13 Posterior Component Separation Via Transversus Abdominis Muscle Release: The TAR Procedure

Yuri W. Novitsky

Introduction

Evolution of hernia surgery has led to popularization of reconstructive techniques. I believe that the goal of most, if not all, herniorrhaphies should be restoration of a functional abdominal wall with autologous tissue repair strengthened by mesh reinforcement. Anterior component separation techniques described in Chapters 14–16 typically involve release of the external oblique muscle and fascia. The traditional approach described by Ramirez involves creation of large skin flaps and associated significant wound morbidity in up to 63% of cases [1–3]. Minimally invasive modifications are known to reduce skin flaps and wound complications, but limit mesh placement to intraperitoneal underlay in the vast majority of cases. In an effort to reduce wound morbidity, I prefer to utilize retromuscular sublay techniques. For moderate-sized defects, classic Rives-Stoppa retrorectus repairs, described in Chapter 12, provide durable outcomes with low morbidity [4–7]. However, the major limitations of the classic retrorectus repair include limited medial myofascial advancement and lack of sufficient sublay space for wide overlap of the visceral sac in many hernias. Although techniques to overcome the limitations of the rectus sheath by utilizing pre-peritoneal or intra-muscular repairs have been described [7, 8], both are fraught with disadvantages of limited myofascial medialization and/or neurovascular bundle damage.

To address the shortfalls of the traditional retromuscular repairs, I have recently developed another novel technique of posterior component separation using transversus abdominis muscle release (TAR) [9]. This modification allows for significant posterior rectus fascia advancement, wide lateral dissection, preservation of the neurovascular supply of the rectus abdominis muscle, and provides a large space for mesh sublay. Most importantly, this technique allows for medialization of the abdominal wall components without raising lipocutaneous flaps. In this chapter, I will describe the history of this technique, its anatomic and physiologic basis, indications/limitations, detailed technical considerations of TAR as well as a variety of clinical outcomes.

History of TAR

The first TAR was performed in the late 2006. Prior to that, an aforementioned Rives-Stoppa with the pre-peritoneal extension was my procedure of choice. As I happened to be involved in the cadaveric dissections during normal anatomy

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classes, I serendipitously noted a significant medial extension of the transversus abdominis muscle (TA) past linea semilunaris as well as its dorsal relationship with the costal margin (Fig. 13.1). The initial series of my TAR patients was first presented at the 2009 World Hernia Congress and received mixed reviews, with skepticism about its efficacy, reproducibility, and potential deleterious effects of TA transection on the stability of the abdominal wall. However, following publication of the technical details [10] of the first 42 patients with longer follow-up and further evidence of safety and efficacy of this approach, there has been a steady increase in the acceptance and utilization of TAR by the surgical community worldwide.

Anatomic and Physiologic Basis of TAR

As mentioned above and described in detail in Chapter 1, the anatomy of the TA muscle makes it the ideal target for posterior component separation. In the upper third of the abdomen, it extends medially far beyond the semilunar line (and the lateral edge of the rectus muscle) (Fig. 13.1) and ultimately inserts into the edge of the costal margin (costal cartilages of 7–12th ribs) and xiphoid process. It also interdigitates with the diaphragm at its cephalad aspect. The medial extent of the TA muscle diminishes as one moves caudally. At the level of the umbilicus and below, only the transversus abdominis aponeurosis and almost no TA muscle fibers are present. In addition, the orientation of the TA muscle fibers is in the direction of the desired (horizontal) advancement of the rectus complex, as opposed to the external and internal oblique muscles. This largely contributes to successful medialization of all abdominal components during TAR.

The physiologic function of TA is another key factor for its targeting during posterior component separation. It is one of the principal muscles in the maintenance of the intra-abdominal pressure and together with the internal oblique, but not external oblique, it provides hoop tension throughout the entire thoracolumbar fascia. In fact, it is widely viewed as the "corset" of the abdomen. Its release and subsequent mobiliza-

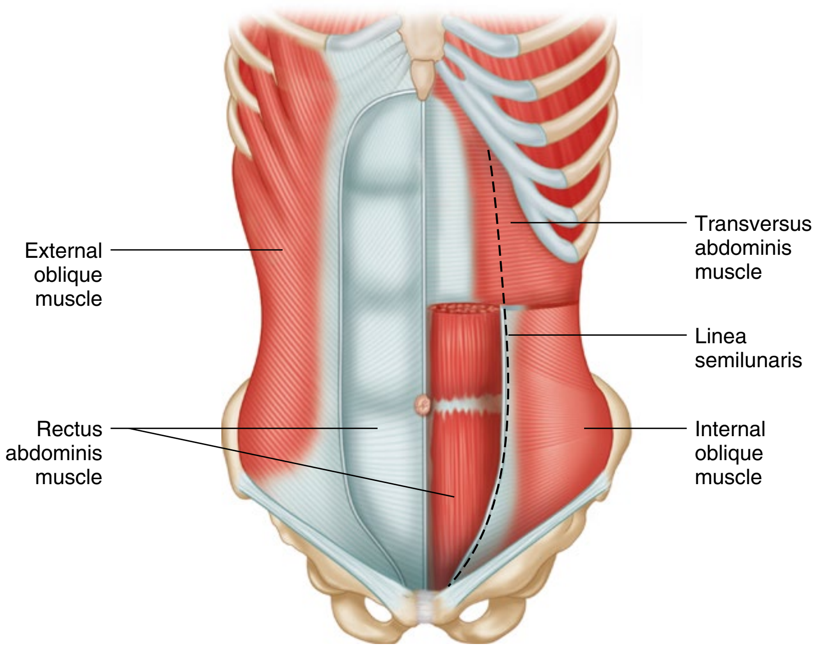


Fig. 13.1 Muscles of the abdominal wall. Notably, the transversus abdominis muscle extends medial to the semilunar line in the upper abdomen

tion off the underlying fascia removes the muscle's contribution to the "tone" of the lateral abdominal wall. Logically, this leads to the largest expansion of the abdominal girth and medial advancement of the entire rectus complex. These physiologic functions are central in the ability of TAR to provide medialization of not only posterior, but also anterior components of the abdominal wall, especially in cases of wide abdominal defects.

Indications and Patient Selection

My personal algorithm for procedure selection for a given patient begins with considering the suitability of the laparoscopic approach. Patients who have small to medium defects (<8 cm wide), without previous intraperitoneal mesh or skin changes/skin grafts/wound healed by secondary intention are generally approached laparoscopically. The remaining patients I will approach via an open technique. While some of the patients undergoing open repairs may be effectively treated using a traditional Rives-Stoppa, most of those patients in my practice would have undergone a laparoscopic repair. Thus, I utilize TAR for the vast majority of my open repairs. Posterior component separation is particularly important for those patients who need myofascial release for their abdominal wall reconstruction, but are not candidates for the anterior component separations. Those may include patients with subcostal/Chevron incision hernias, patients with old appendectomy incisions, and those with a history of abdominoplasty and previous anterior releases, among others. Furthermore, patients with large subxiphoid, parailiac, and suprapubic hernias do not usually enjoy the benefits of anterior component release, and therefore may be best suited for posterior release and TAR. Finally, in my practice, most patients with parastomal herniations are also considered to be good candidates for reconstructions with TAR.

While there are no absolute contraindications to TAR, relative contraindications include previously pre-peritoneal and/or retromuscular repairs, need for panniculectomy/abdominoplasty, and history of severe necrotizing pancreatitis (given resultant scarring of the retroperitoneum). It is also important to point out that TAR should not be combined with the anterior component release. This practice would likely result in significant lateral laxity or lateral hernia formation from creating the environment where internal oblique muscle is a sole provider of lateral abdominal wall integrity. However, in patients who present with recurrences following anterior release, the TAR approach is useful and possibly the "last resort" approach, despite associated risks of lateral bulging in those challenging patients. We have recently reported our experience in those challenging patients, with good short-term outcomes [11]. Of note, in this unique cohort, I advocate the use of a heavy-weight polypropylene mesh to allow for more durable prosthetic reinforcement.

Pre-operative Planning

Careful pre-operative imaging is paramount to a successful ventral hernia repair, especially when any degree of complexity is anticipated. I recommend routine abdominal/pelvic CT imaging. No oral or intravenous contrast is generally necessary. CT delineates all abdominal wall defects: this is of particular importance in obese patients where physical examination carries significant limitations. Furthermore, in addition to uncovering occult intra-abdominal pathology contributing to patient's symptoms, abdominal CT allows for detection of previous synthetic meshes and/or latent infections. I also mandate a screening colonoscopy in appropriate patients prior to undertaking any major abdominal wall reconstructions.

