower and lateral abdomen, the preperitoneal and retroperitoneal fat is more abundant which facilitates dissection and preservation of the posterior elements. Once the lateral extent of dissection of retroperitoneal fat is reached, dissection is performed in a medial direction along the line of reflected peritoneum (Fig. 18.11). A large preperitoneal cave is created which isolates the aponeurotic portion of the TA. The posterior sheath is retracted in a cephalad and medial direction creating a "V" shape. This delineates the separation of the preserved posterior elements from the aponeurotic portion of the TA as it inserts into the lateral posterior sheath. This area is now safe to divide medial to the neurovascular bundles and semilunar line.

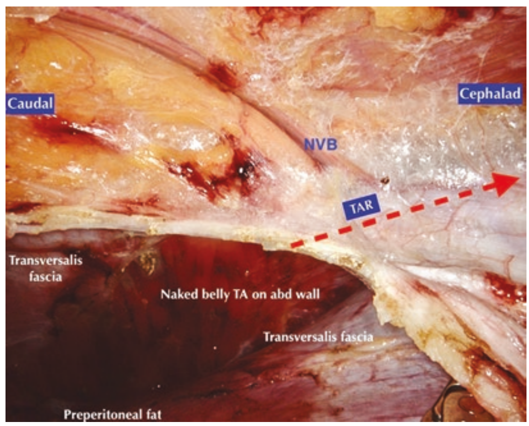

Fig. 18.11 A large preperitoneal cave is created isolating the aponeurotic portion of the transversus abdominis. The TAR is continued along the dotted line along the TA aponeurosis

Continuing cephalad to the mid-abdominal region, there is a loss of preperitoneal fat, which may make the dissection more tenuous. It is often required here to transition dissection between the preperitoneal to the pretransversalis planes, or between the anterior and posterior leaflets of the transversalis fascia, depending on the integrity of the flap. Additionally, the aponeurotic portion of the TA becomes muscular and more difficult to dissect. Once the bottoms-up technique becomes too difficult, a transition is made to either Novitsky's technique or the top-down approach.

Novitsky Way

In the upper third of the abdomen, the muscle belly of the TA is noted to insert more medially on the posterior sheath. The neurovascular bundle needs to be clearly identified to avoid denervation of the rectus muscle complex. Medial to the neurovascular bundles, the posterior lamella of the internal oblique is incised thereby exposing the TA muscle fibers (Fig. 18.12). The TA muscle needs to be carefully divided along the length of the previously created incision, which reveals the underlying transversalis fascia (TF) (Fig. 18.13). Dissection continues laterally in between the transversalis fascia and the cut edge of the transversus abdominis. Pretransversalis dissection is continued laterally until the retroperitoneal fat pad is identified, similar to the bottoms-up approach (Fig. 18.14). The Novitsky technique can be connected with the top-down and bottoms-up approach to complete the TAR dissection.

Top-Down Technique

The top-down dissection begins within the preperitoneal space at the site of the epigastric crossover. Similar to in the lower abdomen, there is typically a significant contribution of preperitoneal fat thereby facilitating dissection. Preperitoneal/pretransversalis dissection is carried laterally towards the retroperitoneal fat

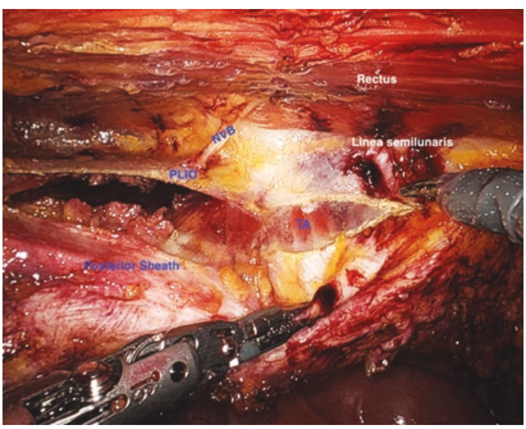

Fig. 18.12 The posterior lamella of the internal oblique is incised to reveal the muscle fibers of the transversus abdominus. Monopolar scissors are used to lift up the TA and transect it. Care is taken to avoid any injury to the neurovascular bundles (NVB)

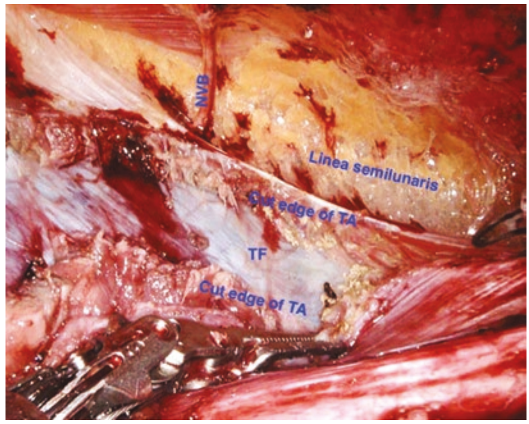

Fig. 18.13 Cutting of the transversus abdominus (TA) muscle reveals the transversalis fascia (TF). What you see here is the cut edge of TA up by the abdominal wall and the cut edge of TA that will lay on the posterior sheath

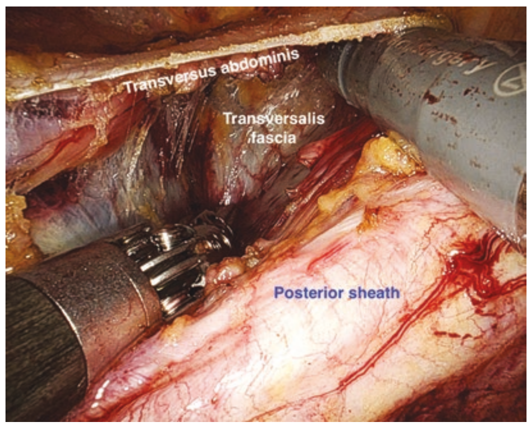

Fig. 18.14 The muscle fibers of the transversus abdominis should be lifted up and the transversalis fascia (TF) brought down with the posterior elements. The goal is to get to the retroperitoneal fat on the lateral abdominal wall

underneath the diaphragm and the TA on the lateral abdominal wall. The fibers of the diaphragm interdigitate with the fibers of the TA; however, there is a sentinel fat pad that can aid in the identification of the position of the overlying diaphragm. Inadvertent dissection into the diaphragm can result in an iatrogenic diaphragmatic hernia and/or inadvertent entry into the thoracic cavity. The goal of this approach is to create a preperitoneal/pretransversalis cave to preserve the posterior elements (peritoneum and transversalis fascia) while separating them from the overlying

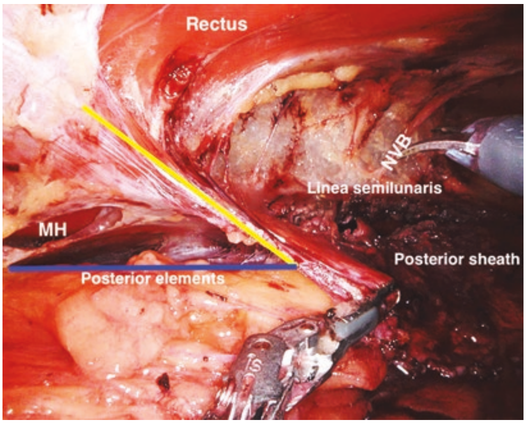

Fig. 18.15 Top-down TAR is similar to bottoms-up TAR in terms of creating a preperitoneal cave. The posterior elements (peritoneum and transversalis fascia) are separated from the posterior sheath to create a "V." Care must be taken to avoid injury at the linea semilunaris to the neurovascular bundles (NVB). If the diaphragm fibers are brought down inadvertently, a morgagni hernia (MH) can be created

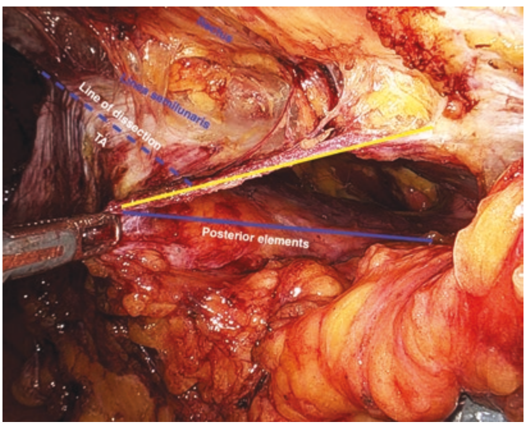

Fig. 18.16 The transversus abdominus is incised at the dotted blue line

TA muscle inserted on the lateral posterior sheath (Fig. 18.15). The diaphragm and TA muscle fibers should be left on the anterolateral abdominal wall and should not be seen on the "floor" of the posterior elements. The TA is incised once an adequate preperitoneal cave has been formed (Fig. 18.16).

The top-down and bottoms-up TAR will eventually coalesce with the prior Novitsky dissection. As the dissection continues, there will be a single pedicle of transversus abdominis that can be easily divided without injuring the posterior elements. This connects all three dissections into one

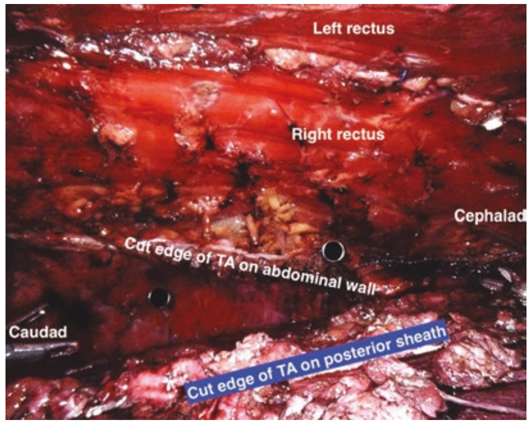

Fig. 18.17 The anterior rectus is brought back together and the linea alba is reconstituted

plane. After this division, the posterior rectus sheath, transversalis fascia, and peritoneum are left down on the "floor" to provide posterior coverage of the mesh. The critical view, or sine qua non, of TAR is successfully achieved when the cut edge of TA is demonstrated on the lateral abdominal wall medial to the preserved NVBs and linea semilunaris, and the other cut edge of TA is observed on the posterior sheath with no muscular layer on the posterior elements (Fig. 18.17). Adequate dissection is obtained when the posterior sheath lays flat over the visceral content without any tenting, ensuring posterior closure without undue tension. This step is accomplished by dissection of the posterior layer to the retroperitoneal fat or the lateral border of the psoas muscle.

18.3.1.4 Initial Deployment and Fixation of Mesh

The dissection must create a space large enough to allow a giant prosthetic reinforcement of the visceral sac. The degree of cranial-caudal dissection is based on the longitudinal size of the defect as well as based on the length of the midline incision to ensure adequate craniocaudal overlap. A minimum of 5 cm of overlap on either side is generally recommended, but often exceeded, to reinforce the entire visceral sac. Once the dissection is completed on one side, the craniocaudal length of dissection and the extent of the flank to midline dissection is measured to choose an appropriately sized mesh.

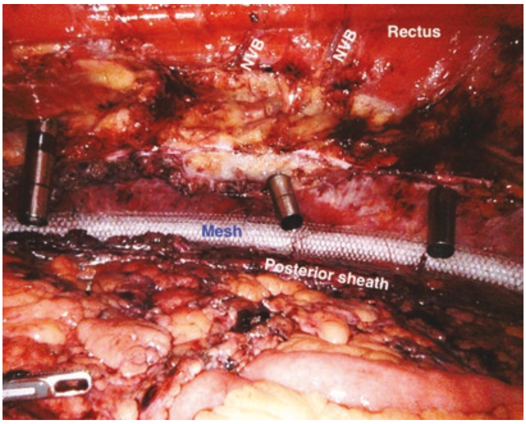

Fig. 18.18 The mesh is deployed and tacked to the abdominal wall. NVB, neurovascular bundle

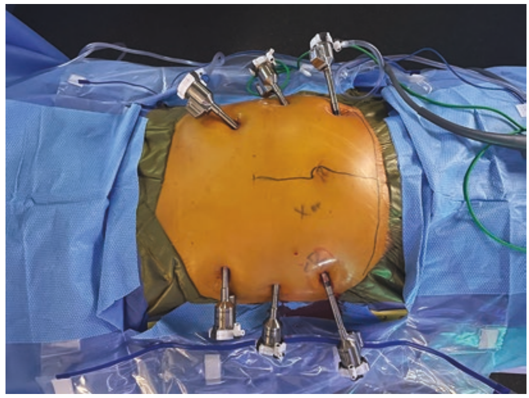

Fig. 18.19 Contralateral ports are placed to mirror the initial three ports

The "Suture trick" involves the placement of an absorbable suture in the top center of the mesh preserving a long tail, which facilitates unscrolling of the mesh atop the posterior sheath. The mesh is rolled up and prepared for insertion into the abdomen. If a bilateral TAR is indicated, contralateral ports are placed above the mesh after its initial deployment on the lateral abdominal wall. Large pore polypropylene synthetics represent our mesh of choice. The mesh is deployed into the retromuscular and preperitoneal/pretransversalis space. The rolled mesh is then fixated with sutures along the posterolateral abdominal wall prior to contralateral dissection (Fig. 18.18).

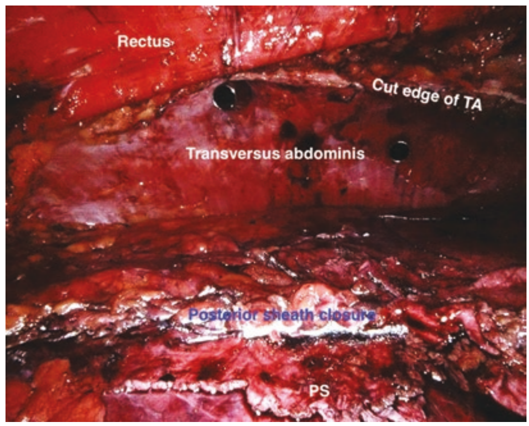

Fig. 18.20 Finished posterior sheath closure

18.3.1.5 Double Docking Method and Contralateral Dissection

If a bilateral TAR is indicated, a double docking technique is utilized, and three 8 mm trocars are placed on the opposite side of the abdomen, mirroring the initial three trocars (Fig. 18.19). Contralateral and symmetrical TAR dissection is performed as described above. Retro-xiphoidal or retropubic dissection is performed as indicated to achieve sufficient cephalad-caudal overlap of the hernia defect. Completion of adequate TAR dissection is confirmed when the two leaves of the posterior sheath rest flat against the abdominal viscera and can be approximated without undue tension (Fig. 18.20).

18.3.1.6 Closure of the Posterior and Anterior Rectus Sheath

Any peritoneal defects are closed with absorbable suture, keeping in mind to avoid injury to the underlying viscera. Running suture is used to reapproximate the posterior sheath. Utilization of barbed suture may facilitate reapproximation. The authors prefer a Connell stitch to minimize contact between barbed suture and bowel.

The anterior fascia is reapproximated with barbed suture which is facilitated by reducing the level of pneumoperitoneum to 6–10 mmHg. The dome of the defect is incorporated within the anterior sheath closure to obliterate the dead space in an effort to minimize the extent of seroma. The bilateral recti are returned to their midline position thereby restoring linea alba (Fig. 18.21).

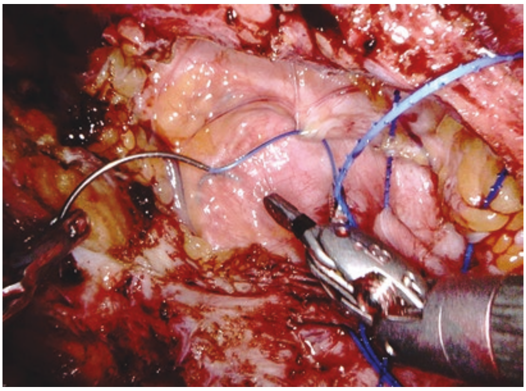

Fig. 18.21 Anterior sheath is closed with an absorbable barbed suture

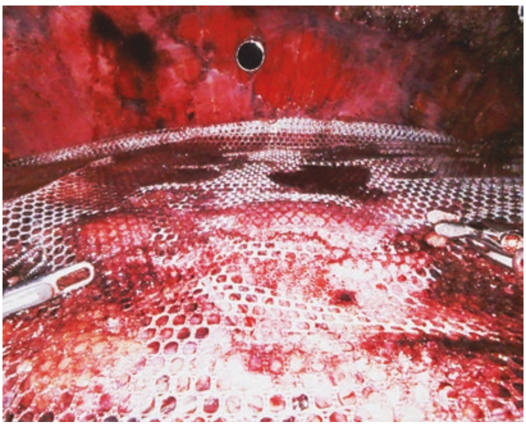

Fig. 18.22 The suture trick is used to roll out the mesh. The mesh should lay nice and flat on top of the flaps without any folds

18.3.1.7 Final Mesh Deployment

The previously placed mesh is unscrolled by the "suture trick"—pulling on the suture that was placed in the center of the mesh until it lays flat atop the posterior sheath and posterior elements (Fig. 18.22). This is performed after restoration of the linea alba. A single retromuscular drain is placed under direct vision through one of the available ports. Hemostatic agents such as powder or glue can be used to assist with hemostasis and seroma control.

18.4 Discussion

The roboTAR allows for a minimally invasive approach to repair large, complex ventral hernias. Open transverus abdominis release is historically associated with a relatively long length of stay when compared to roboTAR, as well as significant patient morbidity, wound infections, and postoperative pain. The benefit of robotic versus open TAR for similar patient cohorts has shown that despite longer operating times, patients had lower morbidity and less severe complications in a 90-day postoperative period; however, the surgical site events and readmissions were similar between both approaches [9].

Halka et al. evaluated a hybrid approach, combining open and robotic repair, in comparison to a solely open approach and found significantly decreased length of stay in those who underwent hybrid approach (3 vs. 7 days, $P < 0.0001$) [10]. Furthermore in a study by, Martin Del Camp et al., a fully robotic approach for TAR decreases blood loss, reduces hospital stay, and has decreased rates of pneumonia, deep vein thrombosis, pulmonary embolism, and ileus [11]. Despite the longer operative time on the robotic platform systemic complications were fewer in the robotic group. Although surgical site infections were not a primary endpoint, there were no surgical site infections noted in the roboTAR group when compared to the open TAR group. The learning curve for achieving proficiency in roboTAR has not been determined; however, with increasing case volumes, the surgeon's proficiency will be achieved, decreasing operative times.

Within the authors' practice, the average hernia defect size is 115 cm^2 with a total of 200 patients over 8 years who have undergone a roboTAR. The average mesh size used is 500 cm^2 to provide adequate coverage. We have had a 2% recurrence rate in our patients following roboTAR which includes: three midline hernia repairs and a bilateral flank hernia repair. These repairs were some of our largest and most complex defects.

The overall surgical site complication rate has been 1% including one mesh infection and one mesh exposure. Our overall length of stay is 1.2 days, likely secondary to decreased postoperative pain from smaller incisions. The average operative time for a roboTAR throughout these 8 years has been 400 min secondary to the learning curve that exists with learning the robotic approach. However, with increased proficiency the operative time decreases.

18.5 Tips and Tricks

Success in robotics, and specifically the roboTAR, is achieved through understanding the abdominal wall anatomy, comfort with the three-dimensional anatomy, and understanding the operative technique. With a lack of tactile sensation, reliance on anatomy knowledge is crucial. In completing a roboTAR, some of the major pitfalls can be—incorrectly identifying linea semilunaris and possible disruption of rectus abdominis neurovascular bundles, diaphragm dissection causing Morgagni hernia, and inadvertent entry into the thoracic cavity.

Through meticulous dissection, the critical view of roboTAR should be achieved, showing the cut edge of transversus abdominis laterally and the cut edge of TA on the posterior sheath with the posterior sheath barren of any muscle fibers. Upon achieving this view, your transversus abdominis release is complete. The utilization of the robot greatly enhances your visualization while also increasing your dexterity to complete the dissection. Upon beginning using the robotic system, the operative time will likely be increased, but with increased proficiency, the operative time will decrease and give way to decreased length of stay and wound complications.

18.6 Conclusion

The robotic approach has opened the door to better visualization, allowing for the ability to perform minimally invasive repairs on increasingly complex ventral hernias. The roboTAR has opened many doors for what was previously to be a large laparotomy incision to be performed through a handful of port sites.

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19 TAR Plus (TAR plus Peritoneal Flap Hernioplasty) for Large Midline Ventral Hernias

Sarfaraz Jalil Baig and Md Yusuf Afaque

19.1 Indications and Case Selection

19.1.1 Background

Transversus abdominis release has become a popular technique for large and complex ventral hernias. It has shown to be an effective technique in very difficult conditions like recurrent hernias [1], open abdomen [2], hernias after liver transplant [3], and kidney transplant [4]. A cadaveric study has shown that the TAR gives medial mobilization of up to around 5 cm on each side [5]. However, some hernias are so large and wide that component separation is not enough to reconstruct the midline. In these situations, certain bailout options are needed. When the posterior layer can not get approximated or is torn beyond repair, the omentum or vicryl mesh may be used to bridge the defect. And when the anterior rectus sheath (ARS) can not get approximated, the mesh is usually stitched to the anterior rectus sheath to the point where it comes without tension. The subcutaneous tissue and skin is closed over this bridging repair. The incidence of bridging repair ranges from 0% to 19% in cases where TAR is performed [6]. However, the bridged TAR has drawbacks. The muscles of the anterior abdominal wall are not approximated in the midline so they do not regain their strength and lack the dynamics of the normal abdominal musculature. A recent study with 96 patients of TAR with bridged repair for large complex ventral hernias observed a composite recurrence of 46% [7]. They reported 10% SSI, 2% mesh exposure, 5% partial mesh excision, and 16% surgical site occurrences requiring procedural intervention (SSOPI).

To overcome these disadvantages, we hypothesized that the TAR can be combined with the peritoneal flap technique (TAR plus) in these complex cases. Peritoneal flap (PF) hernioplasty was first reported by Malik et al. [8] and Petersson et al. [9]. In this technique, the hernial sac (peritoneal flap) is preserved. On one side it is kept in continuity with the anterior rectus sheath and on the other side with the posterior rectus sheath. The retrorectus space is created and the peritoneal flap is used to give a tension-free closure in the posterior rectus sheath as well as the anterior rectus sheath. Critiques have argued that the hernia sac may not be a robust repair. However, proponents of the technique claim that it has sufficient strength with no perceivable bulge (pseudorecurrence) on leg raising and head raising maneuvers on follow up. The peritoneal flap

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creates a "triple-layer neo linea alba" that increases the abdominal volume [10]. They also propose that "the abdominal wall function relies more on an intact circle or ring of abdominal muscle/fascia and that it does not matter if the gap between the muscles is several centimeters wide as long as it is firm and strong, providing a firm ridge of fibrous tissue against which the recti and lateral obliques can pull" [10]. We combined TAR with Peritoneal Flap (TAR Plus) in five complex cases with 3/5 having loss of domain and found satisfactory results on medium-term follow up. Ours was the first study of combined TAR plus PF (TAR plus) [6] which in our opinion is a useful addition to the armamentarium of procedures for large ventral hernias.

19.1.2 Indications

There are very large hernias, often with loss of domain, in which TAR cannot give tension-free closure of the midline and if done they will end in bridged repair or an abdominal compartment syndrome. These are the patients in which combining TAR with peritoneal flap gives a safer repair. The TAR achieves a wide overlap of mesh in retromuscular space which extend craniocaudally from diaphragm to space of Retzius and from psoas muscle of one side to the other. Practically whole of the anterior abdominal wall gets the mesh cover. The PF gives satisfactory anterior as well as posterior coverage to the mesh. The larger the hernia the larger the amount of peritoneal flap for usage, which is a significant advantage of the procedure especially in cases with loss of domain.

We advocate that whenever we perform TAR in a large hernia, we should preserve the hernia sac. At the end of the procedure, we should assess whether we need them or not. If required they can be used; otherwise, they can be excised and TAR alone may be sufficient.

There are only two publications on this technique both showing that this was employed in complex cases. In our series, the average defect width was 15.4 cm (range 12–20 cm), the average defect area was 240.5 cm^2 (range 141.4–314.2 cm^2), and the mean Tanaka's index was 30% [6]. In the series by Yeste & Riquelme-Gaona, the median transverse diameter of the hernia was 13.3 cm (range 10–17) [11]. We think, for defects more than 10 cm, a TAR Plus may be needed to avoid bridging.

19.2 Contraindications

In hernias after the open abdomen in which the skin is directly over the bowel due to healing by secondary intention or split-thickness split graft, TAR plus usually can not be done. This is because there is no hernia sac in these cases and the skin adheres to the bowel (Fig. 19.1).

Fig. 19.1 Open abdomen managed by split thickness skin graft over the bowel, is not suitable for TAR plus

19.3 Instruments and Energy Source

The routine open surgical instruments used in abdominal surgery are required. Electrocautery is used in most of these procedures. If there are extensive adhesions, adhesiolysis of omentum can be done with ultrasonic shears or bipolar cautery. This saves time and decrease blood loss. The choice of mesh is important. We use medium-weight macroporous polypropylene mesh as this resists infection better than microporous meshes and therfore, has more chances of salvage in case of mesh infection [12].

19.4 Team Setup, Anesthesia, and Position

The patient lies supine and the surgeon stands on the contralateral side for performing TAR / PF for convenience. An epidural catheter may be put in for prolonged postoperative analgesia. Antibiotic prophylaxis is needed for not more than 1 day if being done in a clean setting. Deep vein thrombosis prophylaxis is given for all patients.

19.5 Key Steps

- Skin overlying the hernia is excised with an elliptical incision. The hernia sac (PF) is preserved by shaving off the skin and subcutaneous tissue from it. The hernia sac is bisected.
- Opening the retrorectus space on one side just anterior to the hernia sac. This sac lies in continuity with the posterior rectus sheath.
- Opening the retrorectus space on the other side just posterior to the hernia sac. This sac lies in continuity with the anterior rectus sheath.
- Division of the posterior rectus sheath followed by transversus abdominis muscle 1.5 cm medial to the linea semilunaris protecting the neurovascular bundles.
- Creation of wide retromuscular space.
- The peritoneal flap in continuity with the posterior rectus sheath (PRS) is sutured with the PRS of the opposite side.
- The large size mesh is placed in the retromuscular space in a diamond configuration.
- The peritoneal flap in continuity with the anterior rectus sheath (ARS) is sutured with the ARS of the opposite side.

19.6 Surgical Techniques/ Variations

The extent of the hernial sac is assessed, its area is marked all around, and skin-deep incision is given (Fig. 19.2). The skin over the sac is shaved off from the sac by fine dissection with the scissor or electrocautery (Fig. 19.3). The plane of dissection is between the subcutaneous tissue and the sac. Care is taken to not make the sac/peritoneal flap too thin. This dissection continues from the medial border of one rectus muscle to the other.

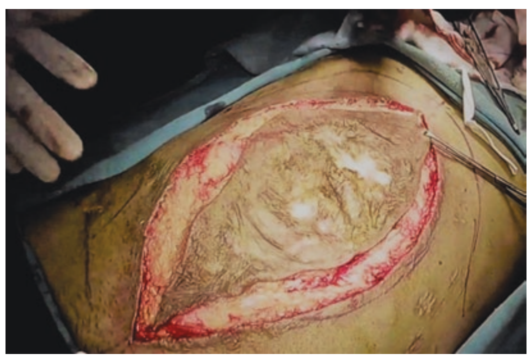

Fig. 19.2 The area of the hernial sac is marked (6)

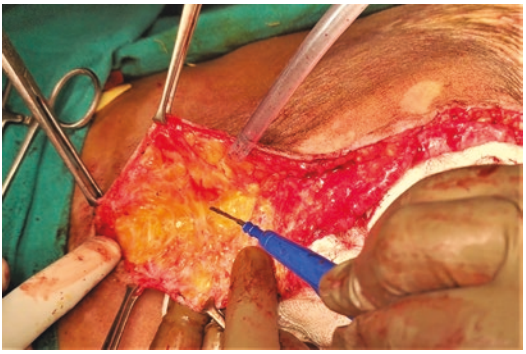

Fig. 19.3 Dissection of the skin from the hernial sac

Fig. 19.4 The hernial sac is opened. After this we have one peritoneal flap on each side

The hernia sac is opened in the midline taking care not to injure the underlying bowel (Fig. 19.4). The inside of the sac is separated from any adhering bowel loop or omentum. The abdominal towel is placed over the bowels so that they do not come into the dissection field.

The sac is divided in the midline throughout its whole length and this creates two peritoneal flaps (PF), one on each side. Next, we keep one peritoneal flap in continuity with the anterior rectus sheath (ARS) and another with the posterior rectus sheath (PRS). We expose the anterior rectus sheath on one side. A longitudinal incision is made on the anterior rectus sheath just adjacent to the PF (Fig. 19.5). This leads us to the retrorectus or Rives-Stoppa's space while keeping the peritoneal flap in continuity with the posterior rectus sheath. After this the retrorectus dissection is done up to the linea semilunaris preserving the neurovascular bundles.