Pre-operative optimization is one of the most important steps to maximize surgical outcomes. General principles of patient optimizations are already covered in Chapter 4. Our hernia center provides nutritional evaluation and counseling for all obese patients contemplating hernia repair. For those with non-obstructive symptoms, major abdominal wall reconstructions are delayed until commonly agreed weight loss criteria are reached. Admittedly, I do not have established BMI criteria that preclude repairs and generally consider multiple factors to decide on appropriate timing of the repair. It is important to point out that a fairly large proportion of obese patients with symptomatic hernias will progress to require urgent and emergent operations, which are significantly more difficult and morbid. To assist with weight loss goals, our bariatric team evaluates patients to select appropriate candidates for weight-loss surgery. Unfortunately, insurance limitations often preclude pre-operative weight-loss surgery for hernia patients. While concomitant bariatric/abdominal wall repairs may become routine in the future, their utility remains investigational at the present time. We also emphasize strict blood glucose control and postpone any elective repairs until HgA1C is less than 8. Smoking cessation is mandatory prior to any elective repairs.

Operative Technique

Patient Positioning

The patient is placed in the supine position. The abdomen should be prepped from the nipples to mid-thigh. Laterally, the prepped field is extended to the posterior axillary lines. I routinely use an Ioban drape (3M, St. Paul, MN) to minimize the risks of mesh infection.

Step 1: Incision/Adhesiolysis

A generous midline laparotomy is performed in the majority of cases. Elliptical or "tear-drop" incisions are used to incorporate previous scars as well as all attenuated or ulcerated skin. For most patients, and especially the morbidly obese with large midline hernias, I recommend routine excision of the umbilicus to minimize post-operative wound morbidity. While some surgeons prefer to remain extra-peritoneal, I advocate a complete lysis of all intestinal adhesions to the anterior abdominal wall. This is essential for several important reasons. First, undivided adhesions may contribute to peritoneal/posterior sheath tears during myofascial release/advancement. Second, the adhered viscera may be vulnerable to inadvertent (and likely unrecognized) visceral injury during tissue releases. Lastly, dense intra-peritoneal adhesions to the anterior abdominal wall may impede medialization of the posterior components. I typically abstain from lysing inter-loop adhesions unless there are pre-operative obstructive symptoms or any intestinal resections are undertaken. Following adhesiolysis, a countable towel is placed on top of the viscera with its edges "tucked" into the gutters, pelvis, above the liver, and toward the esophageal hiatus. This helps to protect the viscera during subsequent myofascial releases.

Step 2: Rectus Sheath Release/Retro-Rectus Dissection

Following adhesiolysis, the posterior rectus sheath is incised. The precise location of this initial incision might be difficult, especially in patients with large defects where the rectus muscles are retracted laterally (Fig. 13.2). It is important to identify the junction of the rectus muscle and hernia sac. Only after that is done, the rectus sheath is incised about 0.5–1 cm from its medial edge (Fig. 13.3a, b). It is critical that the fibers of rectus abdominis are clearly visualized (Fig. 13.4). If this is not done, one may erroneously divide the hernia sac and enter the subcutaneous plane. I typically aim to initiate this step either above or below the hernia neck, in order to access the retrorectus plane where the muscle is not lateralized. Another useful maneuver is to palpate the rectus muscle to facilitate identification of its medial extent. The retromuscular plane is then developed toward the linea semilunaris. For this plane, I utilize bovie electrocautery to control/divide the fine areolar tissue and small perforating branches of the epigastric artery. In addition, blunt instrument or finger dissection could be utilized. An important aspect of this dissection is the constant traction/counter-traction applied by Richardson retractors under the rectus muscles and multiple Allis clamps placed on the medial edge of the incised posterior rectus sheath (Fig. 13.5). The lateral extent of this dissection is the perforators to the rectus muscle, which are the branches of the thoraco-abdominal nerves, penetrating the lateral edge of the posterior rectus sheath just medial to linea semilunaris

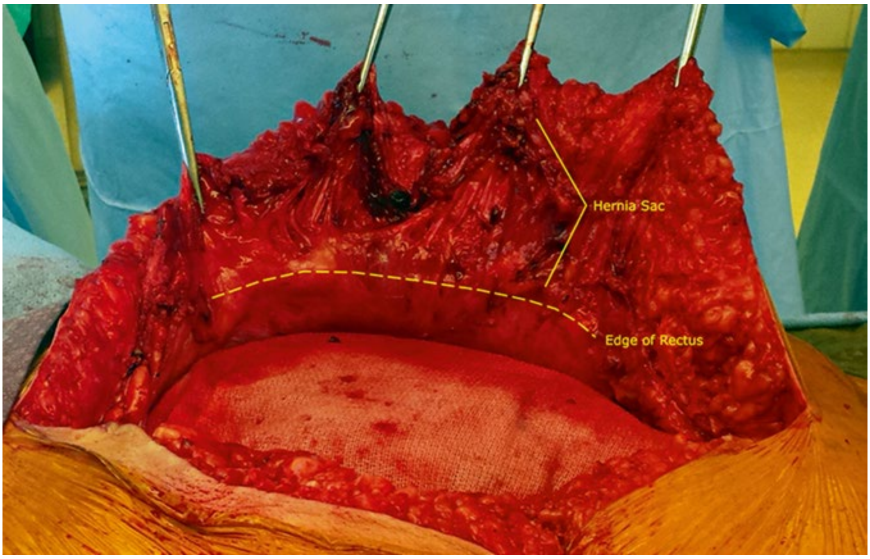
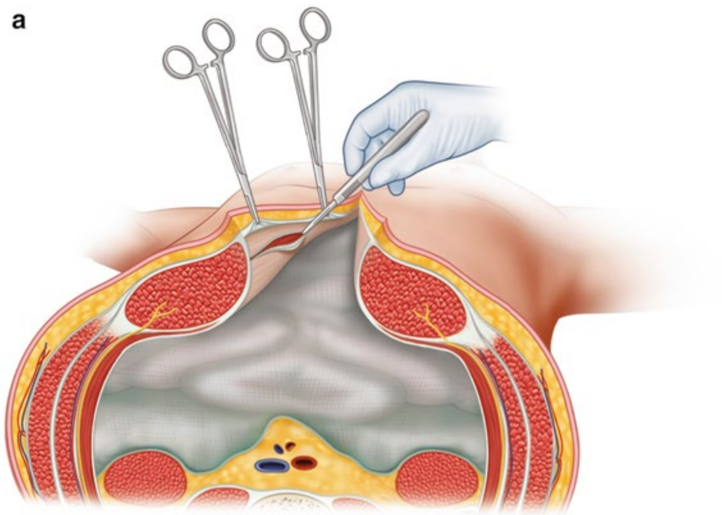


Fig. 13.2 Countable towel covers the entire visceral sac and rectus muscle edge is defined

(Fig. 13.6). The plane is extended cephalad toward the costal margin. Importantly, the attachments of the falciform ligament to the undersurface of the right posterior rectus sheath need to be preserved during the cranial dissection of the right retro-rectus space (Fig. 13.7). The cranial extent of this dissection depends on the extent of the hernia defect and may extend to the epigastric area or all the way to and above the xiphoid process (discussed below). The transition from the retromuscular plane within the rectus sheath into the pelvis involves the division of the medial attachments of the arcuate line of Douglas to the linea alba. Following that, it is imperative to enter and develop the pre-peritoneal plane. The inferior deep epigastric vessels, which run ventral to the transversalis fascia and along the posterolateral surface of the rectus abdominis muscles need to be identified and preserved. Dissection in the pre-transversalis plane may lead to vascular injuries. Caudally, I typically will proceed to dissect into the space of Retzius, exposing the pubis symphysis and Cooper's ligaments (Fig. 13.8).

Step 3: Exposure and Division of the Transversus Abdominis Muscle

Once the retromuscular plane is developed to the linea semilunaris, the limit of the traditional Rives-Stoppa approach has been reached. Posterior component separation and TAR, if necessary, is then undertaken. Starting in the upper third of the abdomen (or at the cephalad-most part of the retro-rectus dissection), the posterior rectus sheath is incised again and the underlying fibers of the transversus abdominis muscle are identified (Fig. 13.9a, b). It is important to make the incision just medial to the perforating neurovascular bundles to minimize their damage and subsequent chance of denervating the rectus muscle (Fig. 13.10). As mentioned above (Fig. 13.1), the medial extension of TA is significantly medial to the linea semilunaris, the key anatomic feature that allows the TAR procedure. If this incision is undertaken too medially, the muscle fibers may be difficult to visualize and peritoneum may be cut. Similarly, if this step is undertaken in the mid or lower abdomen, the muscular portion of the TA is more lateral in those areas and, as a result, more difficult to identify properly. In fact, at the level of the umbilicus, almost no muscle fibers of TA extend to linea semilunaris. Further caudally, only the transversus abdominis aponeurosis persists. The posterior rectus sheath is then incised in the cranial-caudal direction. The lateral aspect of the arcuate line is divided at its junction with the semilunar line (Fig. 13.11).