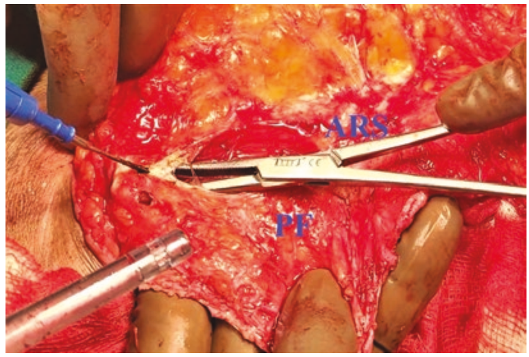

Fig. 19.5 Incision over the anterior rectus sheath for entering the retrorectus space. After this, the PF is in continuity with the posterior rectus sheath

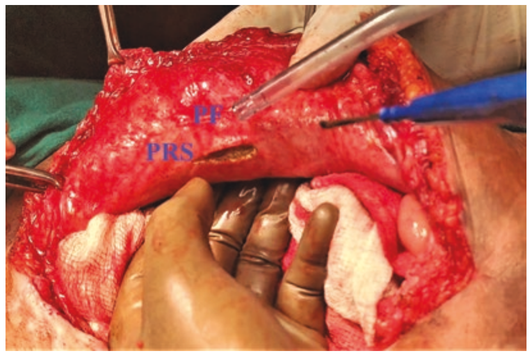

Fig. 19.6 Incision over the posterior rectus sheath

On the other side, we expose the posterior rectus sheath adjacent to the PF. A longitudinal incision is made on the posterior rectus sheath just adjacent to the PF (Fig. 19.6). With this, we enter the retrorectus or Rives Stoppa space keeping the PF in continuity with the anterior rectus sheath (Fig. 19.7). Retrorectus dissection is done up to the linea semilunaris preserving the neurovascular bundle (Fig. 19.8).

Next, we start the steps for transversus abdominis release (TAR). We start this in the upper abdomen as transversus abdominis (TA) muscle is better visible there. We can often see the pinkish hue of the TA muscle lying behind the PRS (Fig. 19.9). Around 1.5 cm medial to linea semilunaris, posterior lamellar of internal oblique is divided longitudinally (Fig. 19.10). This is done in the whole of its length. This exposes the TA muscle. We start the TA muscle division by hook-

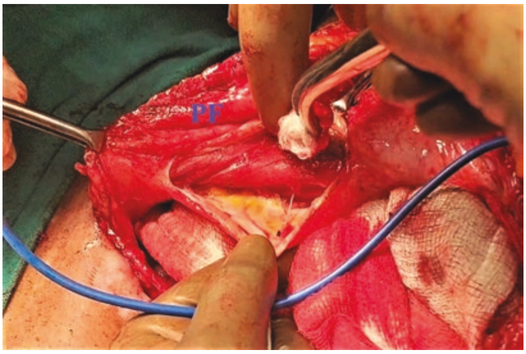

Fig. 19.7 After the incision over the PRS, we enter the retrorectus space. After this, the PF is in continuity with the anterior rectus sheath

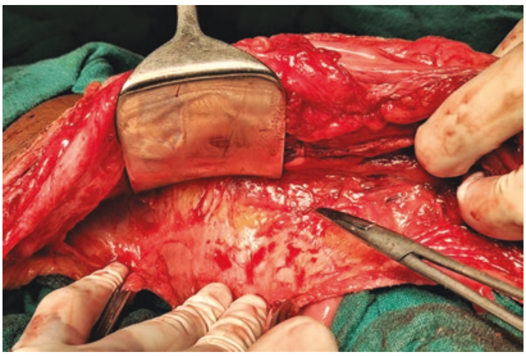

Fig. 19.8 The posterior rectus sheath is visible up to the linea semilunaris. Neurovascular bundles are identified and preserved

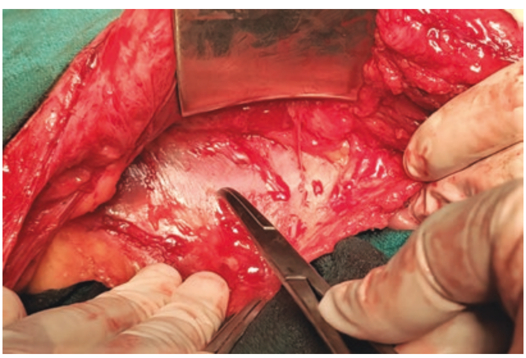

Fig. 19.9 The pinkish hue of the transversus abdominis muscle is visible through the posterior rectus sheath

ing it with the right-angle forceps and dividing with the electro-cautery (Fig. 19.11). It is done in small bits safeguarding the transversalis fascia and peritoneum behind the muscle. As we move

Fig. 19.10 The posterior lamella of internal oblique is divided exposing the transversus abdominis muscle

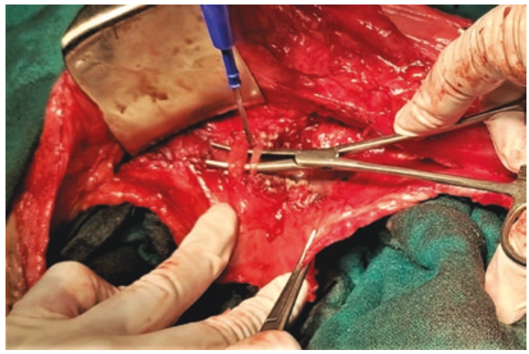

Fig. 19.11 The transversus abdominis muscle is divided

towards the lower abdomen the TA muscle becomes aponeurotic (TA aponeurosis). It is divided with care as it thins out in the lower abdomen. The upper extent of the TAR is till the diaphragm and the lower extent is till the space of Retzius. We enter the lateral retromuscular space by blunt or fine dissection. This is the space to which anteriorly lies the TA muscle and posteriorly the fascia transversalis along with the peritoneum. Care is taken not to tear the peritoneum. The lateral space is created up to the psoas muscle on both sides.

The PF which is with the PRS is sutured to the PRS of the other side (Fig. 19.12). This is by continuous suture with delayed absorbable suture (usually 2-0 polydiaxonane sutures). This forms the posterior layer for the placement of mesh. The hemostasis is checked and the retromuscular space is measured for the placement of mesh. A large piece of polypropylene mesh is placed in a

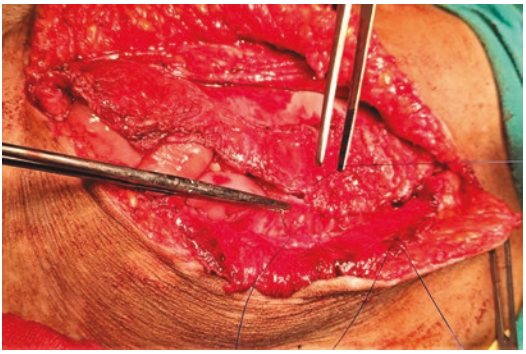

Fig. 19.12 The PF which is continuity with the PRS is sutured to the PRS of the other side

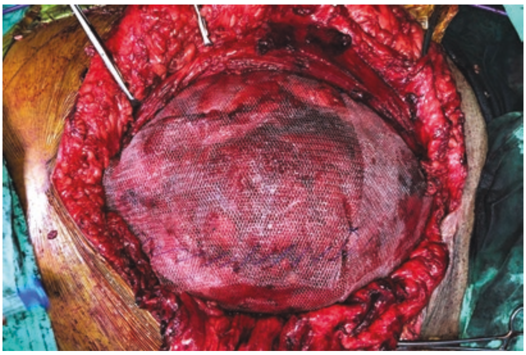

Fig. 19.13 Placement of large polypropylene mesh in the retromuscular space

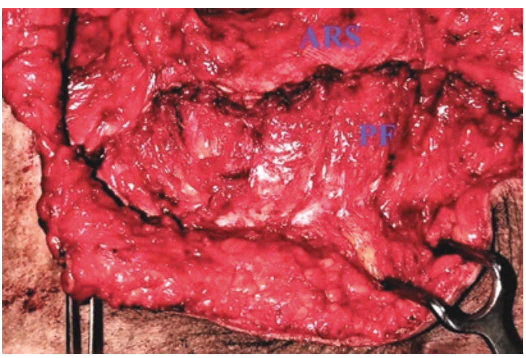

Fig. 19.14 PF which is in continuity with the ARS is sutured to the ARS of the other side

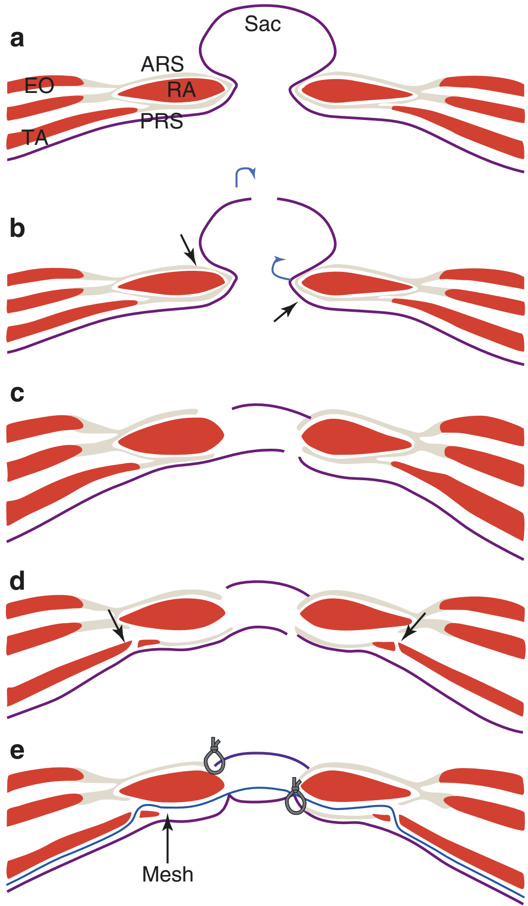

Fig. 19.15 Schematic diagram showing the steps of TAR plus (6). EO, external oblique; IO, internal oblique; TA, transversus abdominis; RA, rectus abdominis; ARS, anterior rectus sheath; PRS, posterior rectus sheath. (**a**) Large ventral hernia with muscles of the anterior abdominal wall. (**b**) The hernia sac with its bisection. Black arrows show the place of incision. Curved arrows show the direction of rotation of peritoneal faps. (**c**) The right-sided peritoneal flap in continuity with the ARS and the left-sided peritoneal fap in continuity with PRS. (**d**) The divided TA muscle is shown. (**e**) The completed procedure with retromuscular mesh (blue line) and suture closure of the right-sided peritoneal fap with ARS and the left-sided peritoneal flap with PRS

diamond configuration (Fig. 19.13). As there is no space for mesh migration, fixation of the mesh may not be required. The suction drain is placed in this space. Next, we suture the PF with the ARS to the ARS of the other side (Fig.19.14). This is by continuous suture with delayed absorbable or nonabsorbable sutures. This covers the mesh. While utilizing the peritoneal flaps it is to be seen that only that much of PF is kept which is required for the tension-free closure. Any excess PF is excised at the time of closure. Subcutaneous tissue and the skin are closed. A schematic line diagram of the steps of TAR plus is shown in Fig. 19.15.

Fig. 19.16 The leg raising test of the patient in the early postoperative period shows no bulge

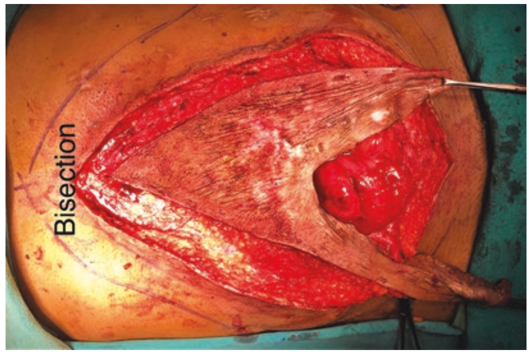

Fig. 19.17 Our modification of bisection of the skin and sac. The bisected skin is then shaved off preserving as much sac as possible

Postoperatively, these patients usually do not require elective ventilation since intra-abdominal hypertension is rare. This is because the abdominal circumference is increased and compliance decreased with this technique. Patients are usually discharged within 5–7 days once they tolerate solid food, and wound appears healthy. In the follow up, apart from checking for recurrence, SSO, and SSI, we regularly look for abdominal bulge/pseudorecurrence on leg rising test. We have not seen any bulge so far. This picture shows a patient with TAR plus in the early postoperative period showing no bulge in the leg raising maneuver (Fig. 19.16).

19.7 Tips and Tricks

- We advocate preserving the sac whenever we go for TAR in a large hernia. At the end of the procedure, they can be used as PF or excised.
- Care should be taken to not make the sac/peritoneal flap too thin. Generally, the sac is surprisingly tough. The sac at the center of the hernia may not be separable from the scarred skin and should be sacrificed.
- PF should be kept only as wide as required for a tension-free closure. Any excess PF should be excised at the time of closure.
- Our improvisations over the Original PF Technique: Sometimes we face problems in dissecting the skin from the hernial sac at the beginning of the surgery. This is especially in the midline where there is scarring from the previous surgery. To alleviate this, we enter the abdomen from one end in the midline and do adhesiolysis under the vision with the progressive bisection of the skin and sac. The bisected skin is then shaved off preserving as much sac as possible (Fig. 19.17).

19.8 Complications and Management

The potential complications of this procedure are seroma, hematoma, surgical site infection, wound dehiscence, post-operative pain, recurrence, and pseudorecurrence (bulge) as with all hernia procedures. In large hernias which usually need a bridging TAR the complication rate reported by Alkhatib et al. was 10% SSI, 2% mesh exposure, 5% partial mesh excision, 16% surgical site occurrences requiring procedural intervention (SSOPI), and 46% composite recurrence (recurrence + pseudorecurrence) [7]. The complication of TAR plus in our series of five patients was one superficial SSI, no seroma, readmission, recurrence, or mortality [6]. In another study of 17 patients, there were five (26%) surgical site occurrence (SSO) (two seroma, two SSI, and one cellulitis) [11]. In the median follow up of 11 (4–28) months there was one (5.8%) recurrence and four (23.5%) bulge (pseudorecurrence). Although the data is small, the comparisons do show favorable outcomes with TAR plus.

19.9 Conclusion

The TAR plus procedure seems to be a useful addition to the armamentarium of procedures for large midline ventral hernias. It has the potential of reducing the recurrence, pseudorecurrence, SSO, and SSI seen in bridging TAR. It is also useful for cases with loss of domain. It has the potential to reduce postoperative ventilatory requirement and intra-abdominal hypertension.

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20 Extraperitoneal Repair for Parastomal Hernia

Eric M. Pauli and Parth Sharma

20.1 Introduction

Regarded as one of the most challenging hernia scenarios, parastomal hernias require a well-planned and well-executed surgical approach to afford the highest chance of a successful repair. Surgical decision-making at the time of ostomy creation has a significant impact on subsequent parastomal hernia formation. Unfortunately, hernias still occur in as many as 50% of all ostomies [1–3]. This chapter will review methods of extraperitoneal repair for parastomal hernias.

20.2 Indications and Case Selection

A comprehensive discussion of the decision to pursue surgical repair of a parastomal hernia is beyond the scope of this work, but in general we reserve operative management for symptomatic patients. Such symptoms include pain, ostomy appliance fitting issues such as leak and/or need for frequent changes (Fig. 20.1), rapid enlargement, ostomy dysfunction, and bowel obstructive issues. It should also be noted that many patients with an ostomy (and a parastomal hernia) will have a concomitant midline incisional hernia. Incisional hernia symptoms need to be included in the decision-

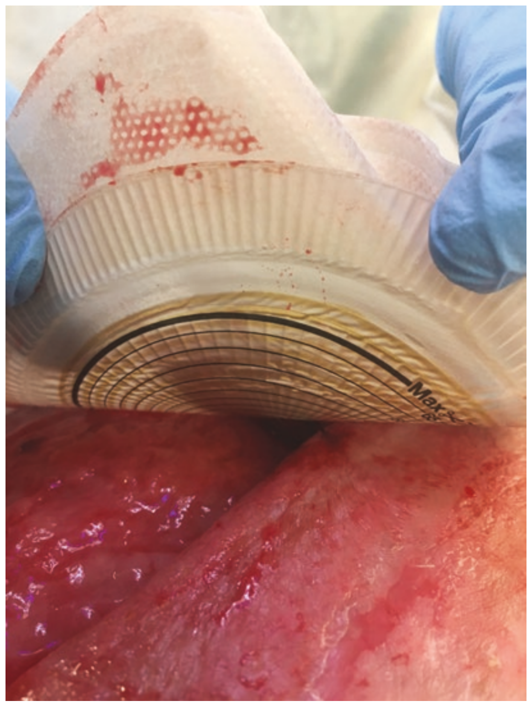

Fig. 20.1 Significant peri-stomal skin irritation from leak of enteric contents under the appliance face plate in a patient with a parastomal hernia warranting repair

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making process for the management of the ostomy hernia as well, as it is frequently impossible to manage one without managing the other; the converse is also equally true.

While the modern descriptions of extraperitoneal parastomal hernia repair were described for an open approach capable of handling midline and parastomal repairs, others have adapted the technique to a minimally invasive/robotic approach as well as for repairs addressing only parastomal hernias (not associated concomitant with midline components) [4–6]. As such, an extraperitoneal approach can be offered to patients via laparoscopic, robotic, or open methods and can be used to address isolated parastomal hernias or those occurring with additional incisional hernias.

20.3 Contraindications

Contraindications to an extraperitoneal repair are based primarily on the overall complexity of these operations. Surgeons inexperienced with extraperitoneal hernia repairs and posterior component separation techniques (open or minimally invasive) should not attempt these operations without mastering more simple operations first. Additionally, these repairs are all mesh-based. As such, patients with a contraindication to mesh, in particular, mesh placed adjacent to the bowel, should not be considered for these operations. Special consideration should be given to patients who have an ostomy as a result of inflammatory bowel disease, in particular Crohn's disease. As with all parastomal hernia operations, loop stomas are challenging to deal with, and consideration should be given to converting the loop ostomy to an end ostomy (or end loop).

Creation of an extraperitoneal space requires significant time, and we generally do not offer these operations to patients in an emergency. Such patients are likely better served with a simpler operation, such as hernia reduction and primary closure. The same is true for patients with medical contraindications to prolonged surgery and patients with contraindications to abdominal access. In such circumstances, an open, extra-abdominal approach (either primary closure or onlay repair) is our preferred method.

20.4 Instruments and Energy Source

20.4.1 Open Approach

Beyond a variety of handheld retractors and a handheld monopolar electrosurgical pencil, no specialty instruments or advanced energy sources are needed for the open extraperitoneal approach for parastomal hernias. If substantial bowel work is indicated (such as a resection or mobilization) an advanced bipolar device or ultrasonic device may be preferred by the surgeon but is not mandatory.

20.4.2 Laparoscopic Approach

For both a traditional laparoscopic approach and an enhanced-view total extraperitoneal (eTEP) approach, standard laparoscopic equipment (ports, 0° and 30° lenses, graspers, needle drivers) are indicated. At least one 10–12 mm port is needed for the introduction of the retromuscular mesh.

Unlike the open approach, many surgeons utilize an advanced bipolar or ultrasonic device for these operations, in particular for the formation of the retromuscular pocket. There is no clinical data to support the superiority of these devices over monopolar energy in these operations.

20.4.3 Robotic Approach

Both the da Vinci® Xi and Si system (Intuitive Surgical, Sunnyvale, CA) have been utilized for extraperitoneal parastomal hernia repairs, generally utilizing a three-port configuration. A single dock method (with ports opposite the ostomy) can be utilized for isolated parastomal hernia, whereas a double dock (six port) method is used if there is a midline or contralateral hernia(s) warranting simultaneous repair. Most surgeons utilize a 30° camera. Commonly used robotic instrumentation includes graspers, bipolar grasper, monopolar scissors, and needle driver(s).

20.5 Team Setup, Anesthesia, and Position

There are no particular team considerations for extraperitoneal parastomal hernia repair beyond those discussed elsewhere in this text for complex open or minimally invasive hernia repairs. Having a team familiar with the key steps of the procedures (see below) and capable of anticipating and managing intraoperative occurrences facilitates a smooth operation. This effect is magnified for minimally invasive (in particular robotic) repairs. Robotic extraperitoneal parastomal repairs are technically demanding operations. Having a good bedside assistant capable of trouble-shooting port issues, making smooth instrument exchanges, and working an assist port (if one is used) can make the difference between a successful robotic repair and the need to convert to an open operation.

Extraperitoneal parastomal repairs occur under general anesthesia regardless of the surgical approach taken. The operations can take significant time to complete (often greater than 4 h) and as such patients need to be appropriately padded, monitored, and prophylactically anticoagulated for a lengthy operation. For open operations, the insensible volume losses can be substantial and volume resuscitation is indicated (i.e., low volume strategies are not needed as there are rarely bowel anastomoses being performed). Despite their length, blood loss is generally minimal for these surgeries, and we do not routinely type and crossmatch patients for transfusion. Pain management algorithms follow standard pathways for nonparastomal repairs. We prefer a transversus abdominis plane blockade with volume expanded liposomal bupivacaine (266 mg/20 mL Exparel; Pacira Pharmaceutical, Inc., Parsippany, NJ with 180 mL of saline and injected into the intramuscular plane with an 18-gauge needle) under direct visualization (Fig. 20.2) or over ultrasound-guided methods [7].

Patients are positioned supine on the operating table. For an open repair, we prefer to have arms abducted whereas we tuck both arms for minimally invasive repairs. Table flex can also be used to open the space between the costal margin and anterior superior iliac spine for minimally invasive operations. For ostomies of the gastrointestinal tract (i.e., ileostomy or colostomy), we sew the ostomy closed at the onset of the case to prevent spillage of enteric content onto the operative field (Fig. 20.3). For ostomies of the urinary tract (ileal conduit, colon conduit, Bricker pouch, Indiana pouch), we place a Foley catheter into the ostomy after we sterilely prep and drape. In all circumstances, we mark out old scars as well as the loca-

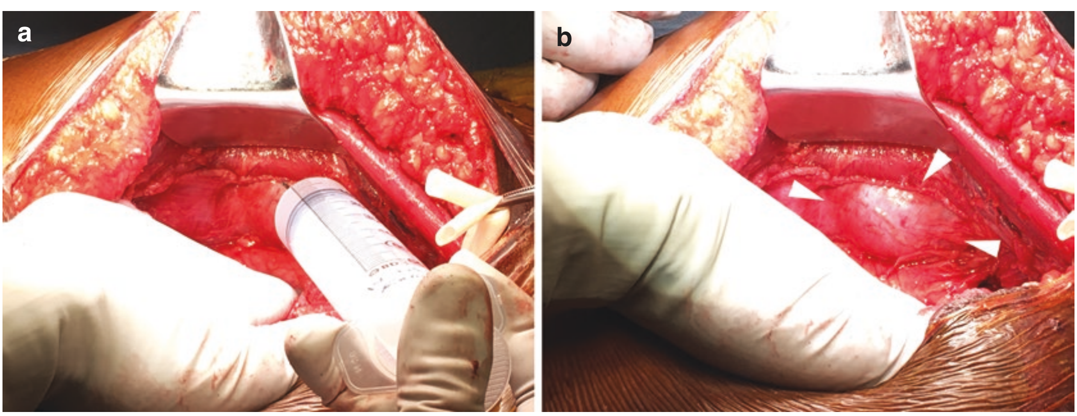

Fig. 20.2 Direct visualization transversus plane block during open extraperitoneal parastomal hernia repair. (**a**) injection of volume-expanded liposomal bupivacaine immediately lateral to the cut edge of the transversus abdominis results in (**b**) building of the transversus abdominis muscle as fluid enters the intermuscular plane below the internal oblique muscle

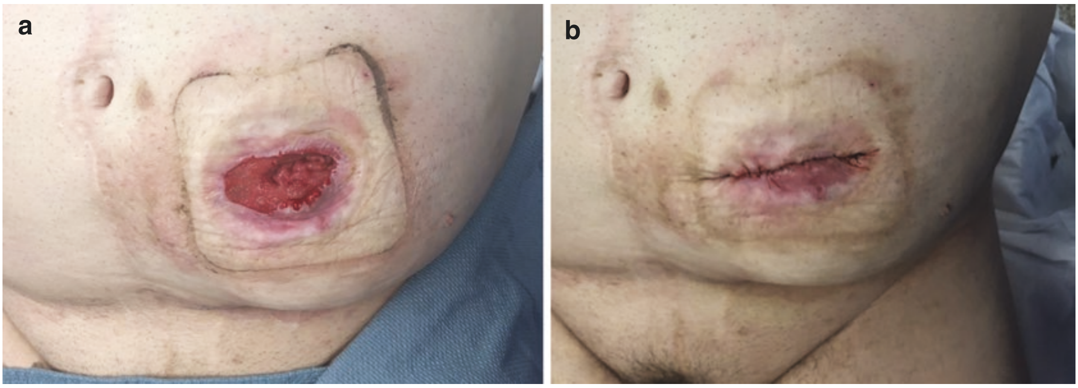

Fig. 20.3 End descending colostomy in a patient with a parastomal hernia (**a**) before and (**b**) after the ostomy has been sutured closed in preparation for surgical repair

tion where the patient's ostomy appliance face plate sits on their skin and then cover the abdomen with iodine-impregnated adhesive drapes.

20.6 Key Steps

The key steps to an extraperitoneal parastomal hernia repair are similar in nature although perhaps different in order based on operative approach (open vs. minimally invasive) and surgeon preference. They include:

- Safe access to the peritoneal cavity (or the retro rectus space in the case of an eTEP operation)
- Reduction of hernia content and safe adhesiolysis (for an eTEP repair this step is negated)
  - If a Sugarbaker mesh configuration is chosen, freeing adhesions to the portion of bowel that forms the stoma is needed to permit tension-free lateralization
- Deciding if the stoma will be relocated to a new position or kept in situ
  - With subsequent takedown and mobilization from the abdominal wall if indicated
- Retrorectus dissection includes the creation of a retrorectus plane circumferentially around the ostomy without damaging it
  - For stomas that are not centered in the rectus body (or are lateral to the rectus) there may be minimal space lateral to create this plane
- Transversus abdominis release (TAR) with lateral dissection in the preperitoneal or pre-transversalis planes
- Contralateral retromuscular dissection (retrorectus dissection with TAR if needed)
  - For eTEP, this step may have occurred first as the access point may have been the contralateral retrorectus space opposite to the ostomy with a subsequent crossover
- Closure of the posterior layers of the repair to create an intact retromuscular pocket with tailoring considerations for the type of mesh configuration chosen (Fig. 20.4)
  - *Cruciate configuration*—a defect is created at the anticipated location of the newly formed ostomy site
  - *Keyhole configuration*—the posterior layer is snugged around the ostomy to prevent additional loops of bowel from entering the extraperitoneal plane
  - *Sugarbaker configuration*—the posterior layer is intentionally divided to permit lateralization of the bowel within the extraperitoneal plane. The large defect is then closed transversely to the midline to prevent additional loops of bowel from entering the extraperitoneal plane

Fig. 20.4 Commonly used mesh configurations for extraperitoneal parastomal hernia repair. (**a**) Cruciate configuration. (**b**) Keyhole configuration. (**c**) Sugarbaker configuration. (Adapted from Wilson MZ, Winder JS and Pauli EM. Open Parastomal Hernia Repair in *Current Principles of Surgery of the Abdominal Wall 1st Edition*, edited by Yuri W. Novitsky, Springer, 2016)

- Mesh implantation, mesh fixation, and drain placement; the choice of these is based on surgeon preference
- Closure of fascial defects; including parastomal and midline defects
- Skin and superficial soft tissue closure
- Maturation of the ostomy (only needed if the stoma was taken down as part of the planned surgery)

20.7 Surgical Techniques/ Variations

20.7.1 Open Extraperitoneal Parastomal Hernia Repair

The modern description of an open extraperitoneal parastomal hernia repair by Raigani in 2014 is based on a TAR retromuscular repair. Interestingly, the basic concept of this type of operation was described as early as 1993 [8]. Alexandre and Bouilloit described a repair technique performed via a midline laparotomy that included ostomy takedown and relocation to a new position, the formation, or a retrorectus pocket with further lateral dissetion occurring between the transversus abdominis and internal oblique muscles (within the intermuscular plane), the placement of a 20 × 20 cm Dacron mesh prosthesis with a hole to pass the intestine to form the new ostomy. This operation widely covered the old hernia site with mesh and also primarily reinforced the new location with mesh at its formation as a form of parastomal hernia prophylaxis.