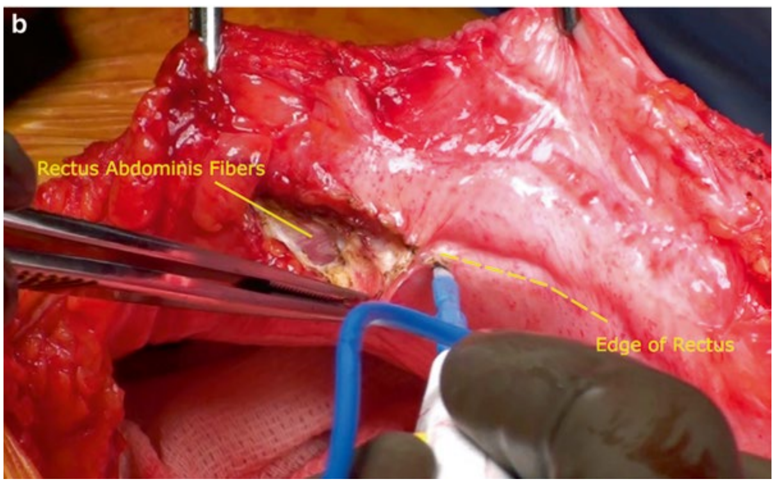


Fig. 13.3 Incision of the posterior sheath just lateral to the linea alba (**a**) is a drawing and (**b**) is an intra-op pic demonstaring the same concept

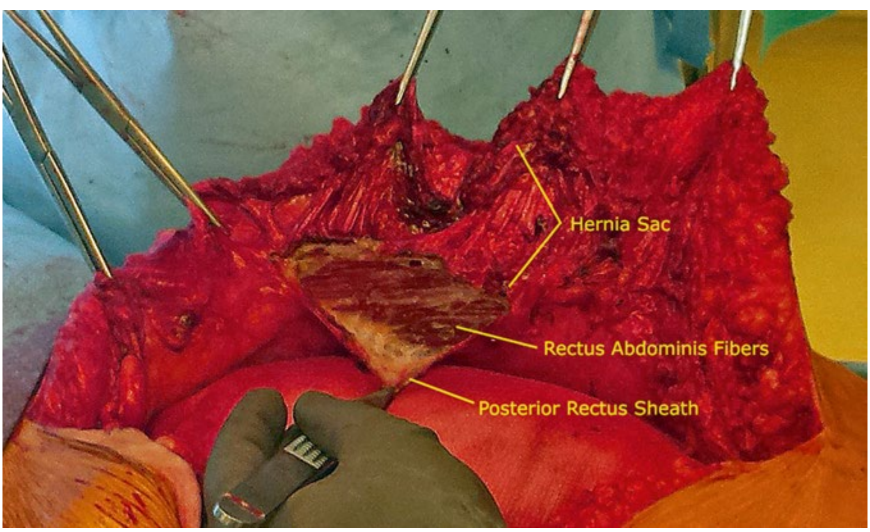


Fig. 13.4 The fibers of the rectus muscle must be visualized to ensure the correct location of the initial incision in the posterior rectus sheath, just lateral to the edge of the hernia sac

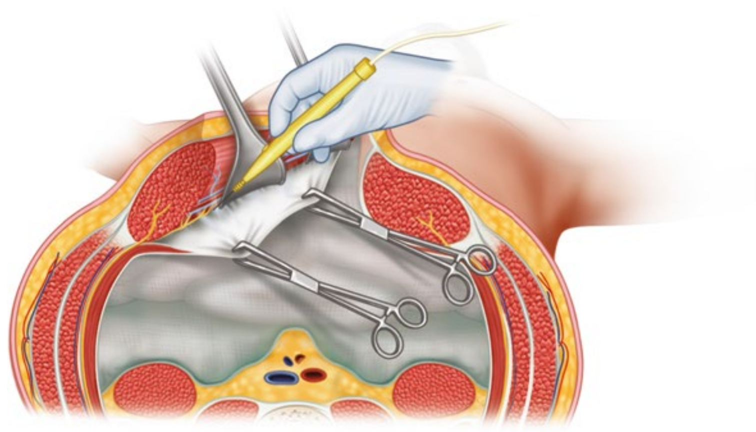


Fig. 13.5 Retro-rectus dissection toward the linea semilunaris

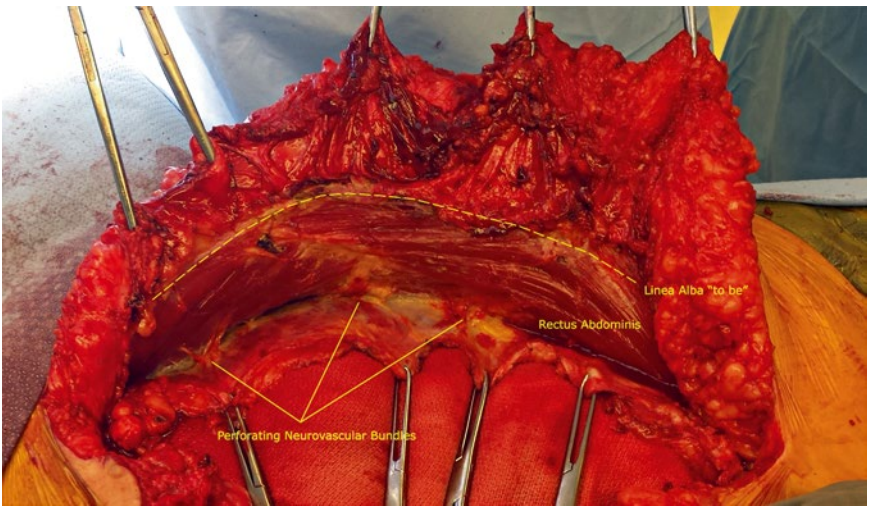


Fig. 13.6 Completed retro-rectus dissection. Note that neurovascular bundles to the rectus muscles that perforate the posterior sheath just medial to the linea semilunaris are preserved

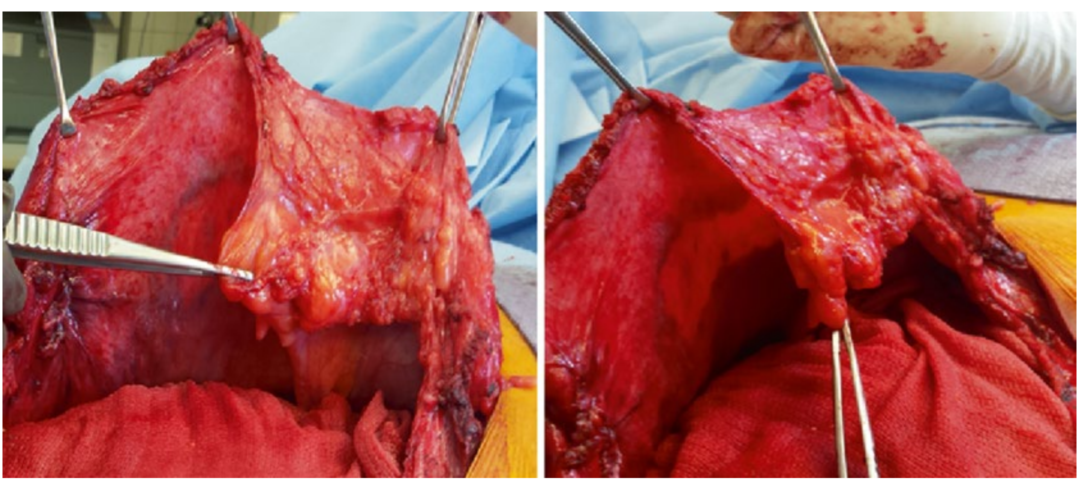


Fig. 13.7 Falciform ligament is kept attached to the right posterior rectus sheath

I then turn my attention to the TA muscle itself. One must avoid dissecting in the plane ventral to the muscle, as this would lead to the intramuscular plane and damage the previously identified perforating nerves. The TA muscle is divided along its entire medial edge using electrocautery. This step is initiated in the upper third of the abdomen where medial fibers of the transversus abdominis muscle are easiest to identify and separate from the underlying fascia (Fig. 13.12a, b). The use of right-angled dissector significantly facilitates this release and minimizes injury to the underlying transversalis fascia and peritoneum. Muscle release allows entrance to the space between the transversalis fascia and the divided transversus abdominis muscle. This is my preferred plane in the upper abdomen. Furthermore, I prefer to perform a limited finger dissection just underneath the costal margin to verify the correct plane of dissection dorsal to the ribs. Being ventral to the costal margin is incorrect; lateral progression should be stopped, TA muscle should be re-identified and divided properly. It is important to understand that the only path from the rectus sheath into the pre-peritoneal plane cranial to the costal margin is via the described division of the TA fibers.

Step 4: Lateral/Retroperitoneal Dissection

Once the TA muscle is divided, the plane deep to it is developed in the medial to lateral direction. To minimize tears of the posterior layers, careful blunt dissection is necessary. I place a right-angled dissector on the cut edge of the TA to provide anterior retraction. The Kittner dissector is then used for blunt dissection between the muscle and underlying transversalis fascia (Fig. 13.13). The Allis clamps on the cut edge of the posterior rectus sheath are used to provide counter-traction. This plane is bloodless and any difficulties/bleeding at this point should alert to the possibility of erroneous entry into the intramuscular plane. Occasionally, the transversalis fascia is difficult to distinguish and it is divided creating entry into the pre-peritoneal plane. One must be careful not to damage the very thin peritoneal layer. If fenestrations do occur, they can be sutured primarily. I utilize running or figure-of-eight 2-0 Vicryl sutures to close those fenestrations in the transverse (but not vertical) direction, in order to minimize tension on this suture line.

The pre-transversalis/pre-peritoneal plane is contiguous with the retroperitoneum and the transition to it is often marked with retroperitoneal fatty tissue. Subsequent blunt dissection will expose the lateral edge of the psoas muscle, if necessary. The lateral edge of the psoas is my "safety" landmark and I use it to guide me during my caudal dissection toward the space of Bogros and myopectineal orifice. At the completion of this step, significant medialization of the posterior rectus fascia and extensive retromuscular pocket is developed (Fig. 13.14).

Step 5: Inferior Dissection

After exposing both Cooper's ligaments and the pubis (described above), the dissection is extended laterally across the entire myopectineal orifice. It is important to follow the direction of the iliopubic tract in order to avoid inadvertent neurovascular injuries. In women, the round ligament is divided routinely. In men, the spermatic cord is identified and carefully de-parietalized (similarly to cord dissection during laparoscopic inguinal hernia repair). All direct and indirect inguinal hernia should be reduced. In fact, if inguinal/femoral hernias are a major concern pre-operatively, this dissection is extended to expose at least 5 cm of the distal psoas muscle with subsequent mesh placement overlapping the inferior edge of the myopectineal orifice, similar to laparoscopic inguinal hernia repairs. The urinary bladder may be filled with saline to facilitate its identification and dissection. This is particularly prudent in patients with previous history of pelvic surgery, such as prostatectomy, cystectomy, etc.

Alternatively, this plane could be dissected from the lateral to medial direction. Starting cranially, after the TA release and dissection into the retroperitoneum is performed (discussed above), one can move caudally along the lateral edge of the psoas muscle to approach the inferior-lateral edge of the myopectineal orifice. At that point, one can begin to bluntly sweep medially to get

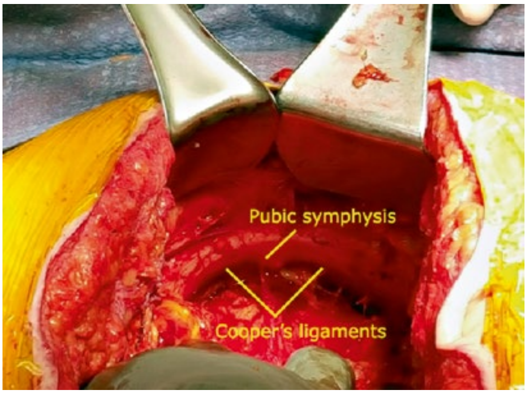


Fig 13.8 Dissection of the space of Retzius and Cooper's ligaments

dorsal to the transversus aponeurosis (but ventral to the peritoneum) and transition to the space of Retzius. I prefer to dissect both myopectineal orifices and Cooper's ligaments prior to connecting the planes underneath the intact caudal portion of the linea alba.

Step 6: Superior Dissection

Depending on the location of the hernia, the superior dissection may extend to the upper epigastrium or above the xiphoid process to the retrosternal space. The maneuvers utilized for each of those scenarios are different and will be described in detail separately.

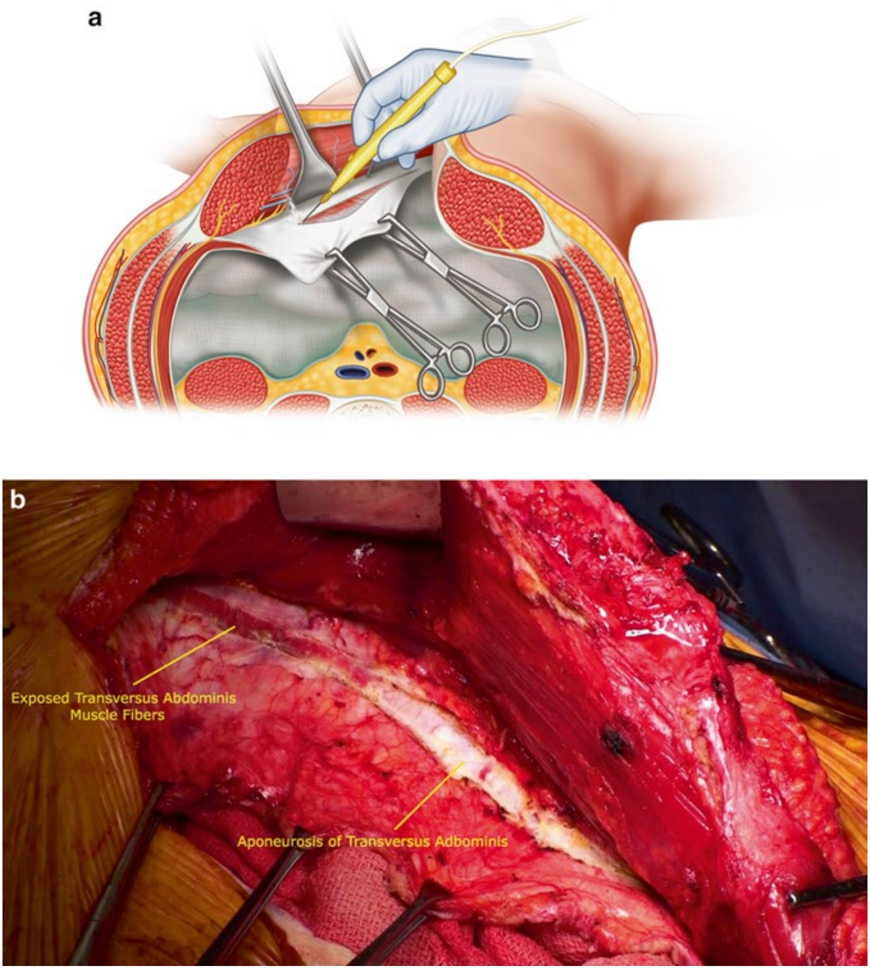


Fig. 13.9 Incision of the lateral aspect of the posterior rectus sheath. This step is best started as cephalad in the rectus sheath as possible (**a**) is a drawing and (**b**) is an intra-op picture demonstaring the same concept

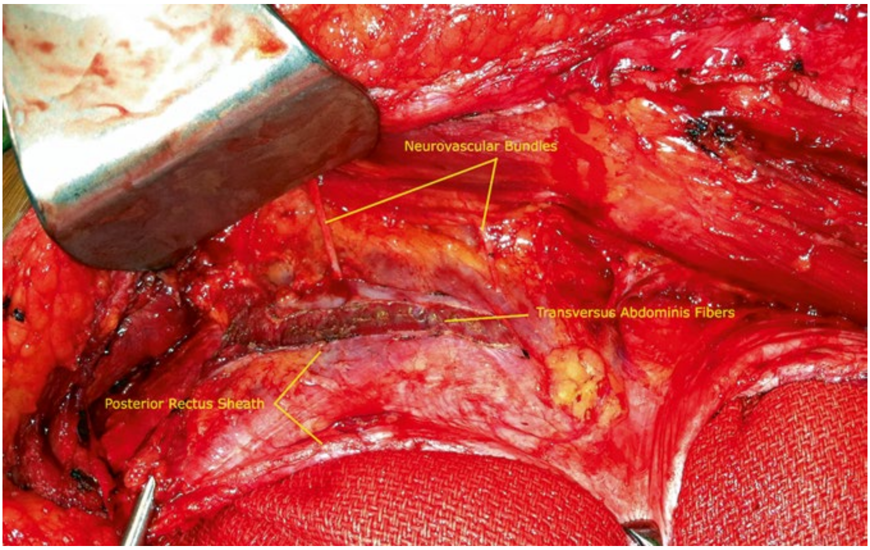


Fig. 13.10 Lateral (second) incision of the posterior rectus sheath just medial to the preserved neurovascular perforating bundles to the rectus muscles