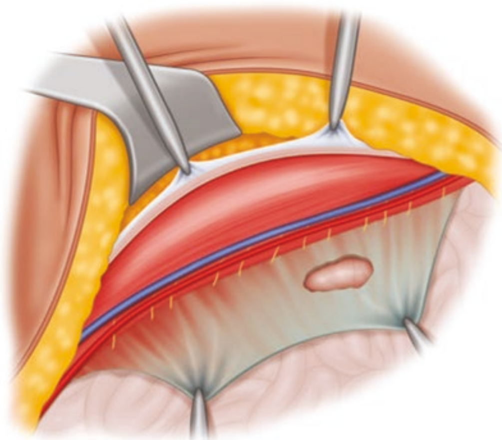

Fig. 20.5 Posterior rectus sheath taken down from the rectus muscles medial to the traversing neurovascular bundles of the linea semilunaris. There is a defect posterior sheath at the location of the old ostomy/parastomal hernia site. (From Wilson MZ, Winder JS and Pauli EM. Open Parastomal Hernia Repair in *Current Principles of Surgery of the Abdominal Wall 1st Edition*, edited by Yuri W. Novitsky, Springer, 2016)

As described by Raigani et al., open extraperitoneal parastomal hernia repair begins with a midline laparostomy incision, followed by complete enterolysis, takedown of the ostomy, and bowel mobilization to permit the ostomy to be reformed on the contralateral side. Release of the posterior rectus sheath then begins with the understanding that there will be a defect in the sheath at the location where the parastomal hernia is located (Fig. 20.5).

Attempts can be made to mobilize the parastomal hernia sac from the subcutaneous tissues and leave it in continuity with the posterior rectus sheath to make closure of this defect easier, but this step is only helpful if the defect is very large. Most defects can be managed with a primary closure without the need for hernia sac utilization. Subsequently, a transversus abdominis release is performed to expand the retromuscular pocket and allow a lateral overlap of mesh with the ostomy site defect (Fig. 20.6). The technical steps of open TAR are well described elsewhere in this book.

On the side contralateral to the parastomal hernia, a similar dissection is undertaken. If the rectus muscles are of sufficient width, release of the posterior rectus sheath may be sufficient to pemit repair of midline hernias with adequate overlap (5–8 cm). However, some patients (with narrow rectus muscles or with large midline hernias) may require a contralateral TAR to complete the repair of the midline hernia. Transversus abdominis release can also be utilized for any hernias lateral of the midline on the contralateral side, which may include old ostomy sites if a stoma relocation has been previously performed. Defects in the posterior layer of the repair are closed. A new defect is intentionally created at the site of the planned ostomy formation. This is generally on the contralateral side, but it can be remateured at the original location. The bowel is delivered through this defect and into the retromuscular space and the right- and left-hand sides of the posterior layer are closed together in the midline (Fig. 20.7).

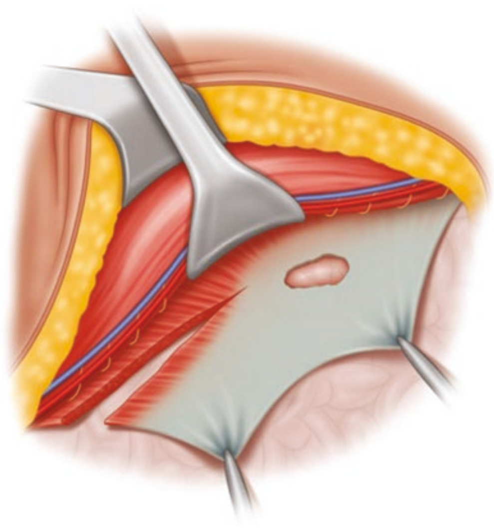

Fig. 20.6 Division of the posterior lamella of the internal oblique and the transversus abdominis muscle belly is performed medial to the linea semilunaris. This permits access to the preperitoneal/pre-transversalis planes. (From Wilson MZ, Winder JS and Pauli EM. Open Parastomal Hernia Repair in *Current Principles of Surgery of the Abdominal Wall 1st Edition*, edited by Yuri W. Novitsky, Springer, 2016)

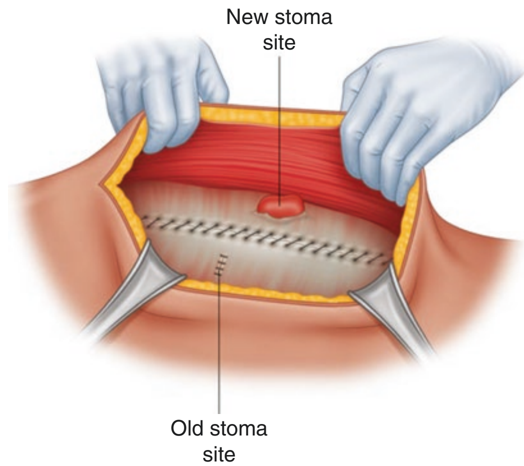

Fig. 20.7 Reconstruction of the posterior layers of the abdominal wall including: closure of the original stoma defect site, creation of a defect for the new ostomy location, and closure of the right- and left-hand sides to create an intact extraperitoneal pocket. (From Wilson MZ, Winder JS and Pauli EM. Open Parastomal Hernia Repair in *Current Principles of Surgery of the Abdominal Wall 1st Edition*, edited by Yuri W. Novitsky, Springer, 2016)

Subsequently, a large piece of mesh is positioned in the retromuscular pocket and fixated. A variety of mesh types (biologic, synthetic) and fixation methods (suture fixation, no fixation) have been described. Our practice is to utilize a reduced-weight macroporous monofilament polypropylene mesh without suture fixation for these types of repairs. We do utilize 20 mL of fibrin sealant to affix the mesh to the posterior layer of the reconstruction. A cruciate incision is made in the mesh sufficient to snugly allow the bowel to traverse to the new ostomy site (Fig. 20.8). The incision created needs to accommodate the bowel without compromising the blood supply, without risking early erosion

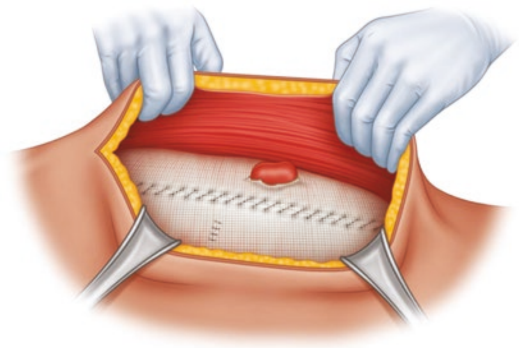

Fig. 20.8 Mesh placement in the retromuscular pocket with a cruciate defect in the mesh to accommodate the bowel for the new ostomy site. (From Wilson MZ, Winder JS and Pauli EM. Open Parastomal Hernia Repair in *Current Principles of Surgery of the Abdominal Wall 1st Edition*, edited by Yuri W. Novitsky, Springer, 2016)

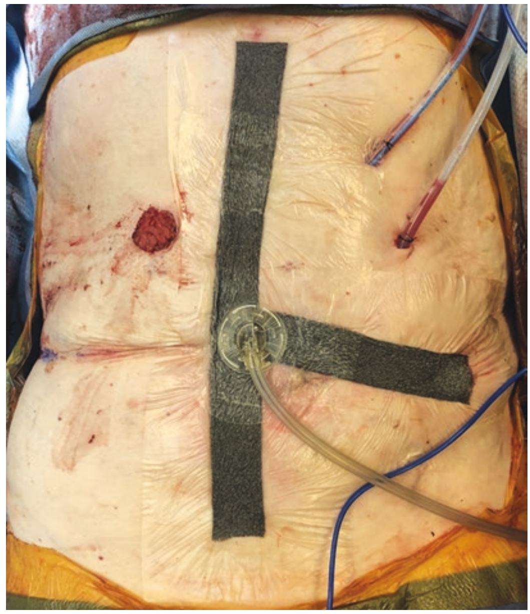

Fig. 20.9 Completion view of an open extraperitoneal parastomal hernia repair. New stoma on the patients right upper abdomen, midline, and old ostomy site skin are closed and have been covered with a closed incisional vacuum dressing. Two surgical drains are present in the left upper quadrant; one manages the retromuscular space while the other manages the subcutaneous space of the old stoma site

but without being so large as to allow additional content to herniate alongside the ostomy.

While not mandatory, we universally place a retromuscular drain to manage postoperative seroma volume. All fascial defects are closed with a monofilament slowly absorbable suture, including the old ostomy site defect and the midline fascial defect(s). The skin is typically closed in layers including a running midline closure. We utilize two strategies to manage the old stoma site. If the subcutaneous pocket created by the hernia content is large, we place a drain and close the skin over the drain. If the subcutaneous pocket is smaller or perhaps had a large amount of contamination from stoma mobilization or iatrogenic injury, we place a vacuum dressing in the wound and allow the skin to close by secondary intention. Regardless of the ostomy site management plan, we typically place a closed incisional vacuum dressing along the midline with a T-shaped extension to the old ostomy site (Fig. 20.9). Although such closed incisional dressings have not been shown to be of high value for routine abdominal wall reconstruction operations, we believe they have value if high-risk situations like open parastomal repairs [9]. Notably, the incisional vacuum dressing protects the wound from the frequently encountered ostomy bag leak that occurs as patients resolve their ileus.

20.7.1.1 Variation 1: Keyhole Mesh Configuration During Open TAR Parastomal Hernia Repair

In some patients, it is neither desirable nor possible to relocate the ostomy to a new position. Such circumstances include urinary conduits (where the conduit length and ureters prevent easy translocation) and patients with a foreshortened mesentery (obesity and Crohn's disease). In these circumstances, the retrorectus and TAR dissection can be performed around the ostomy and a keyhole mesh configuration utilized to reinforce the parastomal hernia. In these cases, we close the slit in the mesh back to itself using a permanent monofilament suture (Fig. 20.4b).

20.7.1.2 Variation 2: Stapled Transabdominal Ostomy Reinforcement with Retromuscular Mesh (STORRM)

In 2018, Majumder et al. reported a modification of the Raigani et al. open parastomal hernia repair method just described [10]. Recognizing that most recurrences with this method occurred at the new ostomy location, they devised a method to form the stoma at the new location without creating a cruciate incision in the fascia or mesh by utilizing a circular end-to-end anastomosis (EEA) staple to create the trephine in the abdominal wall and mesh simultaneously. The method has the added benefit of permitting the stoma to traverse the layers of the abdominal wall (posterior sheath, mesh, rectus muscle, anterior fascia) without the angulation or kinking that can occur if the independent layers are not properly aligned. Unfortunately, the method has a similar rate of hernia recurrence to its predecessor operation. This may be true because the EEA staples do not interlock and permit the trephine to dilate over time (Fig. 20.10) [11].

20.7.1.3 Variation 3: Pauli Parastomal Hernia Repair (PPHR)

In 2016, our group described an extraperitoneal parastomal hernia repair method that combined the advantages of an open TAR parastomal repair with the advantages of mesh in a traditional Sugarbaker configuration (Fig. 20.4c) [5]. The repair begins with a midline incision and adhesiolysis but leaves the ostomy in situ. A release of the posterior sheath and subsequent TAR are carefully performed around the ostomy bowel creating a large retromuscular pocket lateral to the stoma (Fig. 20.11). Subsequently, the elements of the posterior layer of the reconstruction (posterior rectus sheath, peritoneum, and transversalis fascia) are divided in a linear fashion along the direction of the mesentery of the bowel that leads to the stoma (Fig. 20.12). The intentional defect is then closed, permitting lateralization of the bowel within the extraperitoneal/retromuscular plane. The contralateral dissection proceeds as necessary to manage the midline defect(s). Subsequently, the right and left sides of the plane are sutured together to create an extraperitoneal pocket with a large amount of

Fig. 20.10 Axial CT scan images of a patient with a prior STORRM parastomal hernia repair demonstrates substantial widening of ring of circular staples from its original 28 mm size accompanied by a recurrent parastomal hernia

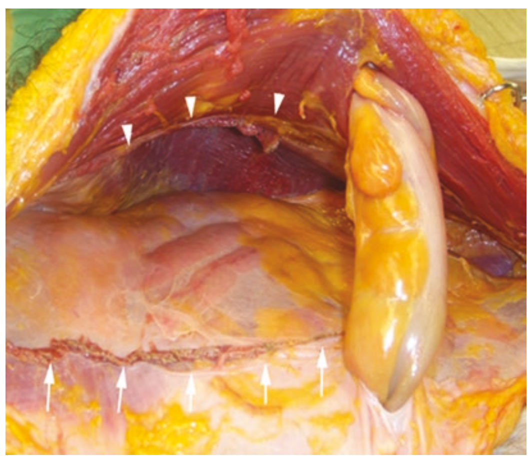

Fig. 20.11 Cadaveric model of a PPHR operation demonstrates a complete division of the transversus abdominis (arrowheads) insertion point on the posterior rectus sheath (arrows) with the subsequent formation of a wide extraperitoneal pocket for mesh placement

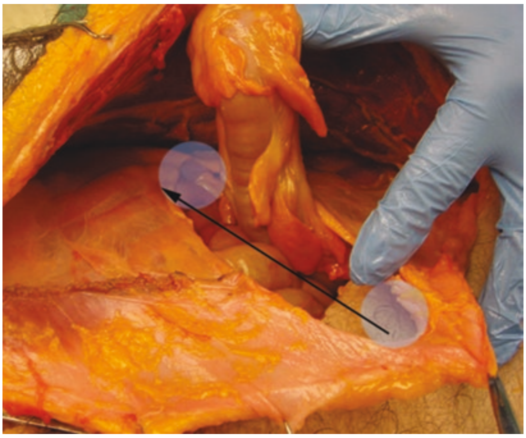

Fig. 20.12 Cadaveric model of a PPHR operation demonstrates the intentional division of the posterior abdominal wall elements to lateralize the location through which the bowel enters the extraperitoneal plane

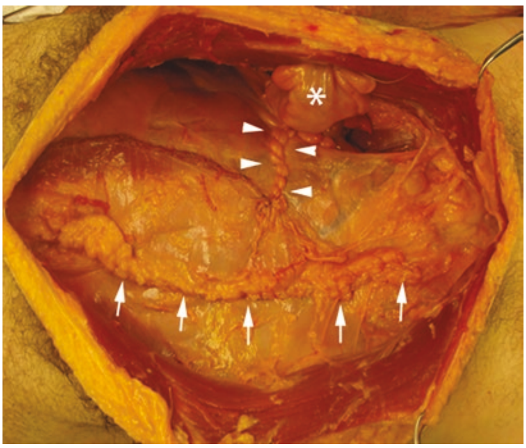

Fig. 20.13 Cadaveric model of a PPHR operation demonstrates the reconstruction of the posterior abdominal wall elements; midline closure (arrows), ostomy lateralization site (arrowheads). This provides a wide extraperitoneal pocket for mesh around the ostomy (*) and the midline fascial closure

bowel in the plane leading to the ostomy (Fig. 20.13). The retromuscular pocket is filled with mesh, widely overlapping the ostomy site defects in a Sugarbaker configuration. Although initially described with transfascial sutures to secure the mesh and lateralize the bowel, we have since abandoned the use of transfascial sutures for these repairs.

20.7.2 Minimally Invasive Extraperitoneal Parastomal Hernia Repair

Although laparoscopic repairs have been described, most surgeons performing minimally invasive extraperitoneal parastomal hernia repair choose to do so with robotic assistance. The major steps of the operation are parallel to those described for the open Pauli Parastomal Hernia Repair described above [12]. Ports contralateral to the ostomy site are placed first, to perform the component separation ipsilateral to the ostomy site (Fig. 20.14). The patient cart is docked at the patient's side opposite from the working ports, with the center column over the patient's hip. For the da Vinci® Xi or Si system (Intuitive Surgical, Sunnyvale, CA), the third working arm is docked. When a bilateral component separation is performed, ports are eventually placed on the side with the stoma under direct visualization, the patient cart is undocked after completing the ipsilateral component separation and moved to the opposite side of the patient.

The key elements of the PPHR remain the same when performed on a robotic platform; including posterior sheath release and TAR performed around the ostomy. An assistant port can be invaluable for retracting the bowel leading to the stoma during robotic-assisted component separation as it is critical that the bowel not be injured during this portion of the operation. Once the TAR has been performed and a wide extraperitoneal pocket has been created, the posterior elements of the abdominal wall are incised and the stoma lateralized in the retromuscular pocket, exactly as described for the open version of the operation (Fig. 20.15). Some surgeons choose to suture the bowel of the stoma to the transversus abdominis muscle with absorbable suture to help hold the bowel in a lateralized position. This facilitates closure of the posterior layer as well as the subsequent mesh placement. The parastomal fascial defect is closed robotically prior to placing ports on the side ipsilateral to the stoma and redocking the robot. Following contralateral

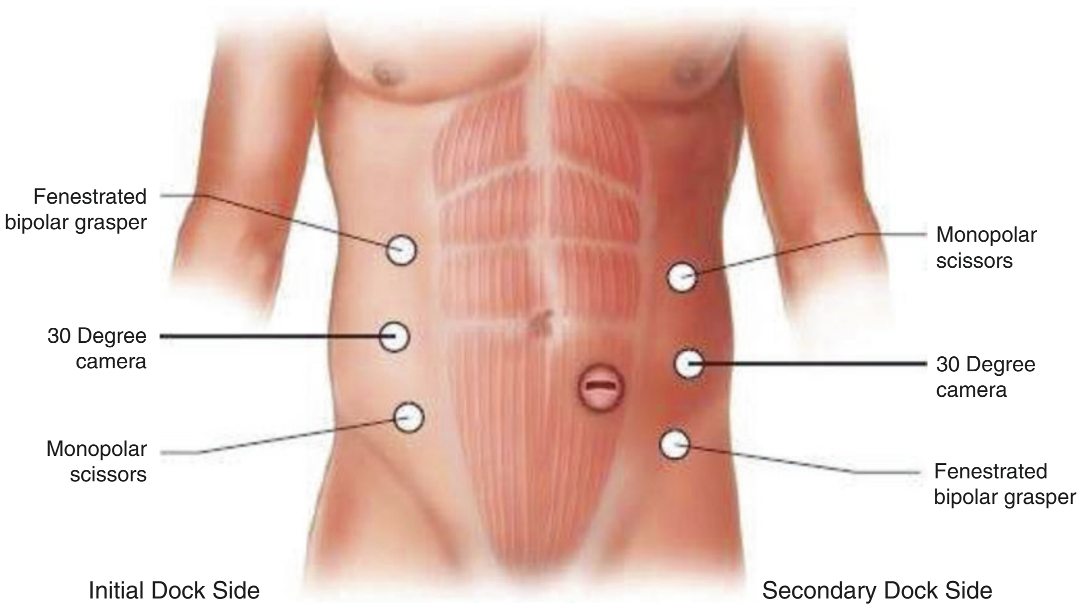

Fig. 20.14 Port placement and instrument choice for performing a robotic-assisted Pauli Parastomal Hernia Repair (Adapted from Morrell DJ, Blatnik JA, Pauli EM. Robotic Parastomal Hernia Repair in *Robotic Hernia Surgery: A Comprehensive Illustrated Guide*, Edited by Yusuf Kudsi. Springer, 2020)

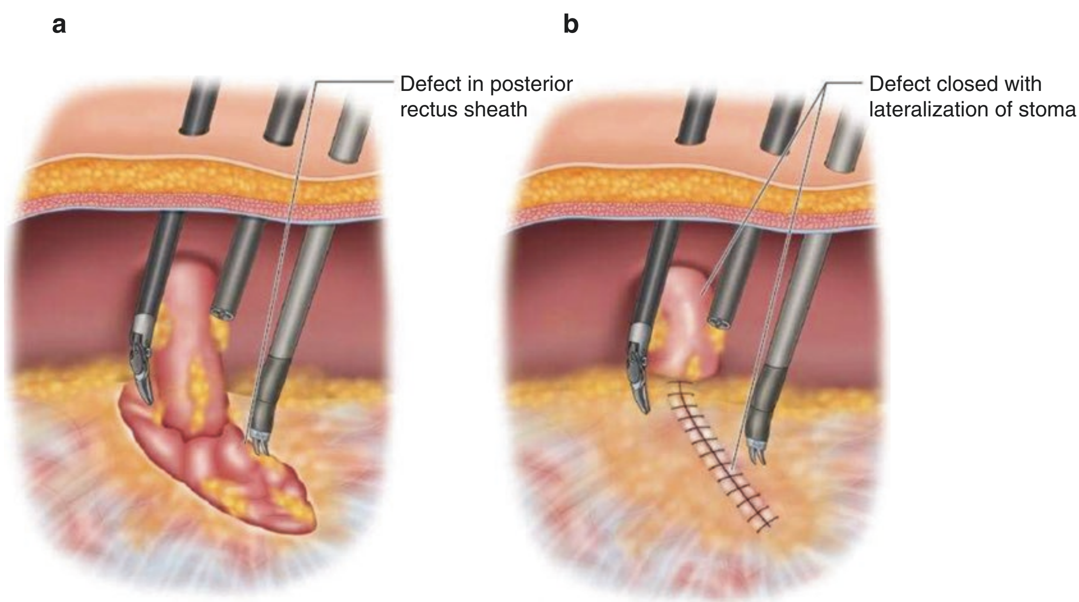

Fig. 20.15 Lateralization of the bowel into the extraperitoneal space: (**a**) the defect in the posterior layer is first extended laterally and (**b**) subsequently closed from lateral to medial, with the final proximal ostomy location lateralized. (From Morrell DJ, Blatnik JA, Pauli EM. Robotic Parastomal Hernia Repair in *Robotic Hernia Surgery: A Comprehensive Illustrated Guide*, Edited by Yusuf Kudsi. Springer, 2020)

component separation, the midline posterior sheaths are sutured to each other in the midline (generally using a 2-0 barbed suture). The fascial defects in the midline are closed (generally with a 0 barbed suture) and the entire retromuscular pocket is filled with mesh, which takes a Sugarbaker configuration around the bowel. The robot is undocked, and ports are removed. Drains can be placed as desired.

20.7.2.1 Variation 1: Single Dock PPHR Operation for Isolated Parastomal Hernia

For patients with an isolated parastomal hernia, a single dock approach to the hernia can be utilized. Three ports are placed on the side contralateral to the defect. The extraperitoneal plane creation begins 5–8 cm medial to the parastomal hernia defect to allow a pocket with sufficient space for medial mesh overlap. In some circumstances, such as a patient with a wide rectus abdominis or a patient with a stoma set lateral within the rectus (or even through the semilunar line), this dissection can begin at the medial edge of the rectus itself. If an additional medial overlap is needed, preperitoneal dissection can be utilized before "plane hopping" into retrorectus plane. The remaining steps of the operation are similar to those described above, but the mesh placement and peritoneal flap closure occur as described in Chap. 13 (Transabdominal Preperitoneal (TAPP) Repair of Ventral Hernia).

20.7.2.2 Variation 2: Single Dock PPHR Operation for Parastomal Hernia and Small Midline Hernias

For patients with small midline hernia(s) in addition to a parastomal hernia, a single dock approach can be utilized as well. Three ports are placed on the side contralateral to the defect with care taken to keep the ports as lateral as possible. Based on the amount of midline overlap needed as well as patient tissue factors the midline hernia elements can be approached via a TAPP approach or via a Transabdominal Retromuscular Umbilical Prosthetic (TARUP) approach. As the dissection crosses midline to the side ipsilateral to the parastomal hernia, the retrorectus dissection and TAR proceed as described above.

20.7.2.3 Variation 3: eTEP PPHR Operation for Parastomal Hernia and Midline Hernias

For patients with small to medium midline hernia(s) in addition to a parastomal hernia, a laparoscopic or robotic enhanced view totally extraperitoneal (eTEP) approach can be utilized. As outlined elsewhere in this book (Enhanced View Totally Extra Peritoneal (eTEP) Repair for Midline Hernia), optical access to the retrorectus space on the side contralateral to the parastomal hernia is obtained. The retrorectus space is opened and additional working ports are placed. Crossover to the contralateral retrorectus space with the management of the midline hernia sac(s) and content occurs. Finally, the retrorectus dissection and TAR on the side of the parastomal hernia are performed. The remaining steps of the operation are similar to those described above, including the closure of the parastomal and midline hernias and placement of mesh in the extraperitoneal plane.

20.8 Tips and Tricks

- All the operations described in this chapter are challenging to perform and should only be undertaken by surgeons who have mastered the non-parastomal versions of the same operations (open PCS-TAR, rTAPP, rTAR).
- For the PPHR variant of the extraperitoneal repair, the incision in the posterior sheath does not need to be made in a straight lateral direction. We incise this layer in the direction of the bowel mesentery, which affords the maximal amount of lateralization. For example, when managing a descending colostomy hernia we incise the posterior layer towards the left upper quadrant, along the descending colon mesentery. For an ileal urinary conduit, the incision is directed towards the right lower quadrant. This is different than in a traditional intraperitoneal underlay mesh (IPUM) para-

stomal repair where the bowel is lateralized to the space between the ASIS and costal margin to permit transfascial suture fixation to the abdominal wall. By abandoning transfascial fixation in the extraperitoneal approach, additional mesh overlap can be obtained.

- For the eTEP variant of the extraperitoneal repair, beginning behind the contralateral rectus muscle and performing a crossover is generally necessary to allow working space to perform the TAR around the parastomal hernia and to afford medial mesh overlap. There may be some circumstances where dissection can start on the ipsilateral rectus muscle, but we do not generally recommend it.
- When configuring mesh for the PPHR variant of the extraperitoneal repair the prosthetic is often capable of reaching beyond the area where the lateralized bowel enters the extraperitoneal space. While the mesh can be cut flush at this level, we choose to make a small keyhole in the lateral most aspect of the mesh and wrap it around the bowel. This places the mesh in a keyhole configuration where the bowel enters the extraperitoneal plane and in a Sugarbaker configuration where the bowel exits the retromuscular plane and traverses the rectus abdominis muscle.

20.9 Complications and Management

Extraperitoneal parastomal hernia repair combines the complications of retromuscular hernia surgery with the complications of parastomal hernia repair. The complications of retromuscular repair have been described in great detail earlier in this text, and include seroma formation, retromuscular bleeding, and incorrectly performed component separations (leading to lateral hernias and rectus denervation). We will not delve into these issues here but will focus on complications unique to parastomal hernia repairs.

20.9.1 Infection

By definition, parastomal hernia repairs are not clean operations regardless of the operative approach or how the ostomy is managed during the operation. As such, they can be anticipated to have a higher rate of complications than a clean ventral/incisional hernia repair without gastrointestinal or urinary tract contamination. Prophylactic antibiotics at the time of surgery should be targeted toward these organisms, and any concern for postoperative infectious complications should also target these organisms in addition to skin flora. Most infections are superficial (Fig. 20.16), but deep infections (including mesh infections) and organ space infections can occur [4, 10, 13]. When assessing an infectious surgical site occurrence in a parastomal hernia patient, it is mandatory to rule out the possibility of stoma-related complication (injury, perforation, leak, ischemia) as the source of the infection.

Fig. 20.16 Surgical site infection in a patient following an open extraperitoneal parastomal hernia repair

20.9.2 Stoma Complications

The stoma site itself remains a source of complications following parastomal hernia repair. Regardless of whether the stoma is taken down and relocated or kept in situ, manipulation of the bowel during the course of the operation can result in iatrogenic injury to the intestine and its blood supply. Stoma-related complication rates are low, and similar across a series of parastomal hernia repairs [4, 10, 13]. They include immediate complications, such as enterotomy, ischemia, mucocutaneous junction disruption (Fig. 20.17), and bowel obstruction as a result of a tight mesh configuration around the bowel leading to the stoma. Long-term complications include mesh erosion into the bowel, a well-described complication of all types of mesh-based parastomal hernia repair methods. Many stoma-related complications require an operative intervention to definitively manage.

20.9.3 Recurrent Hernias

The published literature on the topic suggests that hernias occur/recur at the ostomy site in 6–16% of patients at the 1-year mark [4, 6, 10, 13]. Long-term recurrence rates are likely higher but are not reported in the literature at this time. The mechanisms of recurrence include expansion of the cruciate/keyhole defect in the mesh (Fig. 20.10), inadequate lateralization of the bowel within the retromuscular plane and subsequent inadequate Sugarbaker configuration mesh overlap and central mesh fracture (Fig. 20.18) [14].