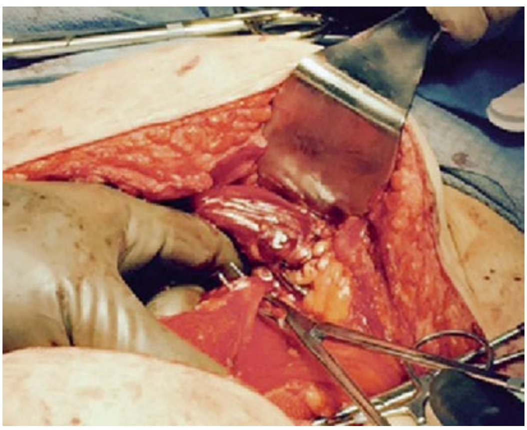


Fig. 13.11 Division of the lateral aspect of the arcuate line, as it joins linea semilunaris

(a) *Transition in the epigastrium*
For midline hernias with cephalad extension at least 6–8 cm below the xiphoid process, a plane needs to be established to connect bilateral retro–rectus spaces across the midline. Typically, the linea alba prevents the continuity of those two planes. To prevent recurrent herniations off the superior edge of the dissection/mesh, the linea alba is maintained in continuity ventral to the mesh for at least 5 cm by dividing the insertion of the posterior rectus sheaths into the linea alba (Fig. 13.15). This is accomplished by cutting the insertion of each posterior sheath in the cranial direction about 0.5 cm lateral to the linea alba on the respective sides. The posterior sheaths will subsequently be reconnected, and the mesh will be placed dorsal to the intact linea alba. To facilitate this step, I usually delay this transition until the rest of the dissection/releases are accomplished on both sides.

(b) *Transition at or cranial to xiphoid process*
For the vast majority of mid and upper abdominal defects, I believe cephalad dissection to the retrosternal space is critical to minimize superior/subxiphoid recurrences. First, the linea alba is divided to the xiphoid process. Then, posterior insertion of the posterior rectus sheath into the xiphoid process is incised as well. This provides access to a fatty triangle that is extended cephalad in a substernal plane. Finally, the continuity of this space with the retromuscular dissection is created. The incision line at the lateral aspect of the posterior rectus sheath is extended to and slightly above the costal margin. This is then followed by complete division of the uppermost fibers of the transversus abdominis muscle just off the lateral edge of the xiphoid.

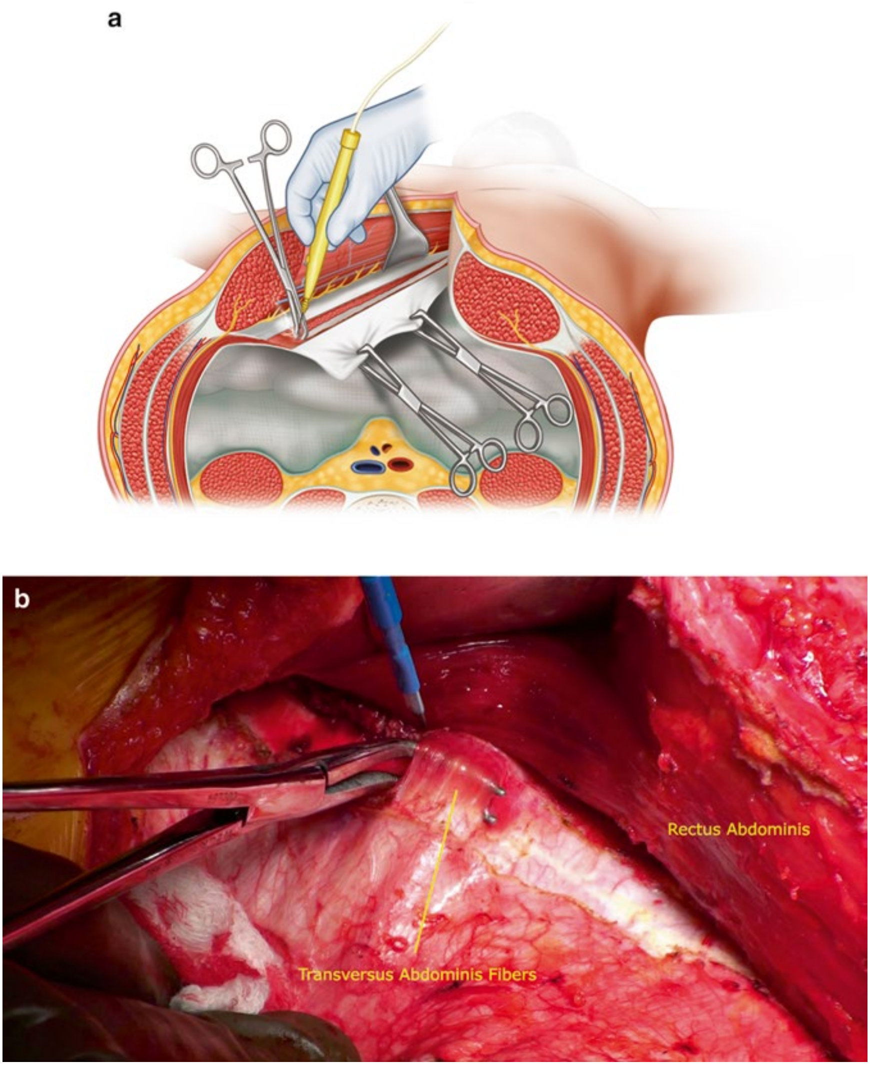


Fig. 13.12 Incision of the transversus abdominis muscle (**a**) is a drawing and (**b**) is an intra-op pic demonstaring the same concept

Care must be taken not to transect the fibers of the anterior diaphragm that are interdigitated with the transversus abdominis in its cranial-medial aspect. Failure to do so may result in an iatrogenic Morgagni hernia. The retromuscular dissection plane can be extended dorsal to the sternum by sweeping the peritoneum/transversalis fascia off of the diaphragm laterally. For the hernia defects in the upper abdomen, further retrosternal dissection to expose the upper aspect of the central tendon of the diaphragm (Fig. 13.16) is necessary for adequate mesh overlap. Once again, this is best accomplished as the last step, once both retromuscular planes have been completely established.

Step 7: Closure of the Posterior Layers

Once similar release is performed on both sides (as is often needed in most complex repairs), the posterior rectus sheaths are re-approximated in the midline with a running 2-0 Vicryl or PDS suture (Fig. 13.17a, b). In rare instances when posterior fascial edges cannot be brought together the gap(s) in that layer are buttressed with native tissue (i.e., omentum), patched with polyglycolic