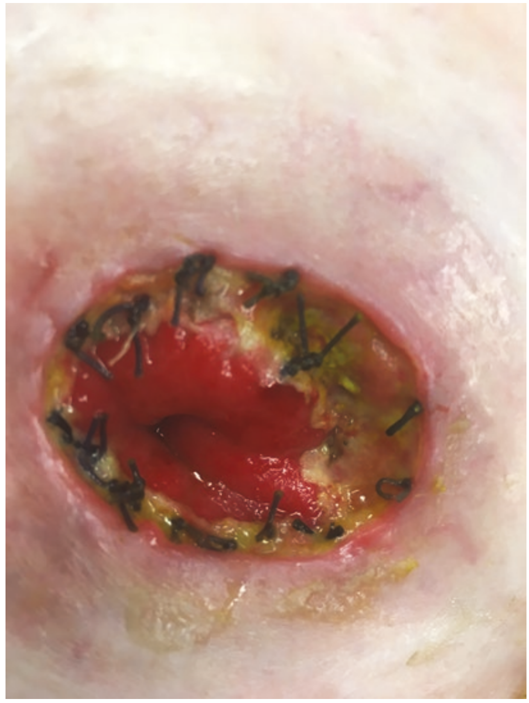

Fig. 20.17 Partial mucocutaneous junction disruption following an open extraperitoneal parastomal hernia repair

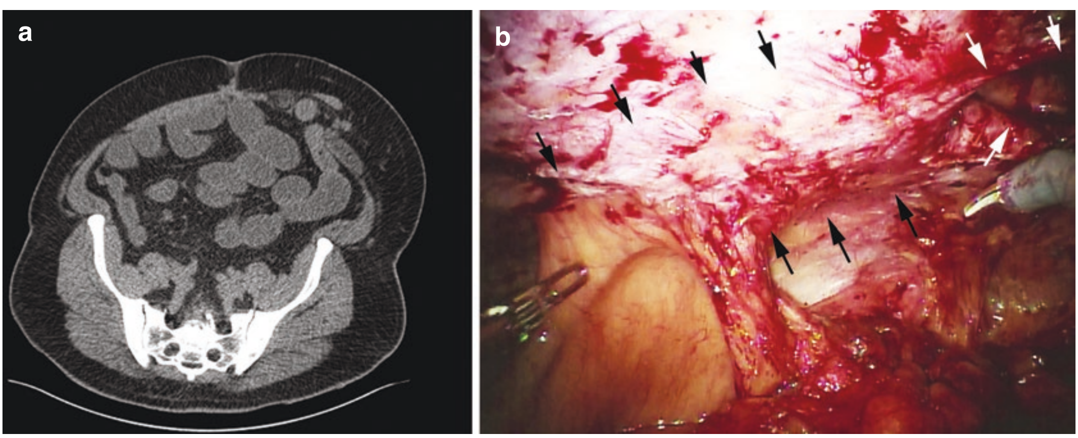

Fig. 20.18 Parastomal hernia recurrence following an open PPHR as a result of central mesh fracture. (**a**) CT scan demonstrates small bowel herniating through the left rectus abdominis. (**b**) At the time of robotic repair, a medial defect with central mesh fracture (white arrows) was identified with the end descending colostomy appropriately configured in a tunnel of retromuscular mesh in a Sugarbaker fashion (black arrows)

20.10 Conclusions

Extraperitoneal parastomal hernia repairs are among the most challenging abdominal wall reconstruction operations to perform but offer a variety of potential advantages over more traditional methods of repair. These operations should only be undertaken by expert surgeons well versed in the indications for such operations, the technical maneuvers needed to afford the repair, the multiple variations of the surgeries to address specific intraoperative clinical scenarios, and in the diagnosis and management of challenging postoperative complications.

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Part IV

Adjuncts in Hernia Surgery

21 Chemical Component Separation Technique: Use of Botulinum Toxin in Hernia Repair

Lydia L. Y. Tan, Davide Lomanto, and Sujith Wijerathne

21.1 Introductions

Botulinum toxin A (BTA) is a protein with neurotoxin activity produced by *Clostridium botulinum* with an inhibitory effect on presynaptic cholinergic nerve endings [1]. In 2006, Cakmak et al. investigated the use of BTA in vivo with 15 rats and demonstrated its potential in facilitating abdominal wall closure through the paralysis of abdominal wall muscles [2]. However, Ibarra-Hurtado et al. were the first to inject BTA in 12 patients between September 2007 and January 2009, successfully demonstrating that paralysis of lateral abdominal muscles allowed reduction of transverse hernia defect for a subsequent surgical tension-free closure [3]. Although BTA is a dangerous chemical [4], small well-calculated doses injected at specific points in the abdominal wall remote to vital muscles and viscera have a good safety profile and provide temporary paralyzing effect [5].

21.2 Indications

BTA has been used to facilitate fascial closure in various settings, such as complex abdominal wall hernia (CAWH), ventral incisional hernia, and even open abdomen.

CAWH is defined as a large hernia defect size larger than 10 cm; rerecurrence; loss of domain; large abdominal wall or soft tissue defect or enterocutaneous fistula; hernia in anatomically peripheral locations; and close to bone or local recurrent infection [6]. Component separation technique (CST) with mesh insertion has been the mainstay for treatment of CAWH, yet recurrence rates range from 4% to 32% [7]. However, CST has its drawbacks. Lateral herniation could be due to iatrogenic deep muscle injury during component separation resulting in lateral abdominal wall weakness [8]. Furthermore, as the lateral abdominal muscles (external oblique, internal oblique, transversus abdominis) insert through the rectus sheath in the linea alba, postoperatively contraction by lateral abdominal wall muscles exert a lateral force vector resulting in insufficient healing of the midline wound and predisposing recurrence of the ventral hernia [9].

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Thus, using BTA as a temporary reversible alternative to the permanent division of aponeurotic tissues in component separation has widened the surgeon's technological armamentarium.

Additionally, preoperative progressive pneumoperitoneum (PPP) described by Goni Moreno in 1947 has been used to aid fascia closure. Rooijen et al. performed a systematic review and meta-analysis comparing PPP and BTA use and found that recurrence with either technique was low, but complications after BTA use were minor (e.g., back pain, cough, bruising at injection sites) whereas for PPP they were more severe (e.g., severe respiratory failure secondary to abdominal compartment syndrome resulting in death) [10]. Furthermore, the flaccid relaxation of abdominal muscles after BTA administration decreases intra-abdominal pressure and reduces the need for and duration of invasive ventilation support.

However, the indications for when BTA should be used preoperatively to facilitate fascial closure have been a debate. Table 21.1 depicts the various research studies of when BTA has been used in clinical practice. They can be divided into three broad categories. Firstly, in large hernia with loss of domain. Secondly, surgeon preference or expected difficulty in closing the midline wound [16, 17]. Thirdly, when dealing with an open abdomen.

Furthermore, BTA can be used for its analgesic purposes such as in treating muscle spasms after laparoscopic hernia surgery, as demon-

Table 21.1 Research demonstrating the use of preoperative BTA for facilitating fascia closure

Author (Year)	Type of study	Number of patients	Types of hernia	Surgical technique
Rodriguez-Acevedo (2017) [11]	Prospective observational	56	Minimum facial defect 6 cm and/or loss of domain more than 20%	Preoperative BTA and laparoscopic mesh repair
Yurtkap (2021) [12]	Prospective observational	23	Primary or incisional ventral hernia more than 12 cm	Preoperative BTA and PPP and anterior or posterior component separation with
Catalan-Garza (2020) [13]	Prospective observational	36	Transverse hernia defect at least 10 cm and loss of domain	Preoperative BTA with primary hernia closure and/or anterior component separation
Bueno-Lledo (2020) [14]	Prospective comparative observational	80	Midline incisional and primary hernias with transverse diameter 11–17 cm	Preoperative BTA followed by open rives repair versus open component separation
Bueno-Lledo (2020) [15]	Prospective observational	100	Ventral incisional hernia with loss of domain	Preoperative BTA and PPP followed by anterior component separation or transvevrsus abdominis release or rives-Stoppa repair
Zendejas (2013) [16]	Prospective comparative observational	88	Incisional hernia	Surgeon's preference in using preoperative BTA to reduce postoperative pain
Nielsen (2020) [17]	Retrospective study	37	Large ventral hernia with loss of domain	Surgeon's clinical suspicion of difficult abdominal closure
Ibarra-Hurtado (2009) [3]	Prospective observational	12	Recurrent incisional hernia after open abdominal surgery	Preoperative BTA followed by simple abdominal closure with or without component separation
Ibarra-Hurtado (2014) [18]	Prospective observational	17	Male trauma patients with hernia secondary to open abdomen management	Preoperative BTA followed by simple abdominal closure with or without component separation
Zielinkski (2013) [19]	Retrospective observational	18	Open abdomen after damage control laparotomy	Preoperative BTA followed by primary fascial closure

strated by Smoot et al. [20]. BTA also has the advantage of offering narcotic analgesia as the blockage of acetylcholine receptors prevents the release of substance P from presynaptic motor nerve endings [21].

21.3 Contraindications

Patients with the following conditions should not be treated with BTA

- Pregnant or breast-feeding patients [22]
- Allergy to BTA or its components [22]
- Known neuromuscular disorder or sensitivity to BTA [22]
- Chronic respiratory dysfunction [23]
- Spinal problems, due to the significant role in truncal and spinal stability conferred by transversus abdominus [24]

21.4 Steps

The following are based on the author's recommendations.

1. Counselling and consenting of the procedure by explaining the steps, risk versus benefit to the patient is first discussed at the surgical clinical visit and then revisited prior to the procedure by the interventional radiologist.
2. Preparation of the setup with 6 vials of 50 IU Botox® (Botulinum Toxin A), Sterile water for dilution, 6 sets of 25 G spinal needles (Fig. 21.1). Ultrasound kit should include minimum of linear transducer (4–12 MHz) in sterile housing; chlorhexidine can additionally be used as a coupling agent.
3. Ibarra-Hurtado's technique [3] is utilized. The patient is placed in a left or right lateral position and five sites are identified. Two on mid axillary line at equal distance, three more on anterior axillary and mid-clavicular lines, and reciprocal is produced for another side as well (Fig. 21.2).
4. Ultrasound is used to identify the external oblique muscle (Ex. Ob M.), internal oblique

Fig. 21.1 Setup of equipment for BTA administration

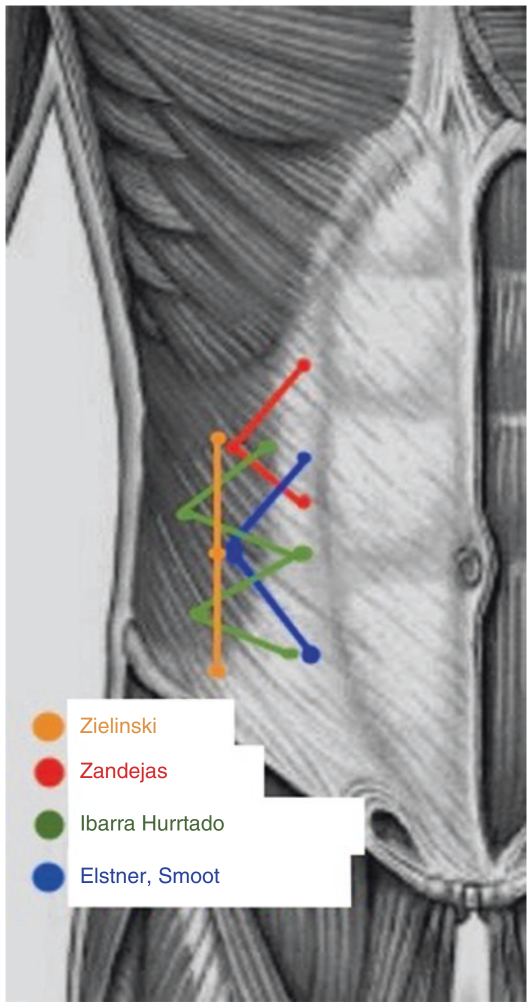

Fig. 21.2 Sites for BTA injection (Image courtesy: Dr. Pallawi Priya, Belle Vue Clinic, Kolkata)

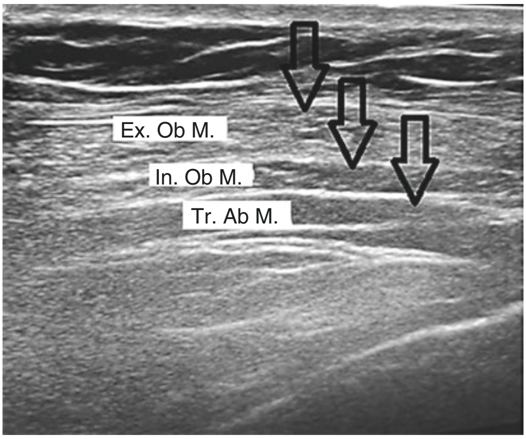

Fig. 21.3 Ultrasound guidance to locate sites for BTA injection. External Oblique Muscle (Ex Ob M.); Internal Oblique Muscle (In. Ob M.); TransversusAbdominus (Tr. Ab M)

muscle (In. Ob M.), and transversus abdominus (Tr. Ab M) (Fig. 21.3).

5. Inject 50 IU of BTA into each external oblique, internal oblique muscle, and transversus abdominus bilaterally under ultrasound guidance (total of 300 IU of BTA used).
6. Advise patients to avoid coughing or taking a sudden deep breath during the procedure to avoid damaging underlying structures.
7. Discharge patients with an abdominal binder to be worn for the next 3–4 weeks, until the hernia repair surgery is undertaken [25].

21.5 Tips and Tricks

21.5.1 Selection of Patient

There is a lack of consensus on the selection criteria for which patients will benefit the most with BTA. Based on our limited number of cases, we recommend using preoperative BTA for patients undergoing CAWR with a defect size of 6–8 cm, to achieve tension–free repair without component separation. This is because the average length of frontal abdominal musculature from the linea alba to mid-axillary line is about 15–20 cm and the length gained by BTA administration is 3–4 cm on each side; equating to 6–8 cm in total. It can also be used for larger defects as an adjunct to CST.

21.5.2 Choosing the Injection Site

Elstner, Ibarra-Hurtado, Zielinski, and Zandejas have described four different techniques but with one end result [3, 16, 19, 23] (Fig. 21.2). They concluded that BTA administration should be between mid-clavicular and mid-axillary line. Pattern could be of straight line or triangular from costal margin to superior iliac fossa. We utilize the Ibarra-Hurtado technique, where the patient is placed in left or right lateral position and five sites are identified. Two on mid axillary line at equal distance, three more on anterior axillary and mid-clavicular lines, and reciprocal is produced for another side as well. These techniques give advantage of increased length and decreased thickness of lateral ventral abdominal muscles.

21.5.3 Volume of BTA Injected

There is great personal bias in the selection of dose for BTA. Doses used are varying in different studies, but the main principle is to inject a “good effective” amount with “best” dilution at an “appropriate” time at the “best site.”

Varying total doses of BTA range from 100 IU [26], 300 IU [16, 23], and 500 IU [3, 18]. In most studies, BTA was diluted with 0.9% saline prior to administration thus reducing the concentration to 2 IU/mL but in some studies, 50 IU/mL and 100 IU/mL concentrations are also used. The diluted BTA was then injected equally into the various injection sites as discussed above.

We propose a more conservative approach, by using 50 IU at each of the external oblique, internal oblique muscles, and transversus abdominus thus bringing the total amount to 300 IU with the six injections given.

21.5.4 Timing of Preoperative BTA

During the early usage of preoperative BTA, studies have shown that BTA requires at least 2 weeks before the paralyzing effect reaches its maximum [5]. However, the systematic review by Rooijen et al. showed that BTA is effective when given 6–45 days preoperatively [10]. We recommend minimum 4 weeks before surgery.

21.6 Complications

Most common complications include weaker sneezing, weaker coughing, dyspnea, or abdominal distension/bloating [23]. This is due to the reduced effectiveness of abdominal wall muscle contraction after the lateral abdominal muscles are paralyzed. Thus, we recommend patients to wear abdominal binder after BTA injection. Furthermore, by reducing the volume of BTA injected, and sparing the transversus abdominis muscle, core muscle strength may be retained to reduce the side effects.

Local complications such as bruising at injection site and back pain may also occur [11].

21.7 Literature Review

Most studies of BTA are weak as they are observational studies conducted in a small population size. Furthermore, there is heterogeneity concerning study design, surgical procedure, and preoperative BTA administration. Additionally, Rodrigo et al. study using electromyography have demonstrated that the effect of BTA-induced paralysis of abdominal muscles may be nonuniform in terms of the degree, distribution, and duration [27]. Figure 21.4 shows abdominal wall muscle paresis after BTA injections contributed by our colleagues.

While most studies have demonstrated the usefulness of preoperative BTA, Rodriguez et al. have suggested the BTA could be used postoperatively as an adjunct to aid healing of the rectus sheath and protect midline wounds during the first 3 postoperative months [11].

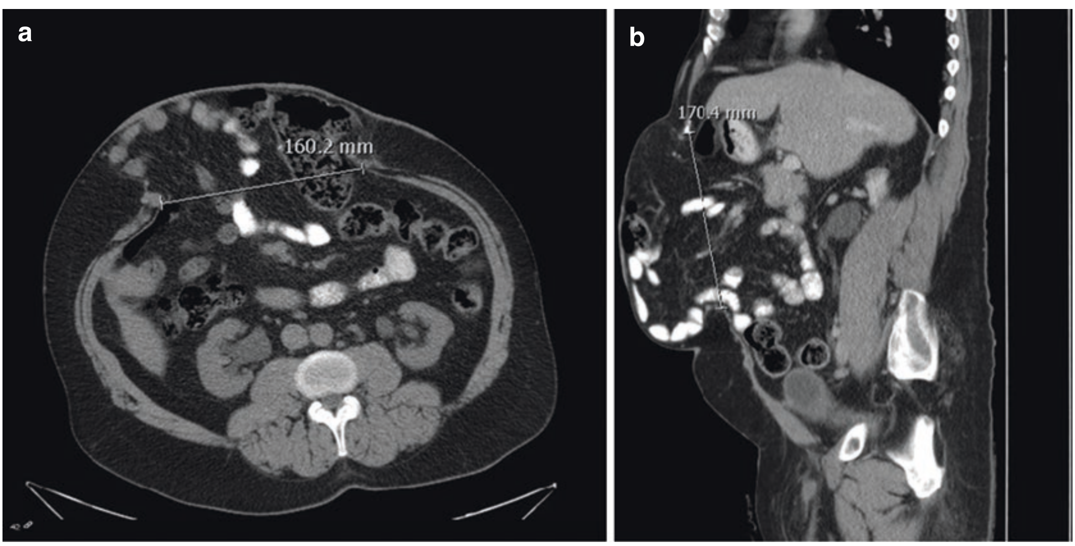

Fig. 21.4 CT abdomen images before and after BTA injection. (**a**, **b**) Before BTA, (**c**, **d**) after BTA. Note the thinning of the muscles post-BTA along with reduction in the sac size (Image courtsey: Dr. Avinash Katara, P D Hinduja Hospital, Mumbai)

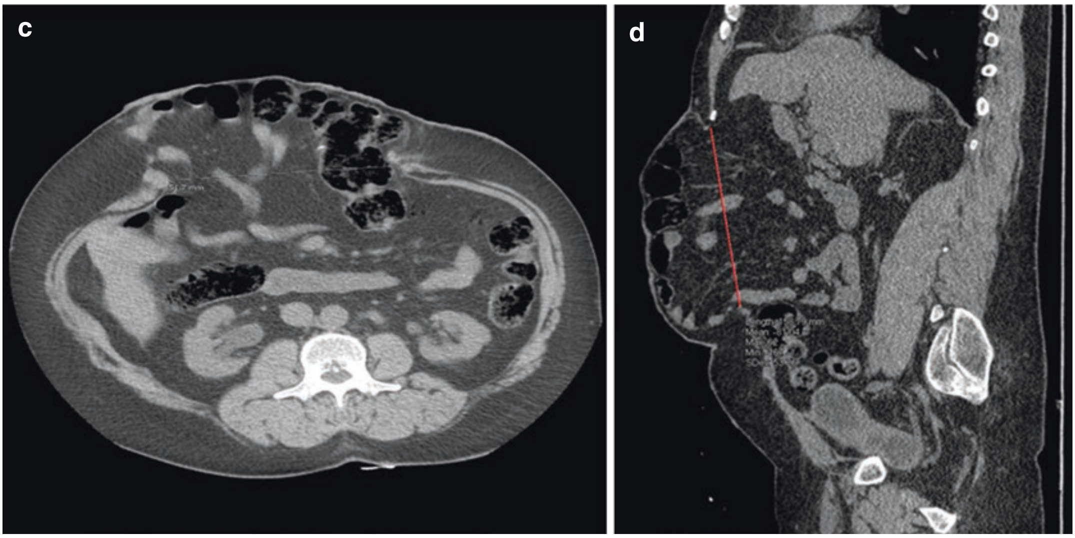

Fig. 21.4 (continued)

21.8 Conclusion

BTA is a useful pharmacological adjunct to aid fascial closure in CAWH and open abdomen, be it used to avoid the need for component separation, or in combination with other surgical techniques. The dual advantages of aiding tension-free repair and analgesic effects have raised the interest of surgeons in using BTA. Perhaps large randomized control studies on the dosage, techniques, and timing of BTA could be conducted for a consensus in BTA administration to be attained.

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22

Chemical Component Separation Technique in Hernia Repair

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22.1 Introduction

Ventral hernias are one of the most common and morbid complications of abdominal surgery, with an incidence of 20–30% following laparotomy [1]. Annually, there are more than 500,000 ventral hernias repaired in this country each year [2]. There are certain patient and operative features, such as obese body habitus or contamination (e.g., mesh infection or fistula), that make abdominal wall reconstruction (AWR) inherently more complex [3, 4]. Repair of large and reoperative hernias also presents a challenge due to scarring and distorted tissue planes in the reoperative field [5, 6]. In large hernia defects or patients with loss of domain (LOD) and lateral retraction of abdominal wall musculature, tension-free closure of the fascia can be challenging and failure to close fascia increases the risk of wound complications and hernia recurrence by three to five times [5, 7, 8]. As a result, rates of hernia recurrence after AWR have been reported up to 30% despite refinement of surgical technique and advances in mesh technology [9]. To improve fascial closure rates, component separation techniques (CST) of the abdominal wall musculature were developed, which involves the division of abdominal wall musculature. The most commonly utilized techniques are the external oblique release (EOR) or transversus abdominis release (TAR) which allow for the additional length of fascia towards the midline to assist with fascial approximation [6, 10]. However, CST does have notable drawbacks, including distortion of abdominal wall anatomy and increased risk of wound complications due to the creation of large subcutaneous tissue flaps [11].

Given the limitations of CST, additional surgical adjuncts have been developed to aid in fascial closure, most commonly the preoperative injection of botulinum toxin A (BTA) or the use of progressive preoperative pneumoperitoneum [12, 13]. BTA works by causing functional denervation of the abdominal wall by blocking the release of the neurotransmitter acetylcholine, which is an excitatory neurotransmitter that acts at neuromuscular junctions [11]. BTA has been used in many areas of medicine, such as for the treatment of achalasia, anorectal disease, and for cosmetic purposes by plastic surgeons (e.g., wrinkle reduction) [14]. BTA was first injected into the lateral abdominal wall of rats and determined to significantly increase abdominal wall laxity after injection [15, 16]. As a form of chemical component separation, its use in AWR was first described in 2009 [17]. Preoperative injection of BTA allows the muscles of the abdominal wall to elongate and become more compliant therefore assisting in achieving primary fascial closure [13]. This is particularly useful in patients with large ventral

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hernias with LOD, or in patients with contaminated fields where implantation of synthetic mesh is not possible or development of tissue planes for component separation would yield even higher wound complication rates. Although its on-label use is in different muscles of the body with the same therapeutic goal, the use of BTA injection in the lateral abdominal wall is currently considered off-label by the Food and Drug Administration. Nonetheless, fascial closure, recurrence rates, and other outcomes of its use in large hernia repair have been thus far excellent making BTA a promising part of the future of complex AWR [18].

22.2 Indications for the Use of Botulinum Toxin in Abdominal Wall Reconstruction

As the use of BTA as an AWR adjunct is fairly new, there is currently no consensus on how to select patients that will benefit from preoperative BTA [19–21]. The decision about whether to utilize BTA is highly customizable and should involve input from both the surgeon and the patient. When selecting patients, it is important to consider not only the hernia defect size, but also, the loss of domain, location, and proximity to bony structures. Generally, BTA use is indicated for wider hernias, which require increased laxity in order to achieve fascial closure. LOD is a commonly used term in AWR with varying definitions. Generally, LOD refers to a loss in intra-abdominal volume in favor of a greater amount of volume being contained in a hernia sac [22]. Significant loss of domain is perhaps the greatest single most indication for the use of preoperative BTA.

Another important consideration for the efficacy of BTA is the location of hernia on the abdominal wall. The authors have found that patients with hernias that are located higher up on the abdominal wall are still likely to require CST despite the use of preoperative BTA [18]. Using the European Hernias Society classification system, patients who have M1 and M2 hernias are more likely to require preoperative concomitant component separation even when BTA is used [23]. Hernias that are more superiorly located are more likely to be more bound by the rib cage and intercostal muscles laterally, making medialization of musculature challenging. Although BTA is more typically used in the setting of vertical midline incisional hernias, it may also be used for patients with hernias from transverse incisions (such as liver transplantation) or hernias that are off of midline [24]. The use of BTA has also demonstrated equal efficacy for patients undergoing open and minimally invasive repair alike, which is an important consideration with the increased utilization of minimally invasive techniques for complex hernias [25].

In addition to the aforementioned indications, there are a couple of other instances in which BTA utilization may be considered. For patients who are at high-risk of developing significant postoperative pain (e.g., patients who have significant preoperative pain), BTA should be considered. BTA acts at synaptic junctions in order to prevent the release of pain-modulating molecules, such as Substance P and calcitonin gene-related peptide [26]. However, this is an area that is still in need of further research. Similarly, although mesh reinforcement is the standard of care for herniorrhaphy, BTA may be contemplated in the elective setting when patients require fascial closure but the surgeon or patient wants to avoid the use of a prosthetic implant.

22.3 Adverse Effects and Contraindications

Although BTA is indicated for a diversity of uses in a variety of muscle groups, its use in the lateral abdominal wall is currently off-label. As a result, it may be challenging to obtain insurance approval in order to cover the cost of the product.

A provider appeal to an insurance company may be required referencing the safety and efficacy of BTA in AWR. In all reported studies, BTA injection in the abdominal wall was found to be safe with no major complications and only a small number of minor complications [13, 27, 28]. Following injection, some patients described pain at the injection site, hematoma, or a temporary sensation of abdominal bloating and a weak cough or sneeze [21]. These symptoms were manageable with an abdominal binder and universally resolved after hernia repair was performed [29–31]. There are a limited number of contraindications for use of BTA in AWR, which are mostly limited to patients with neuromuscular disorders and preexisting neuropathies [32]. A complete list of contraindications can be found in Table 22.1.

Table 22.1 Contraindications to BTA use in abdominal wall reconstruction

Contraindications
1. Neuromuscular disorders
2. Emergent hernia repair
3. Pregnant or breast-feeding
4. Necrotic abdominal wall
5. Ongoing hemodynamic instability

22.4 Technique

The technique for our method of BTA injection has previously been published by Deerenberg et al. in *Skeletal Radiology* (Fig. 22.1) [21]. The timing of injection of BTA is essential. BTA is injected at least 2 weeks prior to scheduled surgery and most often between 2 and 4 weeks. By injecting BTA into the abdominal wall musculature at least 2 weeks preoperatively, it provides ample time for BTA to take effect and have maximal benefit for the patient. After 1 month, the effects of BTA begin to subside. There are instances in which patient surgeries get delayed or rescheduled, and when this is the case, the patient may be injected for a second time before their scheduled operation. For our group, it is not standard practice to inject the patient with BTA again on the day of surgery or postoperatively. However, it may be hypothesized that injection after surgery may maintain decreased tension on fascial closure.

The protocol developed at our institution is a multidisciplinary one that relies on close communication between the AWR surgeons and specialty-trained radiologists. Patients are taken to radiology and placed in a supine position. Injections are performed using either ultrasound (US) or computed-

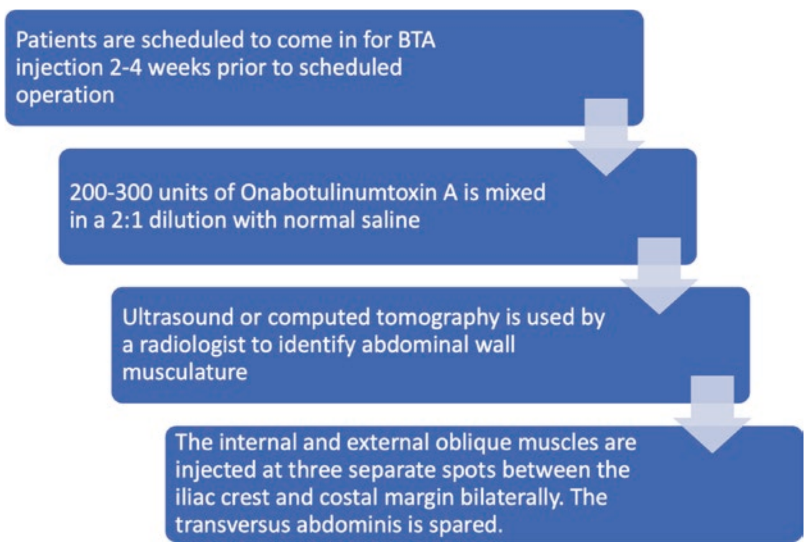

Fig. 22.1 This is a flow chart of our institutional protocol for BTA injection

tomography (CT) guided techniques. Using image guidance allows for the identification of both oblique muscles (i.e., external and internal) as well as the transversus abdominis muscle. US, with the utilization of a high-frequency linear probe (10 MHz or greater), is most common. CT fluoroscopy may be used in patients who are obese in which the distinct layers of the abdominal wall cannot be readily visualized; CT fluoroscopy is performed with settings 80–100 kVp, 10–20 mAs. CT offers the advantage of having an up-to-date image almost immediately preceding a patient's surgery. In our experience, the majority of patients tolerate these injections well with minimal premedication. If needed, a combination of anxiolytic and opiate pain medications is used prior to the procedure. If necessary, conscious sedation can be achieved if unable to tolerate the injections due to level of pain or anxiety [18, 30, 31].