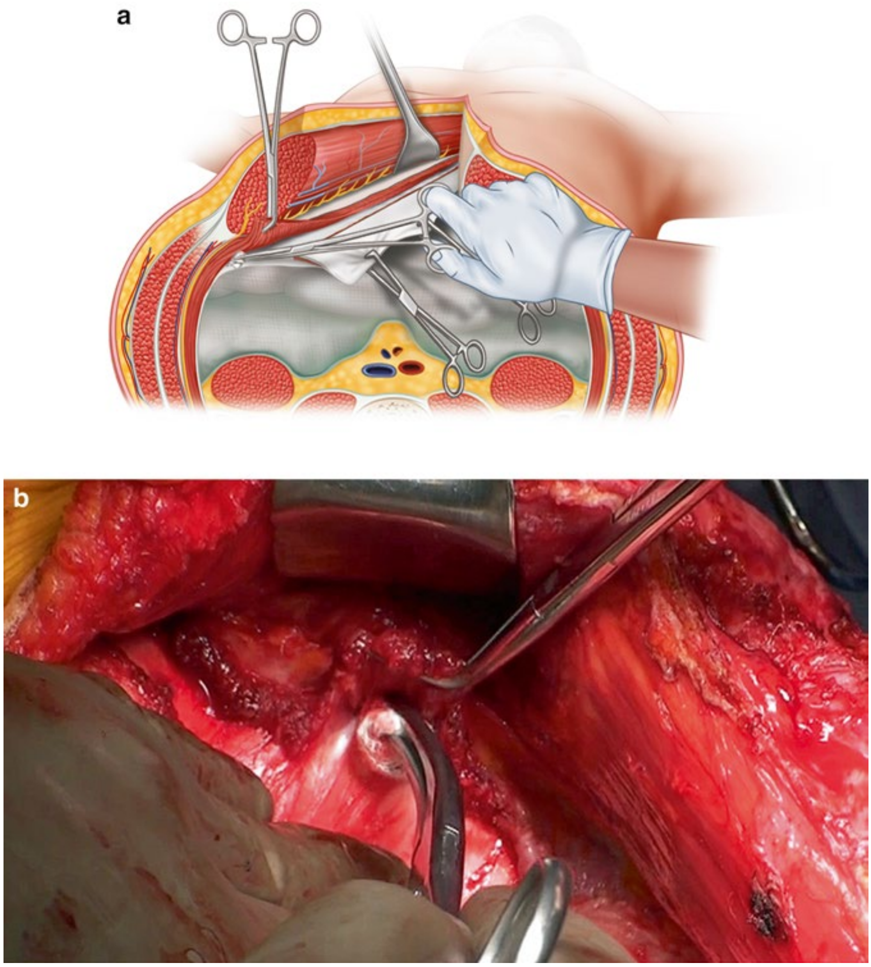
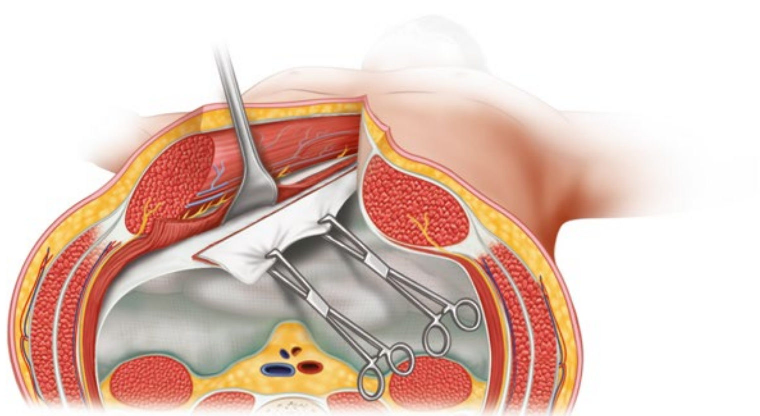


Fig. 13.13 Posterior component separation by dissecting deep to the divided transversus abdominis muscle

Fig. 13.14 Medialization of the posterior layers and retromuscular dissection into the lateral retroperitoneum



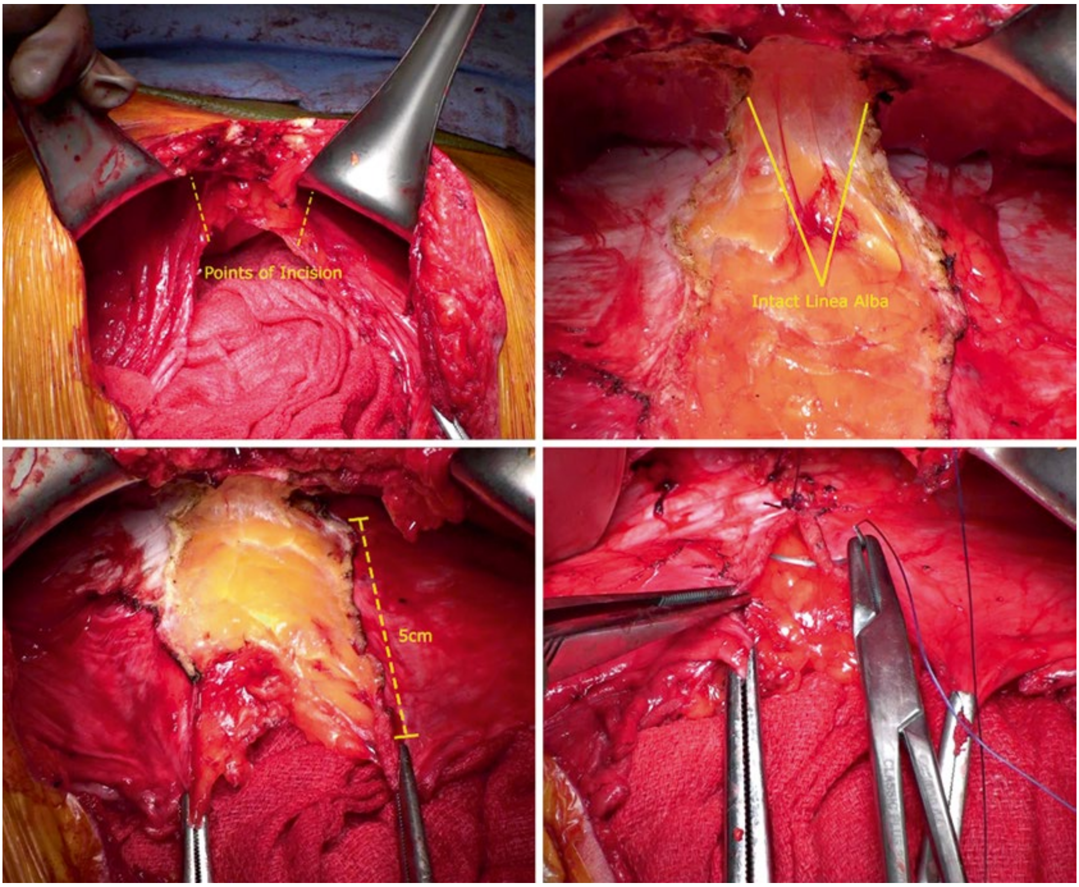


Fig. 13.15 Connecting dissection planes in the epigastric region. The retro-rectus dissection extends for at least 5-cm cranial to the intact linea alba. The advanced posterior rectus sheaths are then reconnected, allowing for sufficient mesh overlap below the intact linea alba, minimizing risks of recurrence of the cranial edge of the mesh

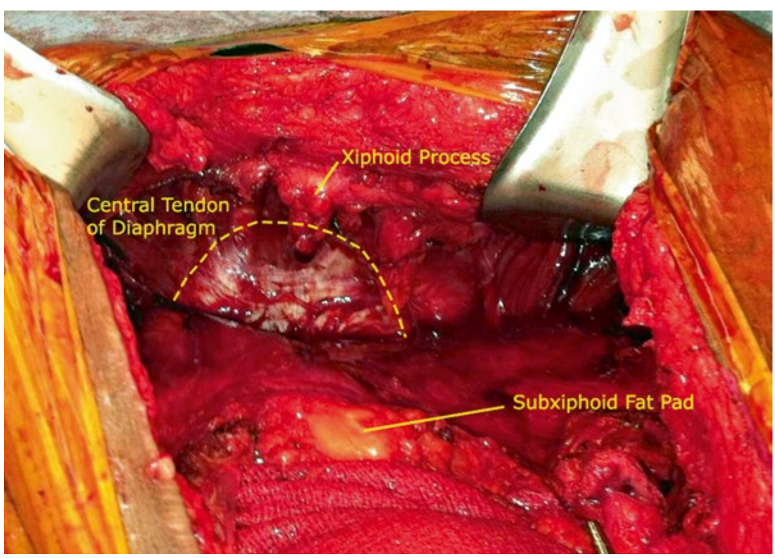


Fig. 13.16 Connecting dissection planes in the subxiphoid/retro-sternal region. The plane may be extended to expose the central tendon of the diaphragm

acid (Vicryl) mesh (Fig. 13.18a), or biologic mesh (Fig. 13.18b). There are several reasons why closure of the posterior sheaths is needed: first, it avoids herniation of the intra-abdominal viscera between the mesh and the abdominal wall layers. Second, it negates the need for costly composite meshes, since there is no exposure of the abdominal viscera to mesh that is placed preperitoneally. Finally, I believe this step might provide some minor additional strength to the reconstruction of the abdominal wall.

Step 8: Irrigation of the Extraperitoneal Space and TAP Block

Once the posterior layers are reconnected, a completely extraperitoneal pocket has been created. In clean contaminated and contaminated cases, I use antibiotic pressurized pulse lavage of the space prior to mesh placement. We have discovered that this strategy results in a significant reduction of the bioburden of contaminated wounds. Following the lavage, a transversus abdominis plane bock can be performed. Since the intramuscular plane that contains the nerves can be easily visualized, I place 80–100 cm^3 of dilute liposomal bupivacaine in both TA planes under direct vision (Fig. 13.19).

Step 9: Mesh Placement/Fixation

The mesh is placed as a sublay in the retromuscular space. Adhering to the principle of "giant prosthetic reinforcement of the visceral sac" is critical to ensure durability of the repair. I aim to place the mesh to at least the anterior axillary line in the vast majority of my TAR cases. Choosing the size of the mesh is not proportional to the size of the original defect, as is commonly done in other type of repairs. This strategy essentially eliminates possibilities of lateral recurrences. For defects that extend to the umbilicus, I dissect the entire space of Retzius and extend/fixate the mesh to the Cooper's ligaments. I typically first place two interrupted sutures, one in each of the Cooper's ligament, (Fig. 13.20a) and then pass the tail through the mesh so that the knots will be tied at the dorsal surface of the mesh (Fig. 13.20b). This strategy not only facilitates mesh placement, but allows us to ensure mesh overlap in the retropubic space. One must be careful to pass the suture tails from each stitch at a distance similar to the distance between the stitches in the Cooper's ligaments. Inferior fixation is essential to counteract the vectors of the intra-abdominal forces that are directed inferiorly, so as to reduce the odds of the suprapubic recurrences. Superiorly, the mesh extends to the epigastric area or to the retrosternal plane (as described above).

Mesh fixation is accomplished by placing a #1 absorbable monofilament suture into the mesh and then pass the tails of the mesh (about 1 cm apart through the abdominal wall) out of the same skin incision using a Carter-Thomason suture passer (Cooper Surgical, Trumbull, CT, USA) (Fig. 13.21). In the past, I have used 10–14 of such full-thickness, trans-abdominal points of fixation. Over the years, however, I found that this was not necessary, especially laterally. If I am able to achieve a desired overlap of the visceral sac and I am able to reconstruct the linea alba in the midline without undue tension, I have evolved to minimize or almost completely forego lateral mesh fixation. However, I still almost uniformly employ inferior fixation to both Cooper's ligament using two interrupted monofilament sutures (as shown above). Superiorly, the mesh could be positioned cephalad to the costal margin and in the retro-xiphoid space. It is secured with interrupted sutures around the xiphoid process. Those sutures are placed 4–5 cm off the edge of the mesh to allow for large overlap, especially for upper abdominal defects.

Mesh selection remains to be a controversial topic. My preferred material is a macroporous mid-weight polypropylene. In patients where linea alba reconstruction is impossible or under excessive tension, a heavy-weight polypropylene mesh is used. In addition, patients with flank defects and those after previous failed anterior component separation are best treated with a heavier weight polypropylene material. I am strongly against utilization of polyester-based meshes during major open abdominal wall reconstructions. The role of bioabsorbable and newer biologic meshes for retro-muscular repairs is evolving.

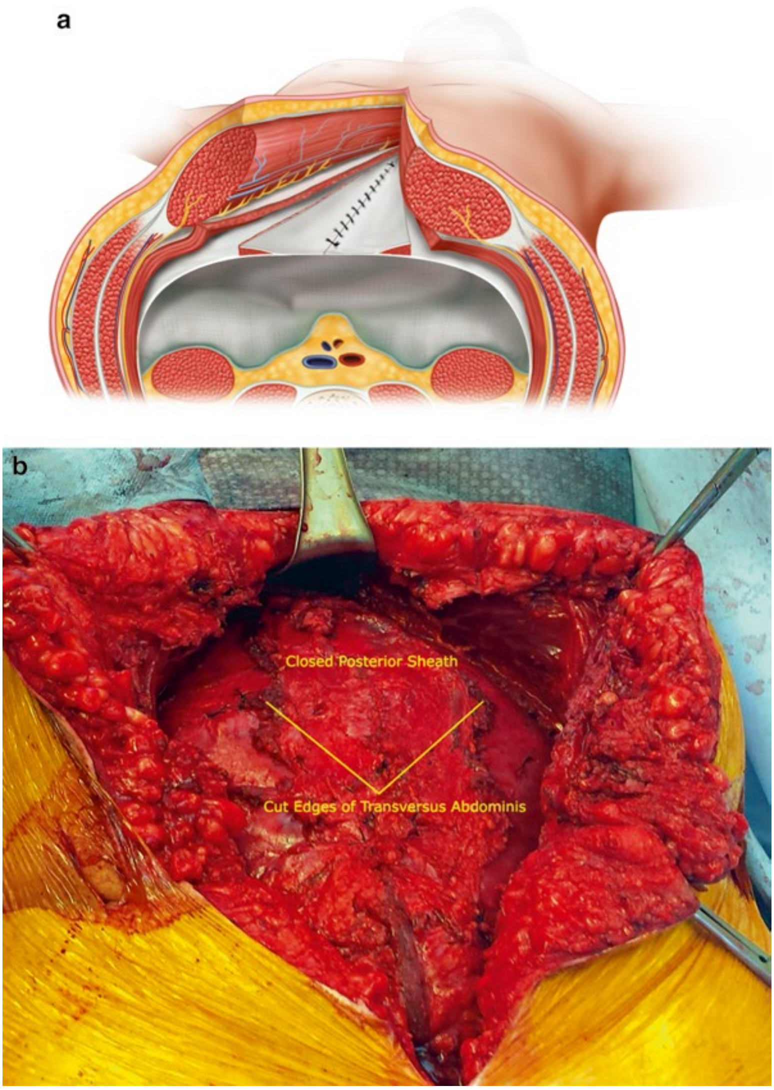


Fig. 13.17 Posterior layers are closed; visceral sac is restored (**a**) is a drawing and (**b**) is an intra-op picture demonstaring the same concept

Step 10: Anterior Fascia and Skin Closure

Large closed suction drains are placed on top of the mesh. Given the medial advancement of both rectus muscles, the linea alba is then reconstructed with a running monofilament suture ventral to the mesh (Fig. 13.22). Occasionally, interrupted figure-of-8 stitches can be placed, especially when restoration of the entire linea alba is uncertain or difficult. The soft tissue is closed in layers. All redundant and attenuated skin and soft tissue should be excised to minimize wound complications. If subcutaneous pockets cannot be eliminated, additional subcutaneous drain(s) are utilized. The skin is closed with a running suture or staples. Areas of tension are reinforced with vertical mattress 000 Nylon sutures.

Post-operative Care

Intra-operative hemodynamics and airway pressures affect post-operative care. Pulmonary plateau pressure has become my most important guide. In patients undergoing complex abdominal

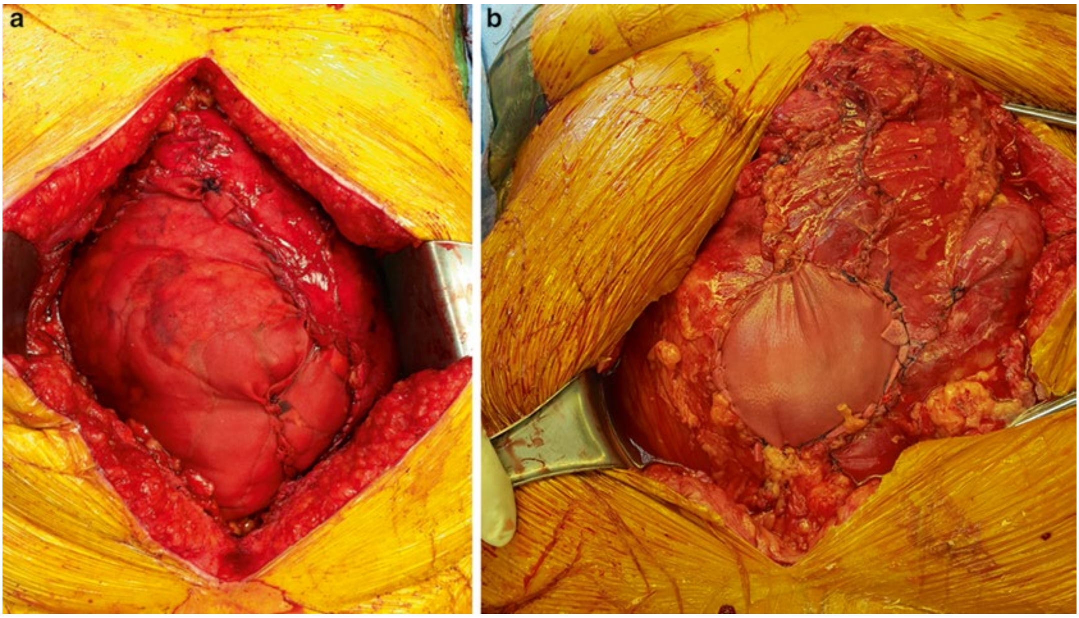


Fig. 13.18 Posterior layer/visceral sac may be patched with an absorbable (**a**) or biologic mesh (**b**)