Our injections consist of 200 units of OnabotulinumtoxinA (Botox®) diluted in 100 cc of saline. This mixture is divided into 12 separate 10-cc syringes, with each syringe containing 8 cc of this mixture (16 units of BTA). Injections are performed with a small-gauge needle at six separate locations within the internal and external oblique abdominal wall muscles. Three injections are performed on each side near the midaxillary line at three equidistant points between the rib cage and the iliac crest (Fig. 22.2). At each location, the needle is directed towards the internal oblique muscle, where the initial injection is performed with the entire volume of a single syringe. After injection into the internal oblique, the needle is retracted into the external oblique muscles for a separate injection of a similar syringe volume. The injection sites are then dressed in gauze and an occlusive dressing, and the patient is sent home until surgery after which they undergo their indicated hernia repair. A video of an ultrasound-guided injection being performed by a radiologist is shown in Fig. 22.3.

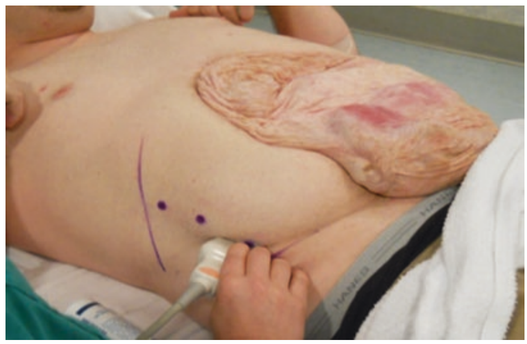

Fig. 22.2 Ultrasound is used to identify the obliques muscles for injection at three equidistant sites between the iliac crest and the inferior costal margin

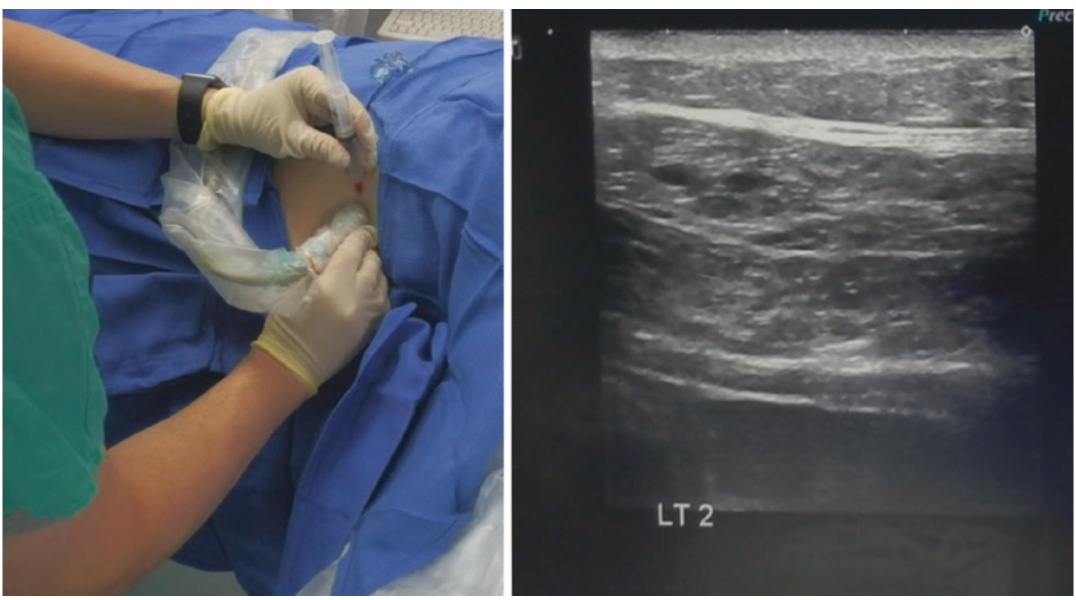

Fig. 22.3 This video demonstrates the real-time ultrasound-guided injection of BTA into the lateral abdominal wall by one of the staff radiologists

22.5 Tips and Tricks

Variations in dosage of BTA, injection number and site, and timing preoperatively are described. Other groups advocate for the injection of the transversus abdominal muscle in addition to the internal and external oblique muscles [20, 33]. We currently do not inject the transversus abdominus muscle as it plays a significant role in truncal stability and sparing it from paralysis may preserve an important component of abdominal wall physiology [18, 19, 30, 34–39]. There has been shown no difference in the ability to close complex fascial defects between the transversus abdominus sparing and non-sparing techniques yet we find that by not injecting the transversus abdominus muscles routinely, the cost (secondary to decrease total dose of BTX) and total time of the procedure are reduced [39]. Other studies have used electromyography (EMG) to localize muscle layers instead of ultrasound or CT guidance [20, 33, 35]. EMG was used to determine if the muscle where BTA was applied was denervated or fibrotic, and injection points were then modified accordingly. Aside from OnabotulinumtoxinA (Botox®), AbobotulinumtoxinA (Dysport®) is the other common form of BTA that is used in AWR. AbobotulinumtoxinA is more dilute than OnabotulinumtoxinA, typically by a factor of two or three.

22.5.1 Prehabilitation

The ultimate goal of any hernia operation is to improve patient quality of life. Improving quality of life is accomplished through minimizing pain, maximizing mobility, and preventing modifiable postoperative complications [40]. By utilizing BTA preoperatively, there is a greater chance that fascial closure will be attained and complications will be minimized [18]. It would be incomplete to omit the other tenets of preoperative optimization for patients undergoing complex AWR. All patients undergoing repair of their incisional hernias are seen in the clinic at our hernia center prior to surgery and evaluated by the surgical team, which includes surgeons, nurses, geriatricians, dieticians, and physical therapy. Patients who are smokers are required to stop smoking at least 4 weeks prior to surgery [41]. If necessary, this is confirmed by a urine cotinine test. Diabetic patients are counseled on glycemic control and encouraged to have a hemoglobin A1c of <7.2 g/dL. While there is not a cutoff for body mass index (BMI), weight loss is encouraged through a combination of a ketogenic diet and exercise and a BMI of <35 kg/m^2 is generally preferred. There is ample evidence to suggest, that is, these preoperative factors, rather than surgical complexity that are the ultimate drivers for improving outcomes for AWR patients although surgeon experience and operative volume also play a role [42, 43].

22.6 Outcomes

Allergic reactions to BTA are very rare however patients should be monitored after injection [44]. In other contexts, reported serious adverse effects of BTA are often related to the use of unlicensed, uncontrolled mixtures, a nonsterile injection technique, or injection in infected tissue [45]. A study of all reported side effects of BTA reported to the US Food and Drug Administration showed no systemic spread of the toxin with licensed products and appropriate dosage [46]. Case series from international institutions describe mild-moderate cases of botulism from cosmetic injection however these were all self-limited [47]. Patients with neuromuscular junction disorders such as myasthenia gravis, Lambert-Eaton syndrome, and anterior horn disorders are particularly susceptible to adverse events of BTA and have been excluded from any studies [44, 48]. It follows that these patients should not be injected; however, a recent review from China suggests that with proper management of coexisting myasthenia gravis and appropriate dose reduction of BTA, the therapeutic benefits of BTA can still be achieved safely; again, more studies are needed on this topic [49].

A meta-analysis of four observational studies revealed that preoperative BTA increases the lateral abdominal wall muscle length by 3.2 cm on each side resulting in 6.3 cm total elongation [17, 25, 30, 50]. This relaxation aids in increasing the compliance and ability to achieve a tension-free repair. The elongation of muscle fibers results in a decrease in preoperative transverse hernia width and a significant decrease in combined muscle thickness of 1 cm bilaterally [17, 28, 33]. Meta-analysis of ventral hernia patients with the combination of BTA with progressive pneumoperitoneum (PPP) demonstrates an increase in the length of the abdominal wall by 3.1 cm per side [20, 36]. Further, two studies demonstrate that a significant reduction of LOD was achieved with the combination of the techniques. Complications in patients who underwent PPP were more frequent and serious, however. A total of 124 complications were mentioned in the 14 articles reporting on PPP use. Of these complications, death occurred three times: once in a patient with a history of severe respiratory failure, and once PPP caused abdominal compartment syndrome, which subsequently led to multiorgan failure and death [27].

Additionally, the increase in fiber length was not different between different types of BTA when considering the amount of injected sites or units, injection including or sparing the transversus abdominis muscle, time between injection and measurement of muscle fiber length by computer tomography (CT) imaging, or the combination of BTA with PPP [21]. In aggregate, this meta-analysis, which is the most up-to-date on the topic, demonstrates that pretreatment with BTA significantly increases the fascial closure rate with a median hernia recurrence rate of 0% (IQR 0–9%) at median 19 months [28].

22.6.1 Summary of Institutional Data

There have been 108 patients at our institution who have undergone AWR for ventral hernias who received preoperative BTA injection [51]. There were no serious adverse reactions to BTA injection. This group of patients was an extremely complex subset—27% of patients were smokers, 31% were diabetic and the mean BMI was 30.5. The mean hernia sac volume for these patients was an impressive 2154 cm^3 with a mean hernia width of 15.3 cm. To add to the complexity, over one-third (38%) of these operations were done in the setting of contamination. Fascial closure was achieved in 91% of these patients, and for patients who did not have fascial closure achieved, half were patients with previous abdominal wall resections and the other half either had multiple hernia defects or had extensive scarring from previous hernia repairs. Concurrent CST was needed for 57% of patients, which was most commonly a bilateral external oblique release (half of the CSTs performed). Notably, of patients who had an M1 hernia component, 88% still required CST following BTA injection. At 14 months follow up, the recurrence rate was 6.4%.

A follow-up study using our BTA patient data, also authored by Deerenberg et al., was published that utilized a propensity-score matching technique that compared BTA and non-BTA patients based on BMI, defect width, and loss of domain (Table 22.2) [18]. A 2:1 match was performed that compared 145 patients without BTA and 75 patients with BTA. When BTA was used, patients had a significantly higher rate of fascial closure (92% vs. 81%, $p = 0.04$), but interestingly, they also had a higher rate of requiring CST (61% vs. 47%, $p = 0.04$). Not surprisingly, given the increased rate of fascial closure and the subsequent avoidance of bridging mesh, patients who received BTA preoperatively had a lower rate of postoperative wound infection (12% vs. 26%, $p = 0.02$). In an even more recent evaluation of our data comparing patients receiving BTA alone versus CST alone, it was determined that there was no difference in the rates of fascial closure with patients receiving BTA having less instances of postoperative wound complications. BTA has become an increasingly utilized adjunct for our care of complex AWR patients. A pre- and postoperative photo of one of our patients who had BTA injected prior to their hernia repair is shown in Fig. 22.4.

Table 22.2 Institutional comparison of BTA Versus non-BTA patients

	BTA (n = 75)	Non-BTA (n = 150)	p-Value
Age (years)	62 ± 12.5	60 ± 12.1	0.46
Diabetes	30%	37%	0.28
Smoking	29%	15%	**0.01**
Body mass index (kg/m^2)	31 ± 8.7	31 ± 6.4	0.44
Hernia defect width (cm)	14.1 ± 4.7	14.1 ± 5.1	0.89
Hernia sac volume (cm^3)	1672 ± 1715	1405 ± 1533	0.24
Hernia sac to intra-abdominal volume ratio	0.52 ± 0.6	0.47 ± 0.6	0.50
Fascial closure	92%	81%	**0.04**
Component separation	61%	47%	**0.04**
Surgical site infection	12%	26%	**0.02**
Hernia recurrence	9%	12%	0.59

Bolded p-values significant for $p < 0.05$
Table adapted from Deerenberg et al. *Am J Surg*. 2021

Fig. 22.4 Shown here is a pre-op (left) and post-op (right) photo of a patient who had BTA injected within the month prior to surgery. Fascial closure was able to be achieved and the patient has not experienced hernia recurrence

22.7 Future Directions

It is crucial to determine the subset of patients who could potentially be spared from CST when BTA is used. Thus far, the location of the hernia on the abdominal wall seems most telling in terms of who could be spared from CST. In the future, through the use of advanced CT imaging techniques and machine learning, it may be possible to develop a better understanding of abdominal wall compliance to decipher the subset of patients who may optimally benefit from BTA. Similarly, relating a genetic profile to abdominal wall compliance could be equally beneficial for determining patients who could benefit from BTA. To date, there are a variety of published regimens for BTA injection and the optimum regimen (i.e., dose of BTA, location of injection) is still up for debate. Long-term effects of the use of BTA in AWR have not been thoroughly studied. Given its finite duration of action, long-term deleterious effects would not be anticipated. However, it may be useful to report instances where reoperation is required in order to understand if there is any distortion of tissue planes or reoperative challenges that occurs from BTA use. Lastly, given patient concerns about mesh, there may be instances, yet undefined, in which BTA may provide a reasonable alternative to mesh reinforcement in herniorraphy [52].

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23 Progressive Pneumoperitoneum (PPP) in Hernia Repair

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23.1 Introduction

Preoperative progressive pneumoperitoneum (PPP) is a technique where, a progressive distended abdomen is created using air or carbon dioxide as part of the preoperative preparation of patients with hernias. The technique was first described in 1940 by Goñi Moreno in Argentina [1]. At that time, all abdominal wall hernias were repaired by anatomical means, and the pioneering surgeon devised this method of pneumatic distention of the abdominal cavity to manage large hernias.

The purpose of this preoperative technique is to prepare patients for the increase in intra-abdominal pressure that they will have postoperatively due to the tension in the closure of the abdominal wall, which compresses the viscera and lungs [2, 3]. Thus, progressively, through the insufflation of gas, various effects related to the increase in the intra-abdominal volume and pressure are achieved. Other theoretical effects of PPP are the progressive lengthening of the lateral muscles of the abdominal wall, decrease in visceral edema, return of the viscera to the abdominal cavity, return of diaphragmatic tone and respiratory conditioning, and release of visceral adhesions. Several of these effects can be seen in the following figure of the comparative computed tomography (CT) images (Fig. 23.1).

The main aim of PPP is the return of the herniated, chronically extruded viscera to the abdominal cavity and obtain the closure of the abdominal wall, avoiding the feared intra-abdominal hypertension and abdominal compartment syndrome. Although this technique is not used by all surgeons who treat abdominal wall hernias at present, there are groups of surgeons who have proven that its use is safe and poses a very low risk for the concerned patients. The indications and technique have a great variability between different surgeons and centers [4–8].

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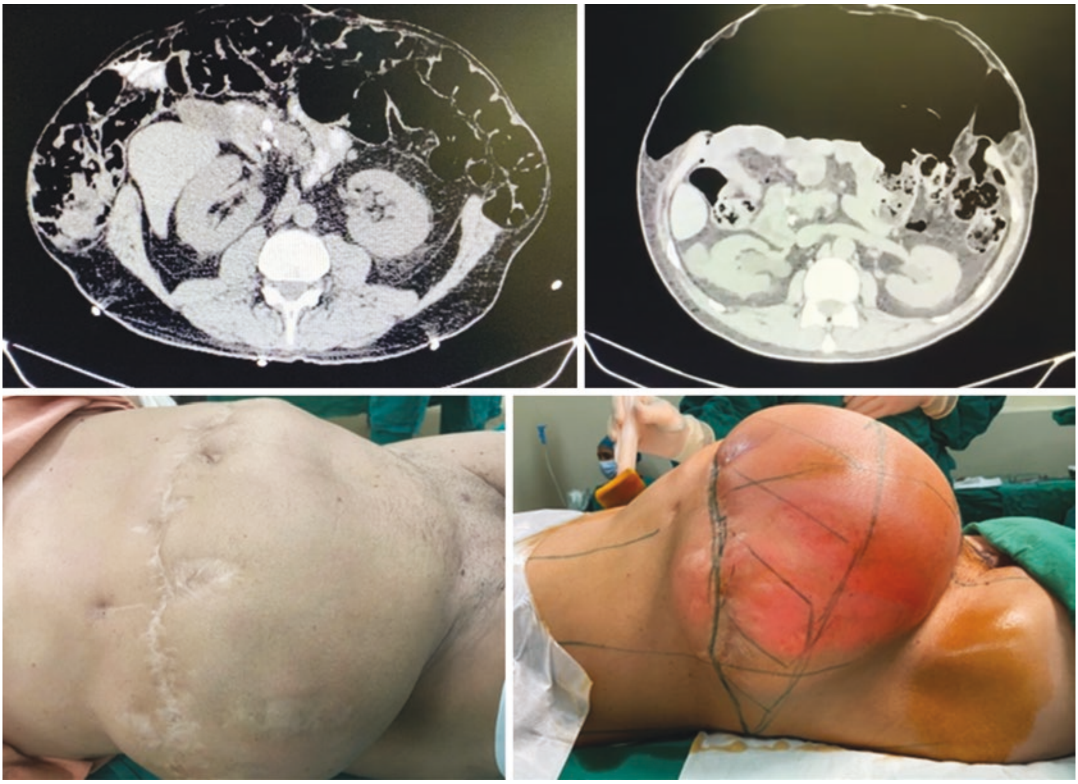

Fig. 23.1 Comparative Images before and after application of PPP in the same patient

23.2 Indications and Case Selection

PPP has been used classically for large hernias. It may facilitate reconstructive surgery in patients that were previously considered inoperable. Most current publications report the use of PPP in incisional hernias. Its use is in primary hernias like inguinal and umbilical hernias is infrequently reported [7].

The definition of a giant, monstrous, or large hernia is vague, which is why the term *loss of domain* (LOD) is more popularly used now. The 2020 Delphi consensus regarding LOD hernias defines it as a hernia where a sufficiently large hernia content is stuck outside the abdominal cavity and cannot be reduced, in the absence of adhesions between the sac and hernia content. Therefore, the indication for PPP is a patient with a loss of domain abdominal wall hernia. In terms of a numerical definition for LOD, world experts have not been able to reach a consensus. The two most commonly used indices to define LOD are the Tanaka's Index and the Sabbagh's index. The Tanaka method theorizes that the hernia and the abdominal cavity are ellipsoids, so it starts from the calculation of the ellipsoid volume, relating the volume of the hernia with the abdominal cavity, and it is expressed as a percentage [9, 10].

In our daily practice, we prefer this method because it is easy to calculate in office and does not require expensive software, applications, or extraordinary knowledge. Although in his original article, Tanaka defines loss of domain as being more than 25% when calculated by this method, we use 20% in our practice. We have seen good results with the combination of botulinum toxin (BT) and PPP in defects with a transverse diameter of more than 12 cm and a Tanaka value greater than 20%. It is rare to find a hernia with loss of domain that has a transverse diameter smaller than 10 cm.

The other method to calculate the loss of domain is Sabbagh's index, which uses software to calculate the intraperitoneal volume and the hernia volume. Some have defined it as more precise than Tanaka's method. Sabbagh uses the entire hernia volume and intra-abdominal volume as a denominator define LOD. In the 2020 Delphi consensus of experts, it was not possible to reach an agreement about which index really represented a loss of domain, and most experts agreed that it is more of a clinical diagnosis than an index alone [11].

Another indication reported in the literature is defects greater than 15 cm in transverse diameter. Although this indication is scarce in the absence of loss of domain, we recommend better use of the BT in these cases.

PPP has also been reported to release adhesions between intestinal loops, it is difficult to demonstrate the exact percentage of adhesion reduction. We have used it in a few cases with marginal loss of domain and the anticipation of strong adhesions.

23.3 Contraindications

PPP acts as a therapeutic test for patients who are scheduled to undergo surgery. If the patient cannot maintain the insufflation and progressive distention either due to respiratory or cardiovascular compromise, it is likely that the surgery will not be well tolerated either.

As contraindications, we can cite all the diseases where abdominal distention can cause problems, with cardiovascular or pulmonary diseases, such as congestive cardiac failure NYHA 3 and 4, or advanced stage chronic renal disease, chronic hepatic failure (Child Pugh C). So, the contraindication is similar to laparoscopic contraindications. Coagulation disorders as well as patients on therapeutic anticoagulation should be considered a relative contraindication because hemoperitoneum may be caused by the release of adhesions. Aortosclerotic diseases such as aortic aneurysms should be optimized or treated before undergoing PPP [12].

Cases in which the catheter cannot be placed due to a very adherent abdomen are not considered a contraindication because the PPP catheter can be placed by a surgical method, resulting in additional theoretical benefits of adhesiolysis. Care should also be taken in the presence of organomegaly. An image-guided placement may help.

Obviously, an active intra-abdominal cancer is a contraindication for the placement of PPP and the presence of a hernia emergency as well. The coexistence of enterocutaneous fistulas related to hernias with loss of domain must be weighed for risks and benefits according to the volume of the loss of domain, and it is not necessarily a contraindication [13].

23.4 Placement of PPP, Instruments, and Energy Sources

The placement methods described for the PPP are as follows:

- Anatomical method with spinal puncture needle
- Anatomical method with central venous catheter
- Image-guided with pigtail
- Anatomical method with Veress needle and central venous catheter
- Surgical method with central venous catheter dissection
- Surgical method with the placement of a Port-a-Cath type reservoir catheter

Initially, insufflation was described with oxygen, using a spinal needle. Moreno did daily punctures to the patient in the left iliac fossa until the desired effect was obtained. The original description by Moreno, who later began to administer ambient air, indicated that the air was added until the abdominal flanks were loose and the hernia content was reducible, so the duration of the process was highly variable. Currently, the process has improved with the introduction of silicone catheters with and without a reservoir to avoid daily punctures, and the development of imaging methods allows us to perform safer punctures. It should be noted that Moreno reported more than 300 cases via the anatomical method without catastrophic accidents, even indicating that when performing an enteric puncture, only the needle was withdrawn and a new puncture was done again several weeks later [14–17].

In the past, the anatomical method with a spinal puncture needle was used, which was accomplished at a site away from scars and with a daily puncture, usually at the left iliac fossa. In the anatomical method, the image guidance is not used, and it is performed via a puncture, without dissecting the spaces. The disadvantage of this technique is that it requires blind repetitive punctures with its inherent risk of bowel injury. Its main advantage is that it can be performed at the office, on an outpatient basis.

The anatomical method with a central venous catheter is the one in which we have the most experience. In this, we do a puncture without image guidance, although it should be emphasized that, in all cases, the tomography images are evaluated prior to catheter placement to determine the best site, always away from scars and hernias. It has the advantage that it can be done at the patient's bedside and with local anesthesia, and the disadvantage is that it is a blind method and can result in visceral injury. We describe this method in the next section.

The Veress needle and central venous catheter method are very similar to the previous one, except that the first air placement is performed using a Veress needle, almost always at Palmer's point. This aids those familiar with the needle to make a more confident abdominal puncture in comparison to a pure anatomical method because the retractable tip of the Veress needle protects the viscera. After the placement of this needle and inflation with 300 cc of air, the central venous catheter is placed through the orifice of the needle following the usual Seldinger method. Sometimes, the Veress needle is used with ultrasound guidance, rendering the process even more secure.

The pigtail image-guided method is the most used by radiologists. After checking the entire abdomen with ultrasound and choosing a safe window, a puncture is made at a place where there is free visceral movement, and once the peritoneum is crossed, the silicone catheter is allowed to slide. It is a difficult puncture for the radiologist because it usually does not go with the goal of a solid lesion or collection, but only to leave the intraperitoneal catheter. We have had difficulties with these catheters because some holes remain in the abdominal wall, with air leaking and the formation of emphysema, and some radiologists, with the fear of puncturing the intestine, have even left the catheter in a preperitoneal position. Moreover, catheters can continuously leak air, causing more gas loss than expected, making PPP ineffective in maintaining intra-abdominal pressure [18].

There are two surgical methods, one with a central venous catheter and the other with Port-a-Cath. They have the disadvantage that the patient needs to be taken to the surgical room and that an incision is needed thus resulting in a greater chance of infection. A mini-laparotomy is performed at a site away from the hernia, and either device is placed. The main advantage is that this is performed by looking directly at the peritoneum, which reduces the possibility of visceral injury. However, they can have more air leaks and emphysema, and Port-a-Caths require repetitive punctures and can become infected, which would require explantation. This is a method we fall back on when the images do not appear safe because the patient has a long surgical history, such as an open abdomen or heavy adhesions (Figs. 23.2 and 23.3).

Fig. 23.2 Surgical placement under local anesthesia of PPP catheter with ultrasound guidance, Veress needle, and central venous catheter

Fig. 23.3 Surgical placement, open, with local anesthesia of PPP catheter with central venous catheter

Fig. 23.4 Pigtail catheter placement in the left upper quadrant for the administration of filtered ambient air in a patient with loss of domain hernia and Tanaka index of 30%

23.5 Team Organization, Anesthetic Options, and Positions

According to the literature, the equipment or devices most used today for PPP placement are multipurpose "pigtail" catheters commonly used by interventional radiologists, subcutaneous "Port-a-Cath®" type reservoirs, and central venous catheters. In our experience, the latter is the best option.

Subcutaneous titanium reservoirs with a silicone membrane require a surgical procedure for placement, and these have increased possible hemorrhagic and infectious complications. We recommend the use of the central venous line (CVC) and multipurpose pigtail catheters; however, with pigtails, we have occasionally had air leaks despite being properly closed and placed (Figs. 23.4, 23.5, 23.6, 23.7, 23.8, and 23.9).

The insufflation device should be placed at sites away from the scars and hernia to avoid possible adhesions. If feasible, most use Palmer's point (left hypochondrium) because it is a well-known point, and the safety is supported by the creation of the laparoscopic pneumoperitoneum. Another point that is recommended is the left iliac fossa (Fig. 23.10).

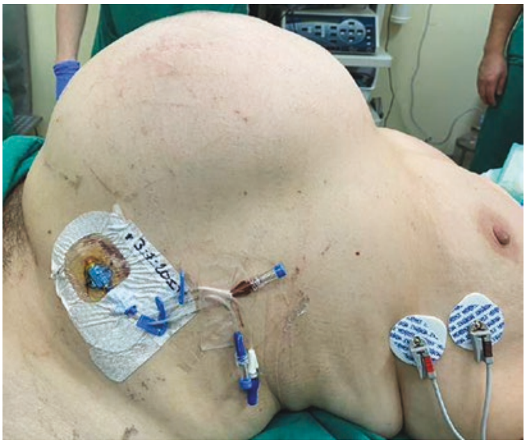

Fig. 23.5 Placement on the left flank of a Pigtail catheter for administration of filtered ambient air in patient with loss of domain hernia and Tanaka Index of 107%

Fig. 23.6 Placement of a CVC-type catheter with Seldinger technique in the left iliac fossa for the administration of filtered ambient air in a patient with loss of domain hernia and Tanaka index of 60%

For the right assessment of the puncture site, the images provided by CT should be analyzed prior to the procedure, in order to identify the most appropriate place away from solid viscera, such as the spleen, and verify that there is a "window" (no loops attached to the anterior parietal peritoneum). It must also be considered that the patient will be positioned laterally at the time of puncture, so the placement of these viscera can be modified.

Fig. 23.7 Placement of a CVC-type catheter with Seldinger technique in the left upper quadrant (Palmer's point) for the administration of filtered ambient air in a patient with loss of domain hernia and Tanaka index of 25%

Various methods can be adopted at the time of insertion of the insufflation device. The most common, in our experience, is the anatomical one, which basically entails introducing the needle without any ultrasound guidance at an anatomical point until the loss of resistance, followed by the instillation of liquid into the cavity. Subsequently, the Seldinger method is used in CVC devices or the needle is withdrawn in pigtails. The other option is ultrasound image-guided placement. If you do not have experience, this method may be safer, but it requires the placement of the pigtail catheter, and in our hospital, we require the help of a radiologist for this purpose [19].

Another modality that we practice is puncturing with a Veress needle at Palmer's point and a subsequent insufflation of 500–1000 cc of air followed by placement of a CVC using the Seldinger method. Under exceptional circumstances, direct vision placement in the operating room may be necessary if the methods described fail.

Fig. 23.8 Placement of a CVC-type catheter with a Cavafix®-type catheter in the left upper quadrant (Palmer's point) for the administration of filtered ambient air in a patient with loss of domain hernia and Tanaka index of 53%

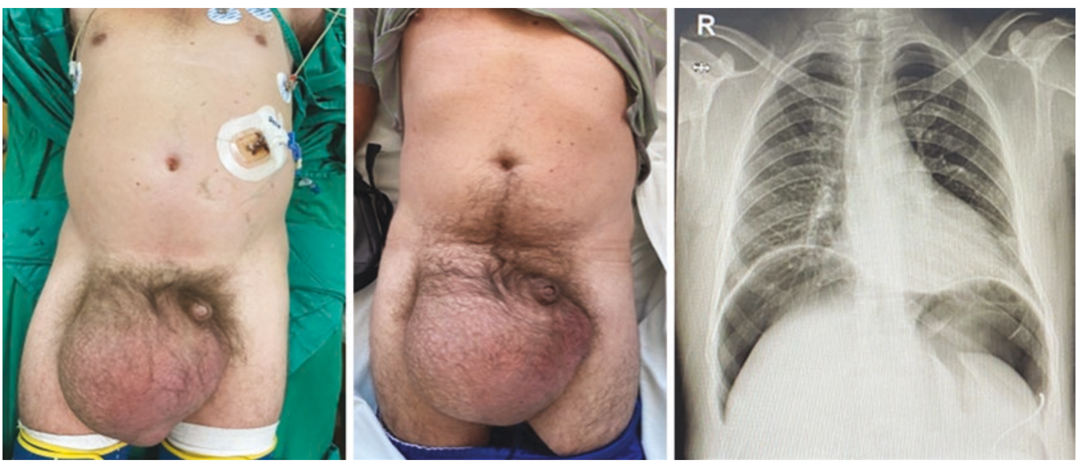

Fig. 23.9 Inguinoscrotal hernia with loss of domain, Tanaka index of 30%. Placement of PPP catheter in Palmer's point with Veress needle. Radiography with pneumoperitoneum

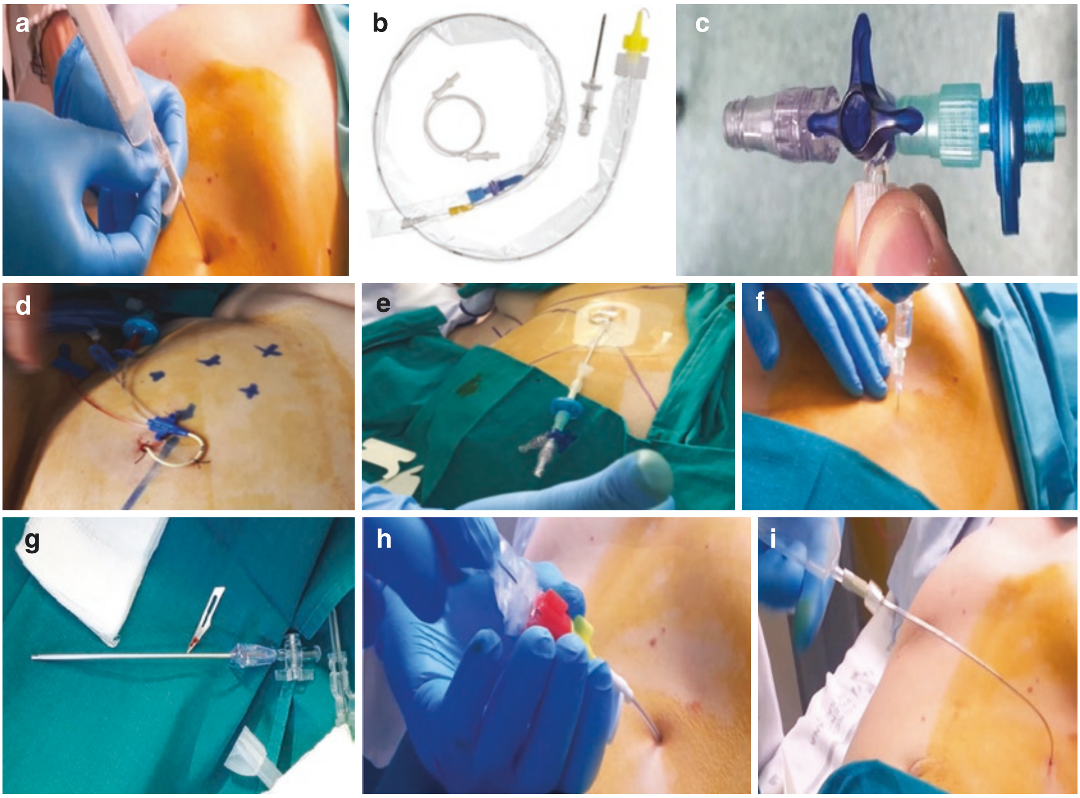

Fig. 23.10 Catheter insertion procedure. (**a**) Veress Needle. (**b**) Local anesthetic administration. (**c**) Cavafix catheter. (**d**) Punction with needle and plastic cannula. (**e**) Withdraw of the needle introducing the plastic cannula. (**f**) Position the catheter using the cannula. (**g**) Air administration for a posterior confirmation with x-rays. (**h**) Fixation to skin with suture and wound dressing. (**i**) Finally, millipore Filter and three-way stopcock

23.6 Materials

– Syringes: 10 and 20 mL
– Intramuscular needle
– Local anesthetic: mepivacaine and scandicaine, saline solution
– Betadine
– Sterile gloves
– Surgical drapes and cloths
– Soaker
– Needle holder or similar
– Silk 2/0
– Wound dressing
– Cavafix
– Three-way keys and plug
– Air filter from millipore
– Pneumoperitoneum sheet to record daily and total insufflation, O_2 saturation

23.7 Key Steps (Fig. 23.10)

- Placement of the patient in a supine position with slight lateralization. Surgical field preparation with 2% alcoholic chlorhexidine or povidone-iodine.
- Infiltration with local anesthetic at the chosen point. It is advisable not to infiltrate deeply so that the pain produced by the passage of the needle through the peritoneum can be identified.
- Two-way venous catheter for the catheterization of the vena cava based on the catheter technique through a cannula (Cavafix® Certo or Cavafix® Duo).
- Introduction of the stainless steel needle to puncture in the chosen place. We try to locate the passage through the peritoneum when

noticing some resistance, and the patient may report mild pain. It can be confirmed whether we are in the abdominal cavity by introducing a little air from the syringe. It can also be useful to introduce a little serum without difficulty and even withdraw the plunger, checking that the remaining serum is introduced into the syringe into the abdominal cavity.

- Withdrawal of the puncture needle keeping the plastic introduction cannula.
- Insufflation of a small amount of air (40–50 cc) and subsequent introduction of the radiopaque catheter by removing the introduction cannula.
- Insufflation of 200–250 mL of air for subsequent radiological confirmation of the correct position of the catheter.
- Fixation of the catheter to the skin with loose stitches and transparent dressings.
- "Millipore" filter of 0.22 micrometer coupled to a three-way stopcock that facilitates subsequent insufflations and a heparin seal (optional).
- Abdominal elastic restraining belt with Velcro®.

23.8 Details of the Insufflation

Ambient air is the general choice for insufflation, but in our specific case, we recommend filtered air with the Millipore filter. Other authors have proposed including medical-grade air, but their experiments did not lead to a better result. Other gases, such as carbon dioxide or helium, are limited for this use.

Most PPP cases are developed over a long in-hospital stay, but if the hospital has the infrastructure and capacity for outpatient care and the patients live near the hospital for daily insufflation, then PPP can be managed on an outpatient basis.

Insufflations should be performed daily, and if the patient is hospitalized, they can be carried out twice a day to relieve distention symptoms. At the end of the PPP period, the insufflations can be spaced 2 or 3 days apart, always taking into account that 100–200 cc of air are absorbed by the peritoneum every day and intra-abdominal pressure can decrease, which is an overall beneficial effect.

Each day, 500–1000 cc can be insufflated, although more volume can be well tolerated in the first days, while the appearance of bothersome symptoms for the patient must be heeded to know when to stop the insufflation. Some authors suggest that these symptoms are always reached to determine how much is insufflated daily because the volume between patients is highly variable. La Fe Hospital's protocol for PPP is the only one with an exact calculation of total and daily air volume to be insufflated, where three times the volume of the hernia plus losses of 100–200 cc per day, divided over 7–15 days, are administered. This protocol combines BT and PPP and can sometimes take up to 21 days if the hernia is very bulky.

The total duration of the PPP in place is highly variable. We know that it should ideally be less than 21 days because that is when complications are most highly reported. However, the criteria for deciding when the PPP is stopped are unclear. It is expected that the hernia content will be reduced with PPP over time, but this is not possible in all cases. Another criterion is the loosening of flanks, and at our center, we wait until the proposed time for PPP and until the calculated volume is reached. It should be noted that all patients must wear an abdominal support belt while on PPP [20].

23.9 Technical Variations

The recommended gas for insufflation is ambient air, which is used by 62% of surgeons [21]. No problems have been reported with the insufflation of ambient air. In our case, we use ambient air filtered by a 0.22 micrometer "Millipore"-type particle filter coupled with a three-way stopcock.

There are other types of gas, but they are not recommended because they are difficult to acquire or are absorbed quickly, such as carbon dioxide or oxygen. A special gas that can be recommended is medical-grade air that causes fewer peritoneal problems.

The daily insufflation volumes, the insufflation interval, and the total period of PPP are highly variable among different studies. Usually during the first insufflation, up to 1500 cc of gas can be administered with a good and adequate tolerance by patients. The recommended interval is 1 day between inflations; sometimes, to achieve an adequate volume per day, it can be divided and performed every 12 h. In other situations, toward the end of PPP, inflation can be spaced apart by 2 or even 3 days, especially if the patient is highly symptomatic of PPP.

It is recommended to insufflate in each session until the appearance of symptoms, so discomfort due to distention in the form of mild dyspnea and omalgia are part of the application of this therapy. Subsequently, the volumes introduced can vary between 200 and 1000 cc. The appearance of uncomfortable symptoms or the desaturation of the patient, evaluated with a pulse oximeter, is an indication to stop the procedure.

An attempt is made to administer a volume equivalent to at least three times the hernial volume of filtered air, plus 700–1000 cc to adjust for losses per week (100 cc per day). Once the total volume to be inflated is calculated, it is divided by days, trying to administer more in the first 3 days. The total period is 12–21 days.

23.10 Some Tips and Tricks

Some advice for the PPP procedure is as follows:

- Look for the Palmer incision point, except in lateral incisional hernias where the hernia sac can make its location difficult. In this case, another point should be chosen after consulting CT images.
- Radiologic support is needed for the right catheter placement; normally, it can be accompanied by ultrasonography. If sonographic placement is not an option, simple abdominal radiology is recommended to control the intra-abdominal catheter and the recent pneumoperitoneum.
- An abdominal belt is mandatory during the PPP procedure to increase the effect of the insufflated volume of air in the abdominal cavity, and not in the hernia sac.
- To perform a CT scan before surgery. It is recommended to check the progress and the results of the PPP.
- The patient must know all the PPP procedures and have information regarding their side effects and complications.

23.11 Complications

In a recent review of the 1216 patients who underwent PPP, 151 experienced some complications, although these were almost exclusively minor and due to the act of insufflations [21]. Shoulder and abdominal pain, subcutaneous emphysema, and dyspnea were recurrent findings that did not need intervention. Enteric puncture and intracolonic catheter placement during its insertion were described in two studies, but these complications did not involve emergency surgery. In one study, PPP was performed again 2 months after an enteric puncture, and the surgery was successful. In a large review on PPP, the real procedure-related mortality was three cases: pulmonary mycetoma in one and respiratory insufficiencies during air administration in the others. Although mortality in five cases was ascribed to PPP, in two patients, the decrease was postsurgical: one from acute myocardial infarction and one from aspiration bronchopneumonia.

The treatment for abdominal and shoulder pain is analgesic, but if the pain is severe, it may be prudent to delay the next insufflation or decrease the administered gas volume. Dyspnea is another expected symptom, and its treatment entails observation primarily; if it is severe, the next insufflation should be delayed or the volume decreased. Subcutaneous emphysema is an expected clinical sign, sometimes striking, which does not need any intervention (Figs. 23.11 and 23.12).

Unusual locations for emphysema are retroperitoneal and mediastinal, but the reported literature indicates that no treatment is necessary, beyond perhaps a delay in the insufflation or, if severe, gas deflation (Fig. 23.13). Less frequently, the ulcerated skin of these patients

Fig. 23.11 Subcutaneous emphysema. Clinical image

Fig. 23.12 Subcutaneous emphysema. CT image

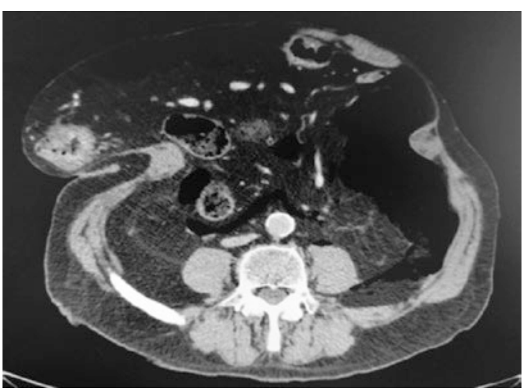

Fig. 23.13 Retroperitoneal emphysema: an unusual location of the air after insufflations

with loss of domain hernia causes skin perforation due to insufflation of air during PPP (Fig. 23.14). Finally, pneumothorax is an unexpected complication, which reportedly received conservative treatment with active observation.

The insertion of the catheter without radiological control can result in complications, such as visceral injuries due to the puncture. Examples of this are inadvertent splenic or hepatic lesions (Fig. 23.15).

Although the puncture made to place the catheter may be secure, injuries like this can be common if there is no simultaneous radiological control. Another more serious complication associated with PPP is respiratory failure. As it has been previously commented, PPP induces a progressive respiratory restrictive syndrome, and in 95% of the patients, it has no clinical repercussions. Progressive respiratory adaptation is beneficial and better than the fast compensation that the patient must perform when loss of domain hernia is repaired without preoperative preparation. It should be noted that a patient with respiratory disease and intolerance to PPP will most likely not be able to tolerate the surgical return of the herniated viscera to the abdominal cavity. In the presence of respiratory failure, the treatment would be to deflate PPP and attempt an intervention with a low gas volume if it seems that the patient can tolerate it.

An infrequent adverse effect is deep vein thrombosis (DVT), which can be prevented with antithrombotic measures, such as subcutaneous heparin and a compression stocking used for the inferior extremities. The causes of this event can be a prolonged time in bed, comorbidities, and vena cava compression caused during the instillation of large volumes of air. A DVT must be treated with anticoagulants, and an assessment should be carried out to balance the risk and benefits of delaying the surgery until the anticoagulation treatment is over. Pulmonary thromboembolism is related to DVT and was reported by only two authors [19].

Dialysis catheters and reservoir ports frequently cause abscesses, infections, and malfunction problems, recorded as minor complications associated with PPP. These device complications

Fig. 23.14 Skin perforation due to insufflation of air during PPP. Sometimes, ulcerated skin of these patients with loss of domain hernia causes this situation

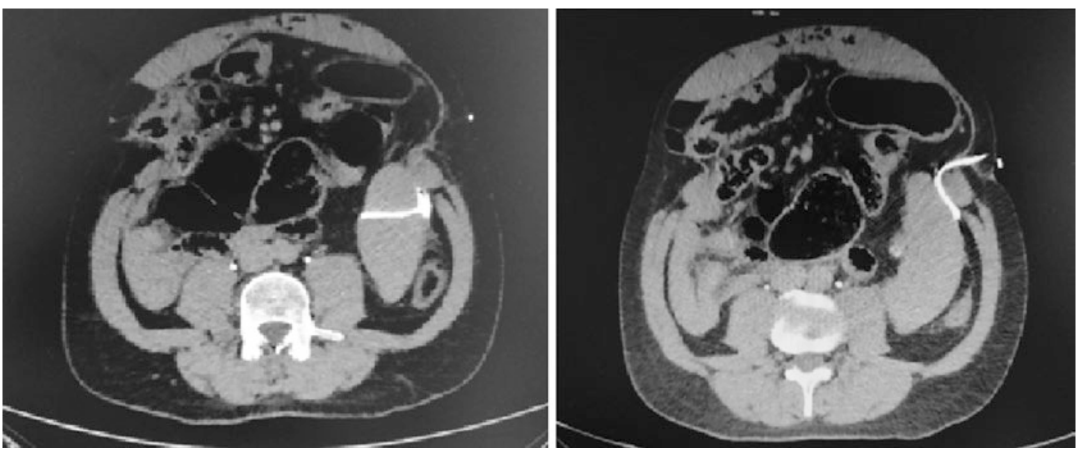

Fig. 23.15 Splenic inadvertent injury during the insertion of catheter for PPP

commonly need surgical correction. Multipurpose pigtail catheters and central venous lines appear to be simpler methods and are associated with lower morbidity. Infection at the puncture site can be treated with antibiotics, even while PPP is being continued.

23.12 Preventive Measures

Preventive measures are emphasized to potentiate the positive effects of air administration and reduce the adverse effects of PPP as much as possible. Accordingly, the abdominal containment belt is suggested to avoid selective distension of the hernia sac and thus maximize the air effect in the cavity; although most groups indicate that this is not really necessary, they still recommend its application. Prevention with formal anticoagulation or an inferior cava vein filter is mentioned only once in the literature, in the series with the highest morbidity. We generally use preventive thromboprophylaxis to avoid the most feared complications associated with PPP: deep venous thrombosis and pulmonary thromboembolism. Another preventive measure adopted is compressive legs stocking if the patient has limited movement and incentive spirometry for all patients to prepare the lungs and diaphragm.

It is common for patients to complain about reflux and epigastric pain. Thus, we normally administer proton pump inhibitors, prokinetics medication, and oral pain relievers for shoulder pain. Mild discomfort because of distention, mild dyspnea, and hyporexia are common, expected, and almost necessary symptoms [22].

23.13 Conclusion

PPP is a useful adjunct in the management of large incisional hernias with loss of domain. Surgeons should have adequate knowledge of the various techniques, risks, and methods to ameliorate them.

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24 Intraoperative Abdominal Wall Extension (AWEX)/Intraoperative Fascia Traction (IFT): Significance and Technique as Applied to Complex Abdominal Wall Hernia

Dietmar Eucker, Henning Niebuhr, and Andreas Zerz

24.1 Development and Principle of the Technique

Eucker, Zerz, and Steinemann [1] were the first to introduce the technique of intraoperative abdominal wall extension (AWEX) in 2012. The idea and principle underlying the technique were to employ available tissue resources in abdominal wall reconstruction as applied to giant incisional hernia and grafted laparostoma.

In the absence of muscular abutment, abdominal wall retraction in hernia, which leads to muscle shortening, is a well-known issue in hernia surgery. The techniques potentially applied to prevent or reverse abdominal muscle shortening already in the *open abdomen* by way of continuous fascial tensioning include the Wittmann Patch (Starsurgical Inc., Burlington, WI, USA) [2], the Abdominal Reapproximation Anchor (ABRA) system (Canica Design, Almonte, ON, Canada) [3], and mesh-mediated traction [4].

The initial authors who published data on intraoperative AWEX focused especially on abdominal wall anatomy and the lateral abdominal muscles—the area in which the most severe shortening of abdominal muscles occurs (Fig. 24.1).

Based on a rat model, DuBay et al. [5] provided a descriptive report in 2007 on the shortening and histological alteration of abdominal musculature under the conditions of incisional hernia. Disuse atrophy of the abdominal muscles was demonstrated in terms of rarefaction of contractile elements in the muscle cells and an increased extracellular accumulation of collagen fibers. Other models describing the shortening of skeletal muscles by discharge can be found in the orthopedic literature.

Techniques leading to preoperative muscular lengthening or extension, including progressive pneumoperitoneum [6] and chemical component separation [7–10], are in use.

The conceptual approach guiding the first describers was to regain the length of abdominal wall musculature without utilizing dissection

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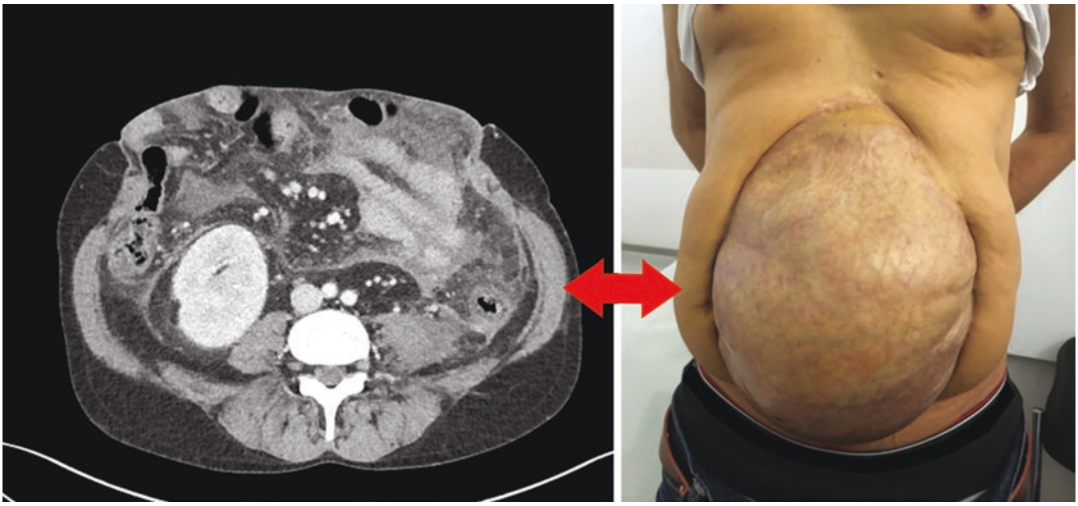

Fig. 24.1 Shortened lateral abdominal wall muscles

techniques [11, 12]. The crucial innovation in AWEX/intraoperative fascia traction (IFT) consisted in applying an *intraoperative* lengthening technique to the abdominal wall/muscles within a circumscribed timeframe.

The results of intraoperative AWEX performed in a small cohort of patients showed an unexpected degree of efficacy and a low level of complications [1]. The technique is suited for regaining the length of shortened abdominal (wall) muscles and is thus an important tool in reconstructing large abdominal wall defects. Moreover, AWEX/IFT can be combined with all techniques of reconstruction, e.g., sublay mesh, intraperitoneal onlay mesh (IPOM), etc.; component separation (e.g., [11], transversus abdominis release [TAR] [12]); and preoperative distension (e.g., progressive pneumoperitoneum [6] and chemical component separation [10]).

24.2 Patient Selection, Surgery Preparation, Teams, and Infrastructure

In principle, everyone presenting with a complex abdominal wall hernia can and should be slated for IFT. All patients with hernias classified as W3 or larger according to the European Hernia Society (EHS) should be considered eligible candidates (cf. the EHS classification [13]).

The absolute size of a hernia in cm is of little use as a parameter, as the likelihood of incisional hernia closure depends on many factors, including:

1. total abdominal volume;
2. volume of the viscera displaced extra-abdominally;
3. circumferential length of the abdominal muscles in proportion to the size of the hernial orifice; and,
4. individual factors (tissue quality, muscle thickness, fibrosis, and duration of hernia presence).

The specialized surgeon's experience is crucial to planning surgery. Basically, IFT can at all times be held ready and its application decided upon intraoperatively.

In general, the patient population slated for complex abdominal wall reconstruction is at risk and mostly presents with a history of multiple abdominal surgeries. Monitoring perioperative risk factors—including possible inflammatory conditions, regulation of blood glucose, nutritional and protein status, optimization of pulmonary and renal function, as well as prehabilitation and postoperative rehabilitation—is to be performed with adequate care and within the framework of a suitable infrastructure.

Along with IFT, a clear concept and a strategy for overall treatment are to be planned in advance in terms of intraoperative reconstruction techniques or component separations and, as may be the case, contingency techniques, such as bridging or plastic occlusions. The patients are to be informed about the planned techniques and their implications, including possible complications, prospects of success, and the status of the technique (standard or specialized technique, special devices).

At this point, we should add a ***word of caution***: Due to its relatively simple handling, intraoperative AWEX/IFT may imply that it is straightforward and safe. However, it is imperative to note that **patients with complex abdominal wall hernia must be treated by specialized and highly qualified teams in experienced centers, which are equipped with the necessary technical and surgical expertise as well as corresponding infrastructure. In particular, innovative approaches, as described in the following, are unconditional to be reserved for qualified specialists**.

24.3 Contraindications

Provided that there is no general contraindication against performing complex abdominal wall reconstruction, no contraindications against applying intraoperative AWEX/IFT are known.

24.4 Application in Open Abdominal Wall Reconstruction

The setup corresponds to that of standard laparotomy or open incisional hernia repair. In addition, the initially experimental AWEX technique required a stable retractor system, as well as eight towel clamps and eight elastic reins (e.g., large vessel loops). In turn, the Fasciotens technique requires the fasciotens® Hernia device, available as a sterile set, and the corresponding carrier (Fasciotens, Essen, Germany).

24.5 Setup and Positioning

In open reconstruction procedures, patients are mostly treated in a supine position. The use of indwelling urinary catheters is advisable to measure intraoperative excretion and, if necessary, to measure bladder pressure postoperatively. It is also recommended that perioperative analgesia be complemented by epidural catheters. In our setting, interventions are done by a team of three surgeons assisted by an instrument nurse and a circulating nurse.

24.6 Basic Technique of Intraoperative AWEX

As first applied by Eucker, Zerz, and Steinemann in 2012 [1], AWEX is a basic and experimental technique and exemplifies the principle of intraoperative abdominal wall extension with the **simplest means initially conceived of as improvisatory and has to be seen as an experimental state in the development of an operation technique**. The improvised setup was based on available materials and marked by simplicity. The original technique, as published in 2017 [1], is described in the following:

1. The procedure is done with the patient in a supine position; disinfection and sterile draping correspond to nursing standards of practice.
2. The fascial edges are prepared and visualized after opening the skin or removing the mesh graft. We recommend adhesiolysis along the abdominal wall; interenteric adhesiolysis is not imperative.
3. The length and width of the abdominal wall defect are measured in a relaxed condition and without traction to the abdominal wall.
4. The retractor system is installed such that the retractor frame or arms are arranged approx. 20 cm above the abdominal wall. ***Attention*: When applying conventional retractor systems, vertical traction at the abdominal wall might be off-label, those devices are probably not certified for the use in abdominal wall traction techniques as**

described here. Resonsibility for the application lies in the hands of the surgeon.

5. In accordance with the original technique, extension is applied at the nondissected abdominal wall, i.e., the rectus sheath remains closed at first after the fascial edges are visualized. At least four towel clamps (or strong U- or Z-sutures brought into the fascia) are attached on both sides. These are now connected to the retractor arms by elastic reins (originally: large vessel loops, folded three times). Traction is now applied to the abdominal wall (Figs. 24.2 and 24.3; see below for a comment on the direction of traction).

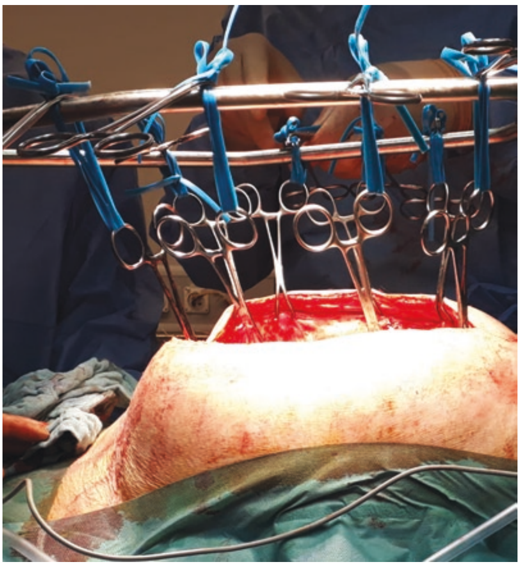

Fig. 24.2 Intraoperative traction in a vertical direction

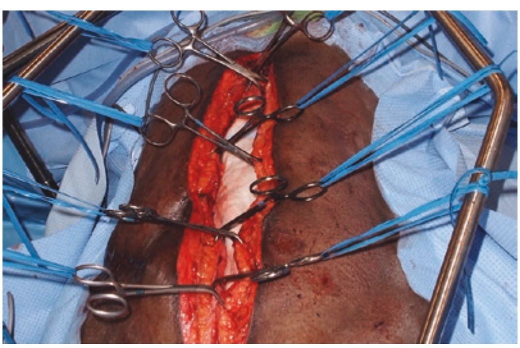

Fig. 24.3 Intraoperative traction in a diagonal direction

6. In installing the elastic reins, it becomes apparent that after applying the final rein, the rein first applied shows a certain degree of loosening thus indicating that the abdominal wall is beginning to stretch. Therefore, all reins are successively retightened over a period of approx. 30 min (based on experience) by using shortening knots or by fastening the reins above the retractor arms with a clamp after retightening (Fig. 24.4).
7. During this phase of surgery, as well as subsequent reconstruction, it is absolutely essential that anesthesia provides *complete muscle relaxation*.
8. Traction should not exceed the elasticity of a standard vessel loop folded three times (approx. 10 kg). Traction is applied gently and continuously.
9. During the tension phase, the viscera are covered with a moist towel. At all times, the abdominal wall can be inspected visually and manually.
10. Experience has shown that after approx. 30 min, it is no longer possible to retighten the reins. This is indicative of the maximum short-term stretchability of the abdominal wall.
11. The reins, clamps, and retractor arms are now disassembled. Perfect relaxation remains imperative.
12. Without substantial tension, the defect width is measured with the fascial edges approximated in the midline.
13. The rectus sheath is opened and the retromuscular space is visualized, as with the standard sublay technique. In the original approach, the principle of anatomical reconstruction was applied in an attempt to close the dorsal rectus sheath, upon which the sublay mesh is placed. At this point, decisions can be made regarding the application of additional interventions such as component separations (e.g., TAR). The decision criteria include residual defects and necessary mesh sizes that exceed the width of the rectus sheath (Fig. 24.5).