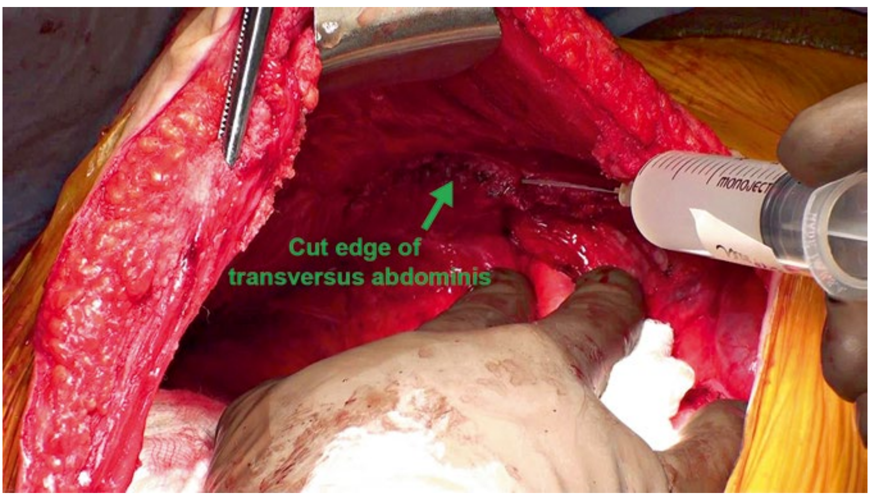


Fig. 13.19 Transversus abdominis plane (TAP) block

wall reconstructions, increase of pulmonary plateau pressure above 6 mmHg necessitates keeping the patient intubated, at least overnight. Provided that myofascial releases are performed, abdominal compliance improves within 12–24 hours post-operatively and pulmonary physiology returns to baseline allowing for safe extubation. In addition, those patients with increase in plateau airway pressures >11 mmHg are kept paralyzed for 24 hours post-operatively [12]. Please note, we have found that bladder pressure measurements are not as useful in this setting. The closed suction drains are kept in place until the output is <30–50 cm^3 per day. However, for patients with synthetic mesh repairs, I usually remove the drains prior to discharge, even in the setting of higher drain output. This is due to fears of introducing mesh infection (via a drain's direct contact

Fig. 13.20 Inferior mesh fixation to Cooper's ligaments. An interrupted monofilament stitch is placed in each of the Cooper's ligaments (**a**) and the tails are passed through the mesh so that the knots are on the dorsal aspect of the mesh (**b**), facilitating mesh overlap in the retro-pubic space

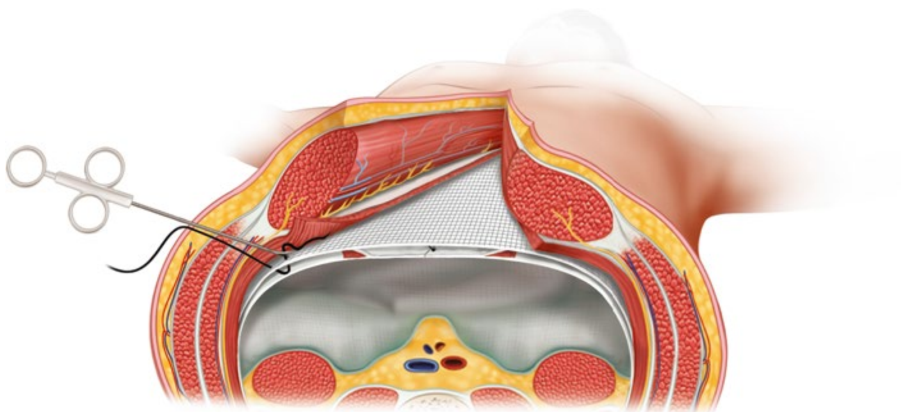


Fig. 13.21 Lateral mesh fixation utilizing a suture-passer. The knots are tied in the subcutaneous space

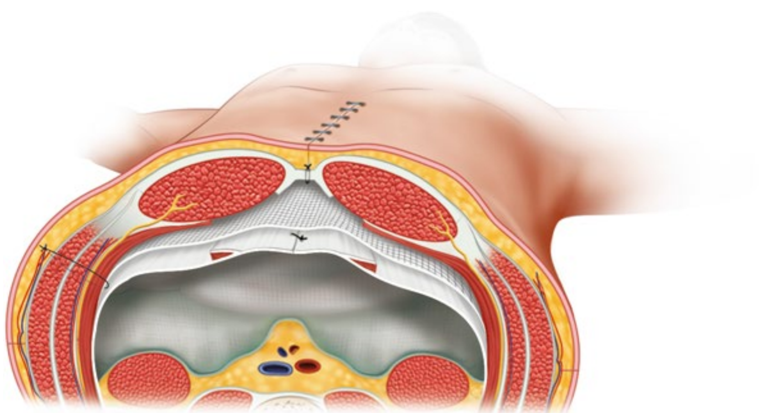


Fig. 13.22 Linea alba is reconstructed ventral to the mesh

Table 13.1 Our validated ventral hernia repair phone survey (VHR-PS)

1.	Do you feel that your hernia is back?
2.	Has any physician told you that your hernia is back?
3.	Do you have a bulge/lump where your hernia used to be?
4.	Do you have any painful areas on your abdominal wall?

with mesh) in the outpatient setting. Alternatively, when a biologic graft is used, the drains are left in place for at least 2 weeks, regardless of the output. The drains are kept longer in the setting of biologics because I found that with increased ambulation after discharge, the drain output increases. Antibiotics are continued for up to 24 hours, unless otherwise indicated. Aggressive deep vein thrombosis prophylaxis is mandatory. I do not use systemic anticoagulation and/or caval filters, unless specifically indicated. Aggressive ambulation is avoided until the second post-operative day. Abdominal binders are used in the early post-operative period. Beyond the first week, their use is liberalized at the patients' discretion. Routine nasogastric tube decompression is avoided. Diet advancement is per our Enhanced Recovery after Surgery (ERAS) protocol [13].

Typical post-operative follow-up consists of a physical exam at 3–4 weeks, 3 months, 6 months, 1 year, and then annually. Abdominal Computed Tomography (CT) scans are obtained routinely at 1 year or earlier to investigate any abdominal discomfort. In addition, we have developed a telephone survey, which is administered to those who miss or are unable to come for a follow-up visit (Table 13.1). We have internally validated this survey to be 100% sensitive, in that no one has ever had a documented recurrence in the setting of all negative responses. Alternatively, any *positive* answer is considered a recurrence until proven otherwise by a physical exam and/or imaging.

Outcomes

The most effective operative approach to complex ventral hernia repairs remains debatable. The TAR procedure allows for safe and reliable medial fascia/rectus muscle advancement and large retromuscular space dissection in patients undergoing major abdominal wall reconstruction. In 2012, I published my first series of 42 patients with massive ventral defects undergoing posterior component release using TAR [9]. Ten (23.8%) patients developed wound complications; requiring re-operation/debridement in three patients. At a median follow up of 26 months, there have been only two (4.7%) recurrences [9]. My recent data on over 400 patients undergoing TAR with synthetic mesh reinforcement revealed 3.7% rate of recurrence at a mean follow up of over 30 months.

The potential deleterious effects of TAR on the lateral abdominal wall and spine stabilization were a matter of early skepticism and concern. However, our recent investigations have alleviated some of those fears. First, we demonstrated rectus muscle hypertrophy following linea alba restoration as well as, very importantly, a compensatory hypertrophy of the external and internal oblique muscles [14]. Furthermore, a dynamometry study revealed an improvement in core abdominal wall functionality post-TAR reconstruction [15]. While the power of the aforementioned results about improvements of the abdominal wall hypertrophy and functionality is insufficient to claim any superiority of TAR, the data clearly support the safety of the division of the transversus abdominis muscle during abdominal wall reconstructions.

Conclusion

Transversus abdominis release is rapidly becoming one of the common approaches to major abdominal wall reconstructions. There are three main advantages to this approach. First, transversus abdominis muscle release results in significant medial mobilization of the posterior rectus sheath and creation of the extraperitoneal pocket. Second, it allows for extensive lateral dissection between the transversus muscle and the underlying transversalis fascia/peritoneum that allows for sublay placement of mesh, reinforcing the entire visceral sac. Finally, it provides for medialization of rectus muscles and linea alba reconstruction in vast majority of complex hernia patients. We found its usefulness in complex scenarios including parastomal, flank, and subxiphoid defects. Furthermore, TAR might be the only reliable approach for patients with failures after open component separation. Overall, the TAR procedure allows not only for a relatively tension-free repair with a large sublay mesh, but also myofascial reconstruction ventral to the mesh, thus markedly minimizing risks of prosthetic infections. Finally, this reconstruction not only provides for a durable repair, but may also facilitate restoration of physiologic properties of the repaired abdominal wall.

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