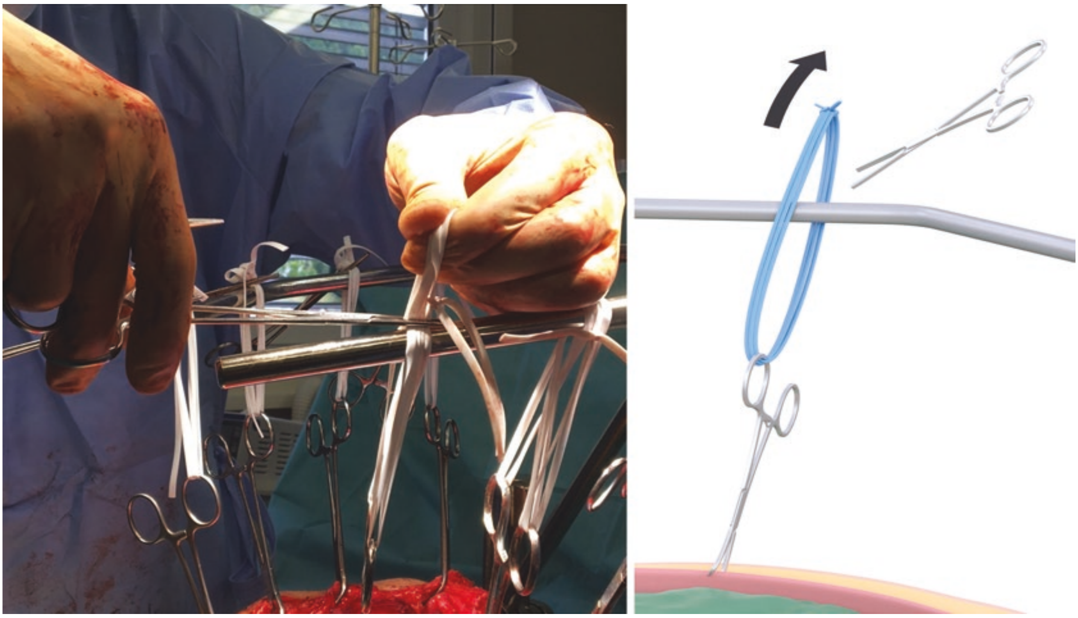

Fig. 24.4 Retensioning of elastic reins

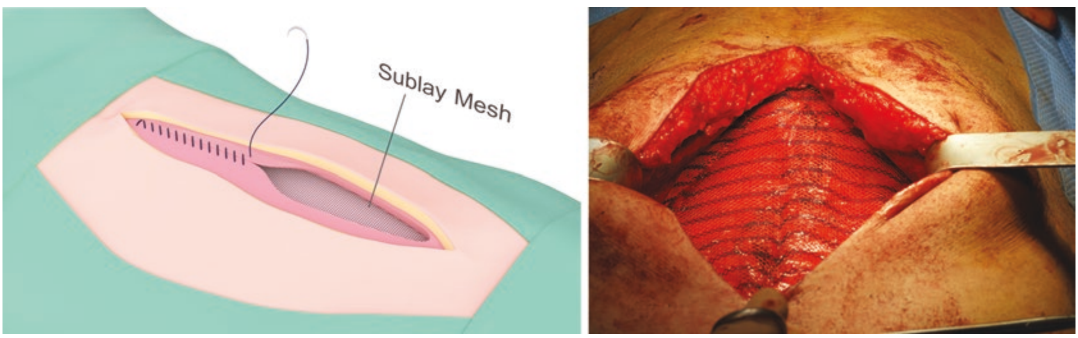

Fig. 24.5 Reconstruction (here: mesh sublay)

14. The abdominal wall is reconstructed as needed and is feasible in the given centre, and the surgeons' standards and strategies.

24.7 IFT with the Fasciotens® Hernia System

From the outset of devising the basic technique described above, which was initially conceived of as improvisatory, the developers envisaged to improve its technical implementation. Eucker and Zerz had developed various techniques to implement a sterilizable device, including standardizable application and data collection options.

Together with the Fasciotens company, developer Dr. Gereon Lill launched the fasciotens® Abdomen device [14–16] in 2017. The device was originally intended to be applied to the open abdomen in the context of damage control surgery and to avoid persisting grafted laparostoma. Due to its similar functional principle (fascia traction) and sterilizability, it proved excellently applicable to intraoperative abdominal wall extension/fascia traction (Fig. 24.6).

The fasciotens® Hernia system is the derivative developed for intraoperative application. With this system, a certified device that offers the standardized application and measuring options, in addition to instructions for initial application, has become available to abdominal wall surgeons. A large number of studies using the application data have now been published on the subject [17–19].

The surgical procedure is as follows:

1. The intervention is performed with the patient in the standard position for open complex reconstruction. Apart from the sterilized fasciotens® Hernia device and its carrier, which are installed after standardized disinfection and draping, only the standard laparotomy set is required.
2. The fascial edges are visualized after opening the skin or removing the skin graft.
3. Before the traction sutures are attached to the fascia, the rectus sheath can be opened and the retromuscular space visualized, as appropriate—either while leaving the hernia sac (Niebuhr's technique) or with traction applied to the nonexposed abdominal wall following adhesiolysis (Eucker's technique) (Fig. 24.7).
4. Six traction sutures are then fixed per side and at similar distances along the length. The sutures are pierced through the fascia in a U-bend with a stitch width of approx. 2 cm. Suture thickness 1 or 2 may be applied with atraumatic needles.
5. The fasciotens® Carrier is attached to the operating table in a sterile manner after which the fasciotens® Hernia device is attached to the carrier. There should be a distance of approx. 10 cm between the thread retainer and the patient. The system should be brought to initial traction of 14 kg. Then, the four sutures in the corners and subsequently the remaining sutures in the thread retainer are connected by using the tensioning clamping mechanism, such that the

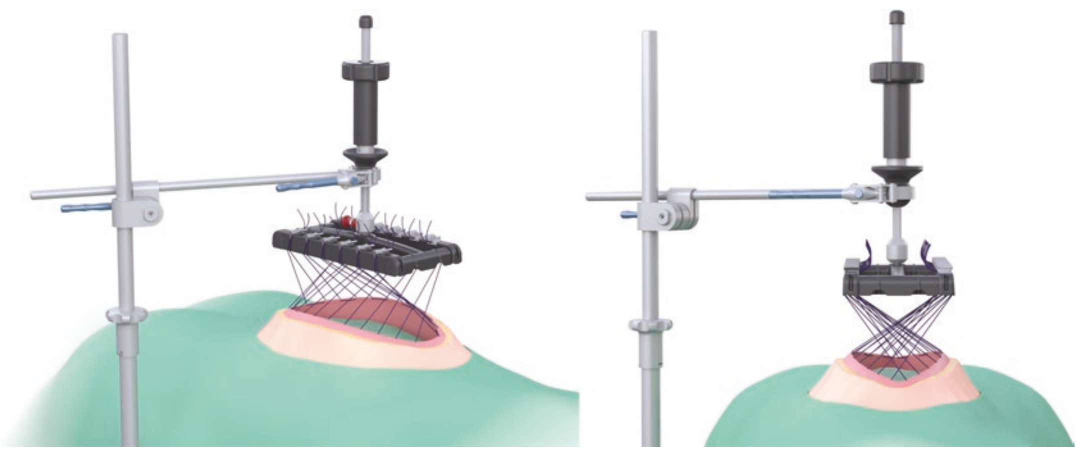

Fig. 24.6 Fasciotens® Hernia device (Figures reprinted with friendly permission of fasciotens®, Essen, Germany)

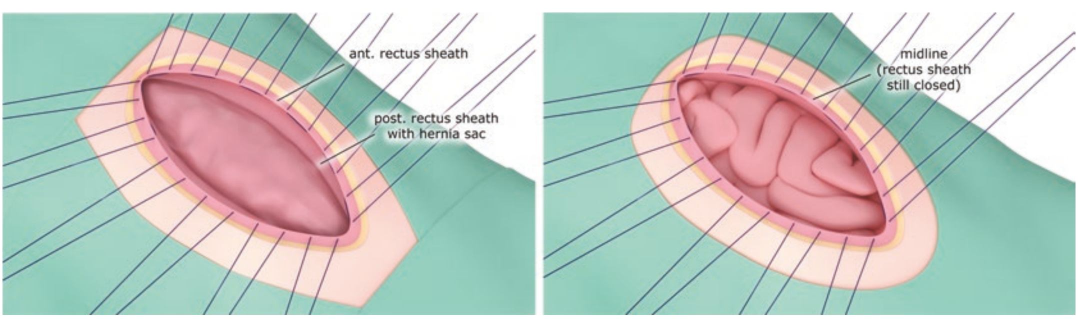

Fig. 24.7 Fascia borders exposed; rectus sheath open before traction (Niebuhr's technique), rectus sheath closed (Eucker's technique)

thread retainer is located approx. 5 cm above the abdominal wall (Fig. 24.8).

6. The sutures are wrapped around the frame from the exterior and fixed to the clamping mechanism under prestress. The direction of traction is crossed (Fig. 24.9; see comment in Sect. 24.8).
7. The traction force can be adjusted in a controllable manner by using the handwheel. Traction forces of up to 20 kg can be applied.
8. The individual sutures can be checked every 2 min for sufficient tension and retightened if necessary, until no further gain in the abdominal wall/fascia can be achieved (approx. after 30 min; Fig. 24.10).
9. After the posterior rectus sheath is prepared and layer dissection of the abdominal wall is completed, the mesh can be inserted before the traction sutures are removed.
10. The retractor and frame are dismounted and the possibly remaining size of the defect is measured.
11. The traction sutures can be left and may prove helpful in closing the fascia.

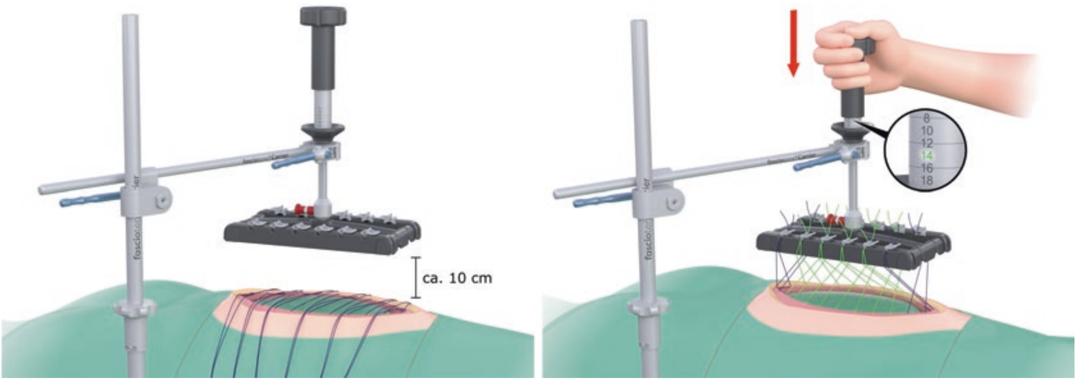

Fig. 24.8 Installation of the device and sutures. Applying tension (Figures reprinted with friendly permission of fasciotens®, Essen, Germany)

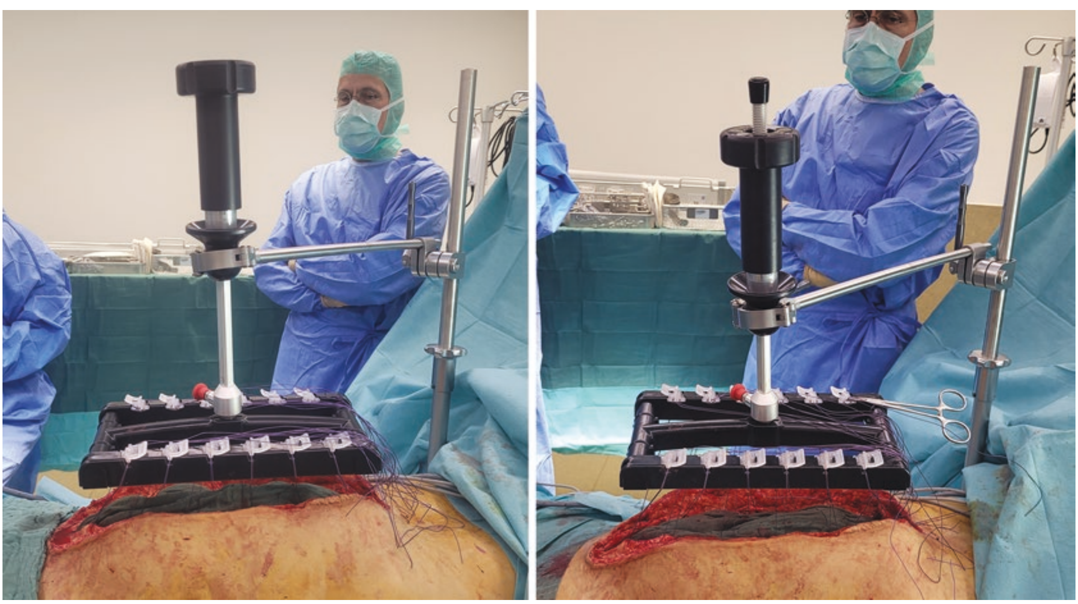

Fig. 24.9 fasciotens® Hernia device installed and with stressed mechanism

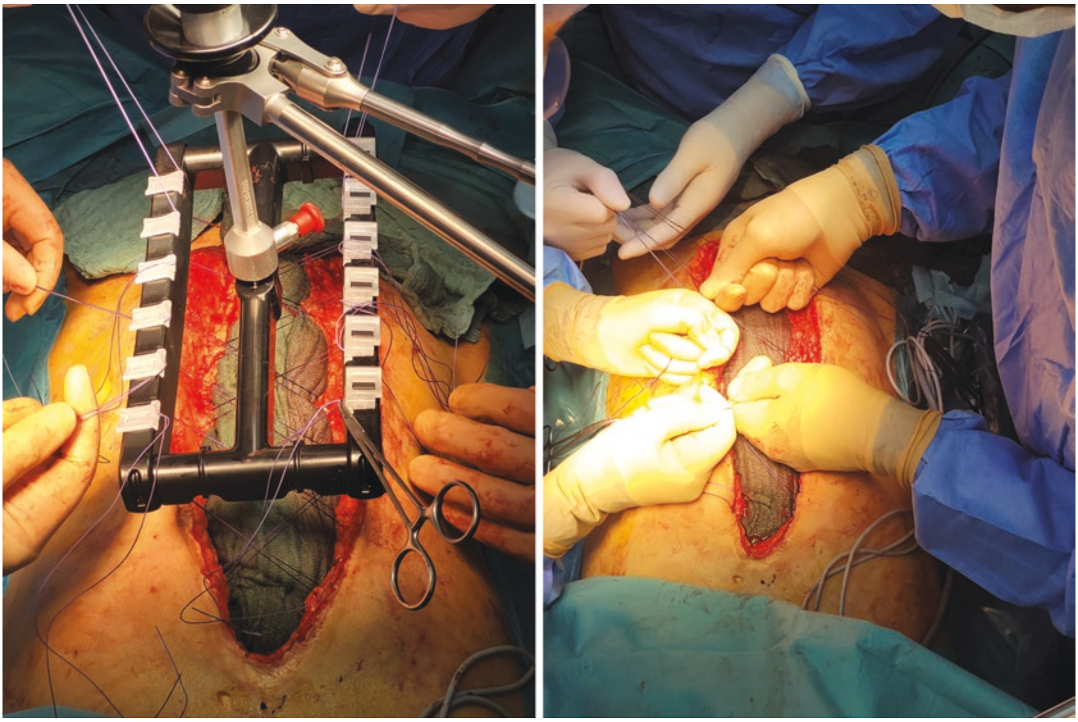

Fig. 24.10 Suture check during traction phase and after removal of traction device

12. As the case may be, the rectus sheath is opened only now and the retromuscular space is visualized. Reconstruction of the abdominal wall is guided by the given center's and surgeons' protocol.
13. From this step on, and as with the original technique, decisions can be made regarding additional procedures in terms of component separations.
14. *Until surgery is completed, absolute and unconditional muscle relaxation remains indispensable*.

24.8 Key Steps, Tips, Tricks, and Variations

The technique, whether described as AWEX or as IFT with the standardized fasciotens® Hernia system, is a novel surgical approach, which has just begun to spread internationally. For this reason, no concluding recommendations can be made regarding several aspects, including:

1. *Direction of traction*: The first describers' idea was to realize a gain in length in the lateral abdominal musculature. Shortening in this area appeared plausible due to CT-based observations of shortening and thickening. The consequence was to induce the traction into the abdominal wall via a force vector, which is particularly well transmitted to the dorsolateral part of the abdominal wall. Thus, the idea was to direct the traction vertically. However, intraoperative measurements showed attempts to arrange the traction in a crossed direction over the defect, and thus to imitate the physiological prestress of the abdominal wall, to be equally effective [17, 18]. Crossed tension could possibly prove beneficial, which would be located closely above the abdominal wall at the beginning of traction and thereby result in a nearly horizontal force. However, in the course of increasing tension, it would redirect the force vector vertically and thus affect various areas of the abdominal wall, especially the dorsolateral areas (Fig. 24.11).

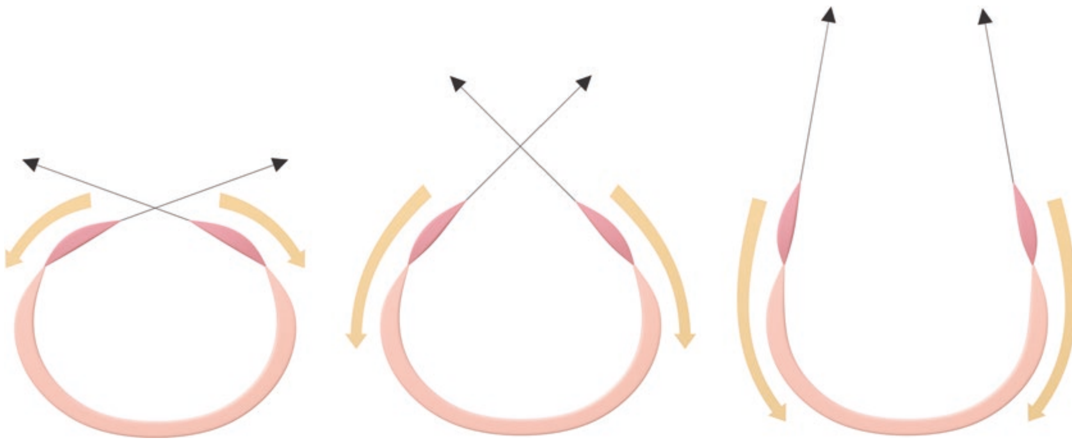

Fig. 24.11 Hypothetically, traction reaches more dorsal abdominal wall areas when applied in a more vertical direction

2. *Problematic marginal zones*: Especially in the epigastrium, the lateral abdominal muscles are relatively short. Still, retraction is significant in this area as well. The external oblique musculature retracts in the area of the costal arches, passing in part before the ribs, with the transverse abdominal and internal oblique muscles behind. In this area, retraction is more difficultly reversed. Horizontal traction has proven superior to vertical traction in the marginal zones.
3. *Dissection before or after traction?*: This question has also not yet been definitely answered. The published studies have not evidenced a substantial difference in terms of effectiveness or gain in length. The advantages of preparing the mesh bed before applying traction include more rapid reconstruction after removing the traction system. Whether occasionally observed abdominal wall reshortening during the processes of exposure happens per se or whether it is caused by suboptimal relaxation remains a matter of discussion.
4. *Torn-out traction reins and clamps, damage to the abdominal wall*: At first sight, the technique of traction to the abdominal wall would supposedly appear to be somewhat coarse. Concerns regarding torn-out reins and clamps have repeatedly been expressed. According to our own experience however such reservations are not justified as long as traction is under careful control. Ultimately, the tensile forces are applied continuously rather than roughly. Standardization including a limitation of force is certainly an important factor. Much feared laceration of muscle layers, development of hematoma, increased postoperative pain levels, and functional impairment have also never been observed and such concerns have proven unsubstantiated. Published reports have shown that the technique of intraoperative abdominal wall extension/fascia traction is associated with a markedly lower (!) level of comorbidity than other reconstruction approaches. The decisive factor is that this technique serves to avoid component separations and other dissecting interventions in a relevant percentage of cases. Long-term investigations [19], with follow-up period of up to 8 years, have shown no structural or functional damage whatsoever to the abdominal wall after applying this method.
5. *Combination with chemical component separation*: In the cohorts presented by Niebuhr et al. [17, 18], reconstruction was in many cases prepared with chemical component separation applied 6 weeks previously. In the cohort presented by Eucker et al. [19], additional measures, such as chemical component separation and combinations with surgical component separations, were referred to, yet not included in the result evaluations. Both

studies showed comparable results in terms of gain in length and absence of comorbidity. While complete intraoperative relaxation may possibly be sufficient for successful abdominal wall extension/fascia traction, final insights into this issue are pending. **The present authors currently recommend to consider preoperative chemical component separation in order to exploit all available possibilities in these complex patient cohorts**.

6. *Combination with other surgical techniques*: IFT is merely an additional tool to intraoperatively gain length at the abdominal wall. The given patient's anatomy, the technical options, the standards of the given center, and the planned surgical strategies are the factors that finally come to apply in deciding on additional measures. Combinations are possible with all conceivable techniques. Intraoperative abdominal wall extension/fascia traction does not obstructively stand in the way of any known reconstruction technique and can thus be applied unlimitedly as a sensible complement.
7. *Application in non-midline hernia*: IFT has also shown efficacy in this setting, e.g., in subcostal incisions, in which traction is then applied asymmetrically, and not lengthwise, to the abdomen. The principle of moving the shortened tissue, as a reserve, back towards its original anatomical position remains the same.

24.9 Combinations with Laparoscopy, Mini- or Less-Open Sublay, and Robotic Repairs

Notable experts have already employed intraoperative fascia traction in combination with the principal modern surgical techniques in use for the abdominal wall. For example, Niebuhr invented the technique of transcutaneous traction via percutaneously stitched holding threads to combine the principles of mini- or less-open sublay (MILOS) and the IFT technique [20]. A relatively small skin incision can be made only above the hernia sac (Fig. 24.12).

Individual cases have been described, in which traction sutures were applied to the fascia to reconstruct a rectus diastasis under laparoscopic control. The sutures were then advanced transcutaneously with a Reverdin needle and connected to the traction system. The midline can then be reconstructed with an extended total

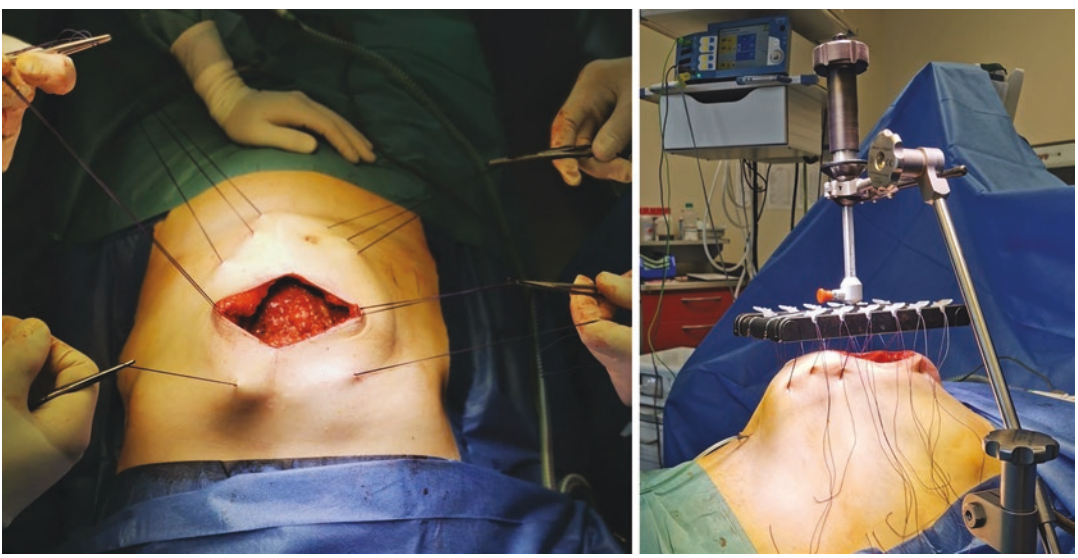

Fig. 24.12 IFT combined with MILOS (Niebuhr 2021)

extraperitoneal preperitoneal (eTEP) approach (Dieter Berger, Zurich 2021, personal communication). Combinations with robotic incisional hernia repairs (r-TARUP and r-eTEP) have been carried out (Bob Bloemendaal, Delft 2021, and Sebastian Lamm, Liestal 2022, personal communications).

Traction to the closed and non-herniated abdominal wall may also prove sensible in specific cases, likewise to an intact abdominal wall in a loss-of-domain situation with a massive inguinal hernia.

24.10 Conclusions and Prospects

Due to its convenience, low complication rate, and excellent combinability with all current reconstruction techniques, the principle of intraoperative abdominal wall extension/fascia traction has come to occupy an important place in reconstructive abdominal wall surgery. Although the technical possibilities to successfully exploit traction have definitely not yet been developed to the full, multiple variations in application and scientific investigations are probably to be expected over the coming years.

The basic AWEX system should be considered experimental and a state of the development of an elaborated technique.

Implementation of IFT with a standardized system and a certified device is the benchmark at specialized centers and in terms of high-quality requirements. *We recommend the currently available fasciotens® Hernia medical device*.

To our minds, planning complex abdominal wall reconstructions would point to a kind of categorical imperative, which we refer to as the **"Cathegoric algorithm of complex abdominal wall reconstruction"**:

1. Preoperative chemical component separation;
2. Optional progressive pneumoperitoneum;
3. Application of IFT;
4. Optional application of additional component separation techniques;
5. Reconstruction with synthetic implants preferably arranged outside the peritoneum; and
6. Open IPOM and bridging as alternative techniques.

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25 Abdominoplasty in Ventral Hernia

Rajan Tondon and Akhilesh Kumar Agarwal

In the last two decades, abdominoplasty along with ventral and umbilical hernia repair has grown in numbers owing to the desires and expectations of the patients, fed on dollops of media exposure. Refinement of surgical technique, team approach, and safer anesthesia practice have led to better outcomes and lower surgical morbidity [1–3].

Appropriate case selection, preanesthetic evaluation, patient counseling, meticulous planning, and teamwork remain the key to successful outcomes.

25.1 Surgical Anatomy in Ventral Hernia

The anterior abdominal wall musculature helps protect the intra-abdominal contents, stabilizes the lumbar spine, and helps in trunkal flexion.

The aponeurotic layer of the oblique muscles splits to form the anterior and posterior rectus sheath, which further interdigitate with their contralateral counterpart to form the Linea Alba. Hence, the musculoaponeurotic layer of the anterior abdominal wall along with the lumbar spine and posterior abdominal wall create a "trunkal cylinder."

Disruption of the "trunkal cylinder" due to ventral hernia leads to loss of resting tone of the oblique and recti muscles and suboptimal muscle contraction. This results in poor lumbar spine stabilization and lumbar lordosis [4].

In addition to lumbar lordosis, the ventral hernia itself creates significant traction on the overlying skin and fat. Both these factors accentuate the anterior bulge (Fig. 25.1). Further, the perfusion of the skin overlying the hernia sac would be jeopardized once the sac is dissected off the skin. This is because, over time, a large part of the stretched skin and fat starts receiving its blood supply from the sac. Therefore, we term it as "parasitic skin" (Fig. 25.2).

It is obligatory for the reconstructive surgeons to consider the altered functional and vascular anatomy prior to planning the incision and the extent of excision (panniculectomy).

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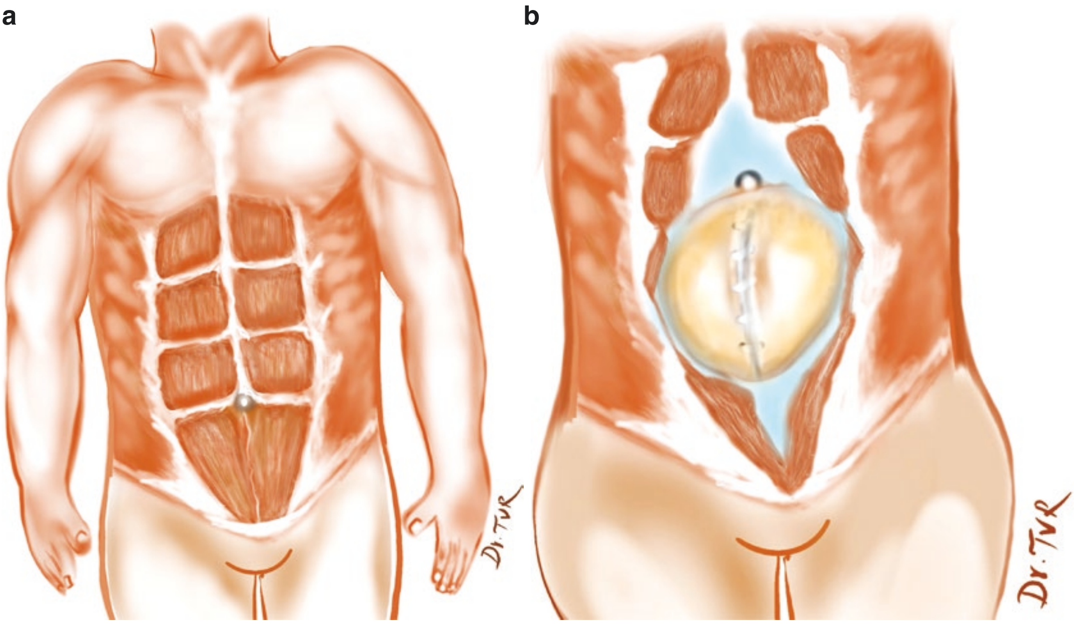

Fig. 25.1 Surgical anatomy in Ventral hernia. (**a**) Normal anatomy of anterior abdominal musculoaponeurotic system. (**b**) Altered anatomy in ventral hernia. Illustration by Dr. T Varun Raju

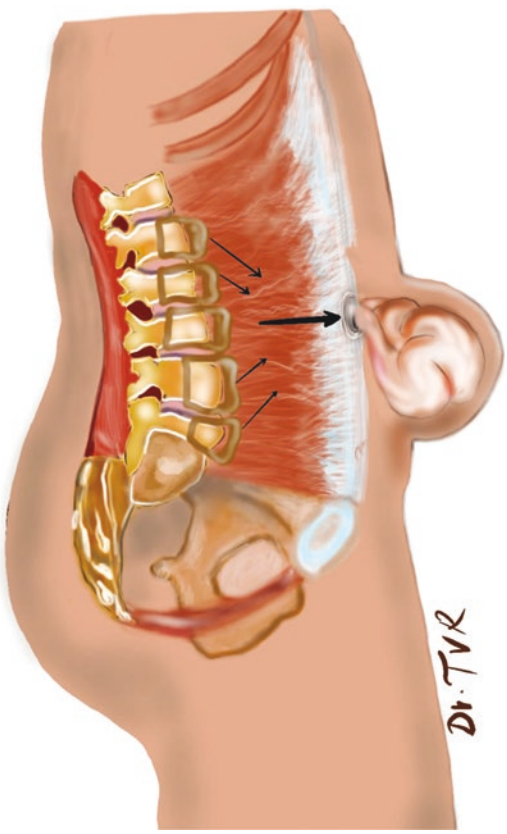

Fig. 25.2 Exaggeration of lumbar lordosis due to ventral hernia. Illustration by Dr. T Varun Raju

25.2 Patient Selection (Table 25.1)

While most patients with large hernia and redundant skin will need some form of panniculectomy and an informal abdominoplasty, patient selection for a formal abdominoplasty needs to be careful. Young, motivated patients (BMI < 35 kg/m²) with moderate to severe skin redundancy are ideal candidates for abdominoplasty with ventral hernia reconstruction [1].

25.2.1 Preoperative Optimization

Smoking should be stopped 3 weeks before and 3 weeks after the procedure, as it impedes the healing process due to poor skin flap perfusion [3]. Further, smoking leads to poor ciliary function of the bronchial airway which leads to higher pulmonary complications in the postoperative period.

Fair glycemic control in diabetic patients is mandatory and HbA1c >7.4 is a relative contraindication to perform abdominoplasty [3].

Since abdominoplasty patients are more likely to develop DVT, preoperative thromboprophy-

Table 25.1 Case selection

BMI < 35 with abdominal skin redundancy
Young, motivated patients
Psychologically stable
HbA1c <7.4 (in diabetics)
No major systemic insufficiency
Acceptable lung function
Smokers to stop 3 weeks before and after surgery

laxis with low-molecular-weight heparin is started the day prior to surgery.

Optimization for other systemic illnesses is the same as that before any other abdominal surgery under general anesthesia.

25.3 Surgical Technique (Table 25.2)

Table 25.2 Surgical steps

Markings
Tumescent liposuction
Excision of redundant skin and fat
Hernial sac dissection
Hernioplasty
Midline recti approximation/bridging
Quilting of skin flaps
Umbilicoplasty
Skin closure in layers

Markings are performed preoperatively after taking clinical photographs in the standing and sitting positions. It helps delineate the hernial sac, liposuction areas, and skin redundancy in the abdomen.

After anesthetic induction, the patient is catheterized aseptically and pneumatic compression devices are started for DVT prevention.

Tumescent liposuction of the flanks and surrounding abdominal skin allow the skin flaps to become pliable while preserving the skin perforators and cutaneous nerve branches. 1:10,00,000 Adrenaline solution of Ringer's lactate with local anesthetic is infiltrated in the areas of liposuction 15–20 min prior to the liposuction. It reduces bleeding and permits hydro dissection in the deeper fat planes, preserving Sub-Scarpa lymphatics and musculocutaneous perforators and nerves (Fig. 25.3). No liposuction is performed in the hernia sac area, marked prior to anesthesia.

Following liposuction, the redundant skin is excised and the hernia sac is visible. The amount and location of redundancy dictate the choice of skin resection pattern. In large ventral hernias involving the supraumbilical abdomen, "anchor" abdominoplasty [3] or Fleur de Lis abdominoplasty is usually necessary (Figs. 25.4 and 25.5). When the laxity is limited to the lower abdomen, traditional infraumbilical skin resection [1, 2] is performed (Fig. 25.6).

Fig. 25.3 Honeycomb appearance post-liposuction, showing Scarpa's fascia

During infraumbilical skin resection, sub-Scarpa lymphatics are preserved and diathermy use is limited to attain hemostasis only. This helps reduce seroma formation postoperatively [5, 6].

Hernial sac dissection and hernioplasty are performed by the Hernia team. Rectus muscles are approximated over a sublay [7], macroporous Polypropylene mesh (Fig. 25.5g–i).

Prior to definitive skin closure, hemostasis is ensured and "tailor tacking" is done by bringing the skin flaps together with skin staplers from lateral to medial, sequentially reducing the tension at the midline closure. This step helps to trim residual redundant skin and prevent dog ears, both of which can be extremely dissatisfying for the patient and a cause for unnecessary complaint postoperatively [3].

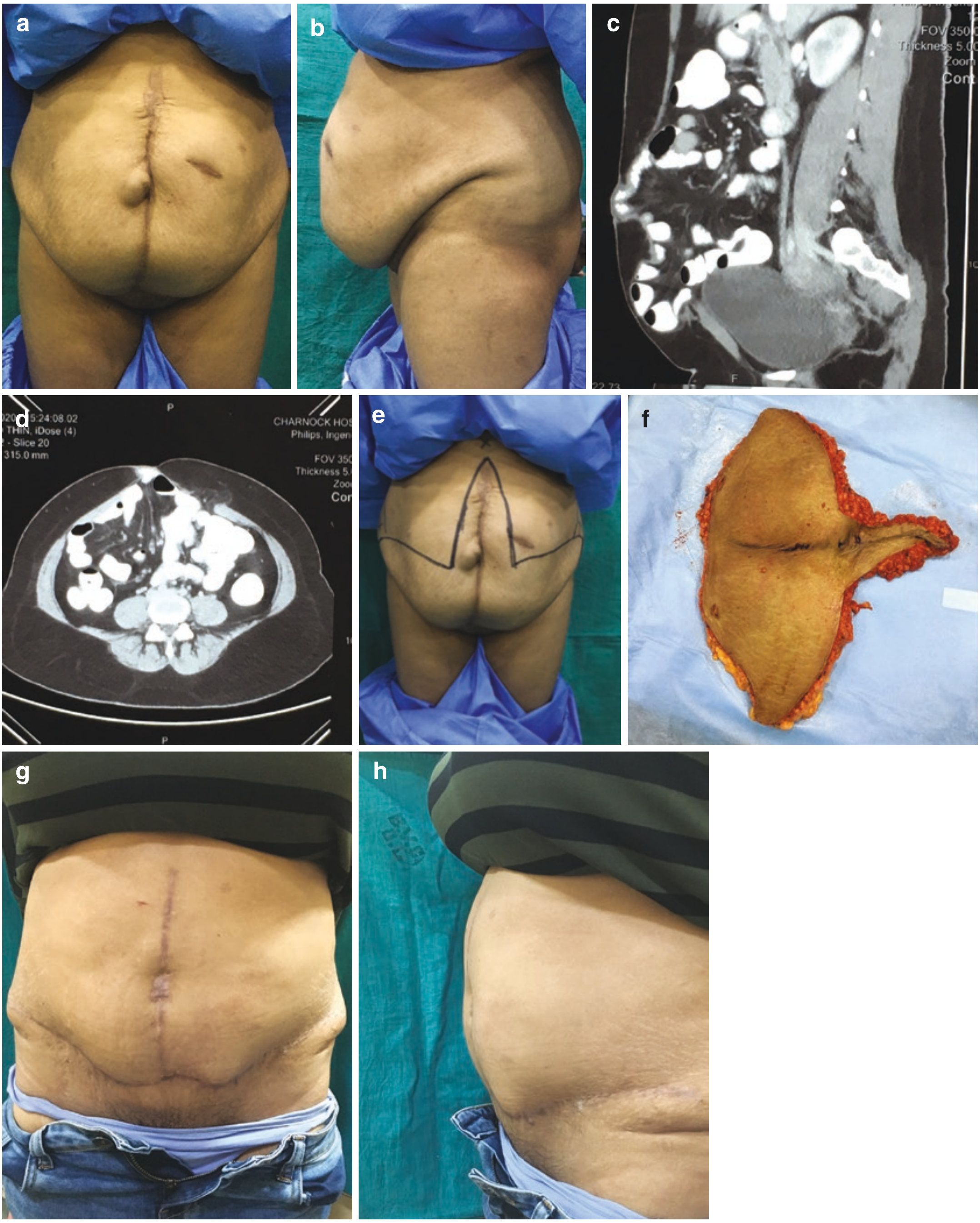

Fig. 25.4 33-years-old female patient with BMI 29, underwent umbilical hernioplasty and Fleur de Lis abdominoplasty with primary umbilical reconstruction. (**a, b**) Preoperative. (**c, d**) Preoperative abdominal CECT images. (**e**) Preoperative markings. (**f**) Panniculectomy specimen. (**g, h**) 8 months postoperative

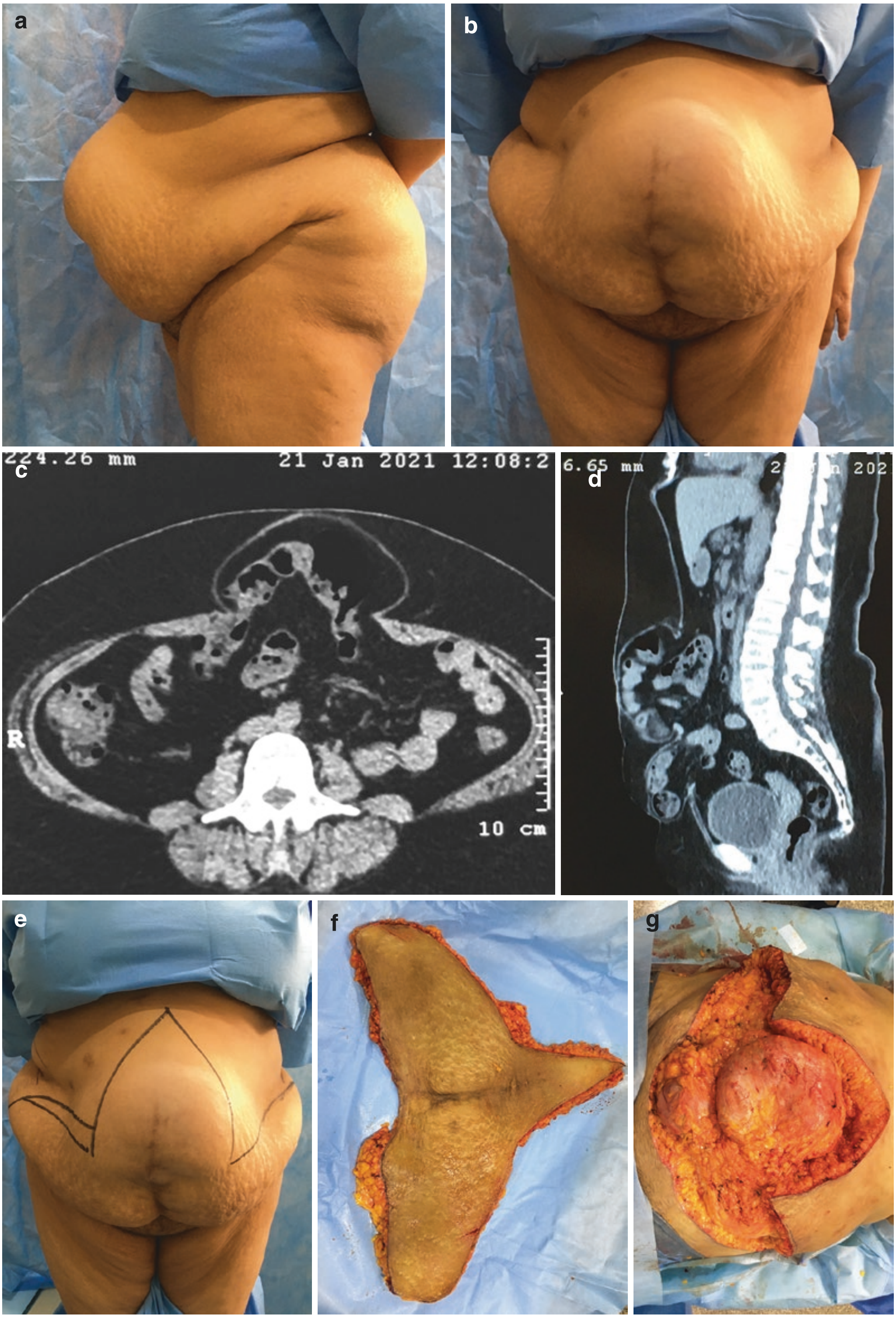

Fig. 25.5 56-years-old female with BMI 33 underwent ventral hernioplasty and Fleur de Lis abdominoplasty. (**a, b**) Preoperative. (**c, d**) Preoperative abdominal CECT images. (**e**) Preoperative markings. (**f**) Panniculectomy specimen. (**g**) Hernia sac exposed. (**h**) Retrorectus mesh placement. (**i**) Midline recti closure. (**j**) Abdominoplasty closure. (**k, l**) 3 months postoperative

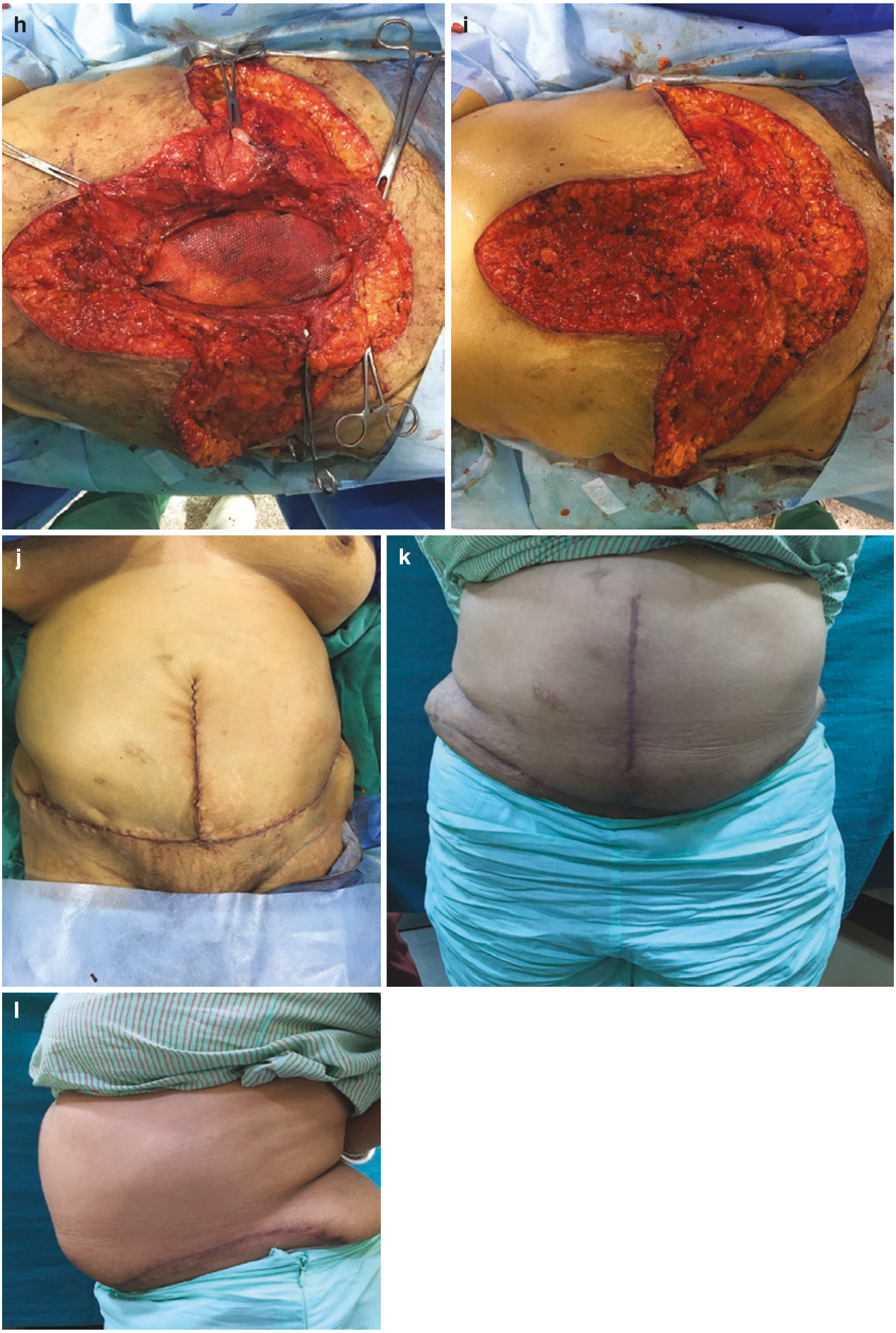

Fig. 25.5 (continued)

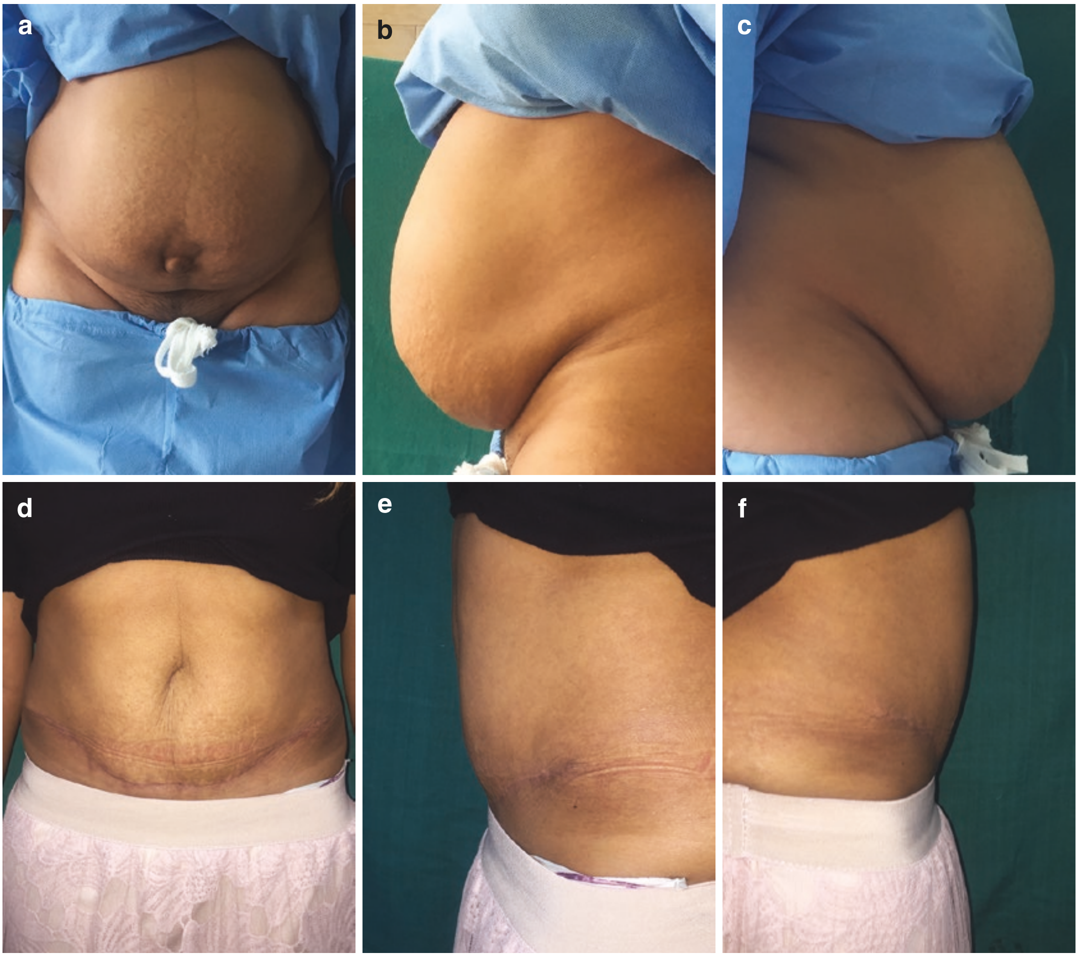

Fig. 25.6 29-year-old female patient with BMI 26 Kg/m^2 underwent ventral hernioplasty and abdominoplasty with primary umbilical reconstruction. (**a–c**) Preoperative. (**d–f**) 5 months postoperative

Umbilicus inset is performed in the skin flap, resecting a narrow kite-shaped skin (2 × 1 cm) at the designated position, defatting the skin marginally for umbilical inset, creating a natural depression at the scar [8].

Sequential "quilting" of the thinned skin flap is done in the midline, anchoring the umbilical dermis to the fascia at 12 and 6 o'clock positions with 3-0 PDS sutures. This reduces the dead space [9] and tension on the scar and helps create the slight midline depression, which is desirable [1, 2].

The umbilical inset is done by four to six 4-0 poliglecaprone dermal sutures, keeping the umbilical scar hidden. The superficial fascial (Scarpa's) layer is closed from lateral to medial with interrupted 2-0 polydioxanone sutures, reducing the tension on the midline closure. The skin is closed with 3-0 polydioxanone continuous barbed dermal suture, followed by adhesive skin closure bandages across the scar.

25.4 Postoperative Care

Patient is nursed in Fowler's position for 2 days. Pneumatic compression stockings are used until the patient is mobile. Ambulation is started the day after surgery. DVT chemoprophylaxis (Enoxaparin) is started 12 h following the surgery and given for 2 days only or until the patient starts ambulating. Daily showers are started from postoperative Day 2. The patient is discharged on postoperative Day 3 or 4 after reviewing the scars. Light pressure elastic garments are prescribed for 3–6 weeks to reduce edema.

The patient is instructed to walk at home and perform light activities and is followed up every week for 3 weeks and then, every 3 months for a year, and annually thereafter. Heavy exercises and exertional activities are permitted after 3 weeks, once the scars have healed well.

25.5 Complications (Table 25.3)

25.5.1 Local Complications

Bleeding and hematoma are commonly due to inadequate hemostasis and unstable blood pressure in the immediate postoperative period. Small hematomas may resorb spontaneously. Hematomas >30 mL need ultrasound-guided aspiration after they have hemolysed. Large hematomas with skin bruising, although rare, may need surgical drainage [3].

Table 25.3 Complications

Local	Systemic
Bleeding and hematoma	DVT with pulmonary embolism
Seroma	Abdominal compartment syndrome
Skin flap necrosis and dehiscence	
Scar stretching and hypertrophy	
Deformed umbilicus	
Dog ears	
Local sepsis	
Dysesthesias	

Seromas following abdominoplasty can be prevented by adjunct liposuction, retaining the sub-Scarpa lymphatic vessels and minimizing dead space formation by quilting sutures. Small seromas may resorb over a period of time, while those larger than 25 mL may need serial ultrasound-guided aspiration and local steroid injection. Rarely, encapsulated and persistent seromas will need surgical drainage [6].

Skin flap necrosis and dehiscence (especially in the suprapubic area) are usually attributed to over-exuberant resection, smoking, and excessive tension at closure [3, 4]. This can be prevented by meticulous preoperative marking and planning. Marginal skin necrosis usually heals over 3–4 weeks by secondary intention (Fig. 25.7).

Wider areas of skin necrosis require surgical debridement, negative pressure dressings, and secondary closure (Fig. 25.8).

Scar stretching and hypertrophy are usually related to marginal necrosis and healing by secondary intention.

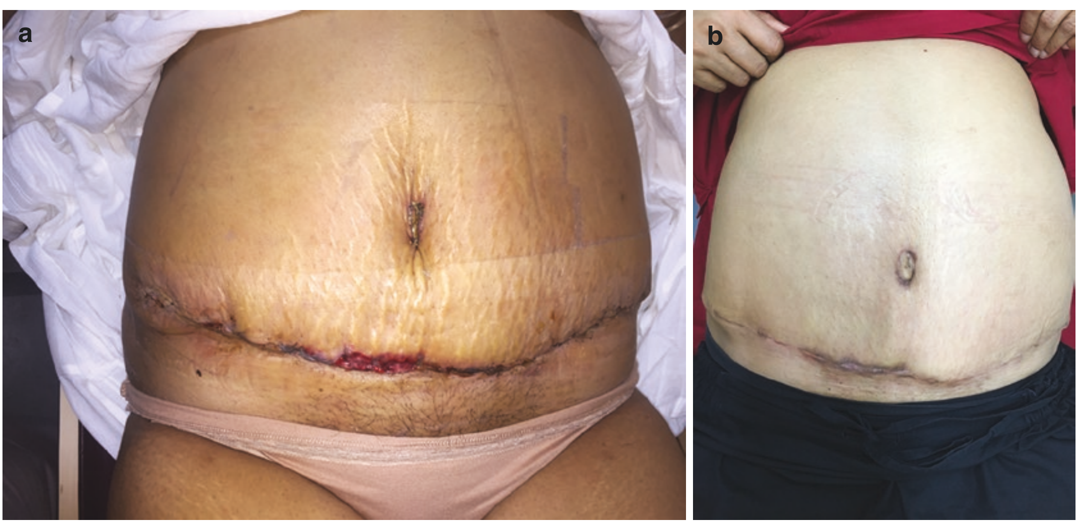

Fig. 25.7 (**a**) Marginal skin necrosis. (**b**) Healed by conservative care in 4 weeks

Fig. 25.8 (**a**) Marginal flap necrosis with slough at 3 weeks postoperative (BMI 39). (**b**) 2 weeks post-debridement and NPWT dressings. (**c**) 2 weeks post-secondary suture

Dog ears at the edges of the scar are best prevented. They rarely improve with time and ultimately need surgical revision [3].

Umbilical deformities are usually related to malpositioning and excessive visible scarring. Often, the umbilical cicatrization is due to a poorly perfused umbilicus [2, 8].

Dysaethesia is transient in the areas of liposuction and can last for 4–6 weeks.

25.5.2 Systemic Complications

The incidence of deep vein thrombosis and pulmonary embolism are 8–10 times more following lipoabdominoplasty as compared to truncal liposuction. Therefore, prophylactic measures (SCD pumps and LMWH) are very important in all patients undergoing abdominoplasty [4].

Abdominal compartment syndrome (ACS) results from a tight midline approximation of the Recti muscles. Therefore, a tight closure should be avoided and measures should be taken to reduce postoperative bowel edema and ileus. In the event of impending ACS, early detection and decompression are the key to gut survival and preventing mortality. Negative pressure wound therapy for 5–7 days may be used as a “bridge” to help the gut and parietal edema to subside before secondary closure is attempted.

25.6 Summary

A complete understanding of the altered anterior abdominal wall anatomy in presence of ventral hernia as well as the vascularity of the musculature and skin is imperative for planning abdominoplasty in hernia patients. Further, CECT of the abdomen helps in illustrating the expected musculoaponeurotic defect and the hernia characteristics.

Abdominoplasty in ventral hernia is a gratifying surgical procedure, provided proper case selection, meticulous planning, and skillful execution are carried out.

Abdominoplasty in well-selected and prepared patients leads to improvement in quality of life, activity levels, and self-esteem; without increased morbidity [10].

The outcomes are excellent if a good coordination exists between the hernia surgeon and plastic surgeon.

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