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HOW-I-DO-IT

# Technical considerations in performing posterior component separation with transverse abdominis muscle release

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## Introduction

The retrorectus Rives-Stoppa repair of midline incisional hernias is the preferred open approach of many herniologists [1–4]. With larger hernias; however, a tension-free medialization of the anterior and/or posterior sheath or the rectus muscles may not be possible. This often results in a bridging-type repair or "patching" of the hernia with exposure of the prosthesis in the subcutaneous space, which is not well vascularized. Moreover, the lack of medialization of the rectus muscles leads to a less functional, engineered abdominal wall [5]. In this situation, the anterior component separation, as proposed originally by Ramirez et al. [6] was described to allow a more tension-free medialization of the rectus muscles with autogenous closure of the medial edge of the anterior rectus fascia. This technique of full lateral mobilization of the skin/subcutaneous complex off the anterior abdominal fascia was modified by Dumanian, Butler, Rosen, and collegues [6–9] to minimize disruption of the perforating blood vessels supplying the skin and subcutaneous tissues of the advancement flap. The posterior component separation, also often referred to as the transverse abdominis release (TAR) as described more clearly by Novitsky et al. [10, 11], was developed to prevent disruption of the perforating blood vessels and to release the lateral force generated by the transversus abdominis muscle and aponeurosis rather than the oblique force of the external oblique muscle. These maneuvers restore the midline continuity of the musculofascia of the abdominal wall, allegedly maximize abdominal wall function, place the prosthesis extraperitoneally, and cover the prosthesis with vascularized autogenous tissue (rectus muscleanteriorly and posterior rectus fascia/peritoneum/preperitoneum posteriorly).

This treatise will review the relevant anatomy as well as describe tricks by the authors that aid in performing a posterior component separation during a retrorectus sublay repair of a large incisional hernia. The posterior component separation is more tricky and harder to understand, thus this in-depth description of the technique.

## Relevant anatomy

### Anatomic terms used

| | |
|---|---|
| Fascia | The fibrous sheath surrounding the muscle |
| Aponeurosis | The "tendon" of the abdominal wall muscles representing the extension of the muscular fascia |

The rectus abdominis muscle on each side is enclosed anteriorly and posteriorly by the rectus sheath (anterior and posterior rectus fasciae). The anterior rectus fascia extends the entire length of the muscle and fuses with the tendinous insertion of the muscle cranially and caudally. In contrast, the posterior rectus sheath is complete in the upper two-

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thirds of the muscle, but posterior to the caudal one-third of the rectus muscle, the posterior rectus fascia gradually fades away at the semi-circular or arcuate line (line of Douglas) about mid-way between the umbilicus and the pubis. Caudal to this line, the rectus abdominis muscle is enclosed posteriorly only by the transversalis abdominis aponeurosis, any preperitoneal connective tissue, and the peritoneum. The rectus sheath is formed from desiccating fibers from all three lateral abdominal muscles—the external oblique, internal oblique, and transversus abdominis each of which form a bilaminar aponeurosis at their medial borders. The anterior rectus sheath is composed of both leaves (or laminas) of the external oblique aponeurosis and the anterior lamina of the internal oblique aponeurosis. The posterior rectus sheath is composed of both laminas of the transversus abdominis aponeurosis and the posterior lamina of the internal oblique aponeurosis (Fig. 1). The lower thoracic and upper lumbar nerves perforate the lateral-most aspect of the posterior rectus sheath; actually to be specific, these nerves perforate the posterior lamina of the internal oblique aponeurosis to enter the rectus muscles laterally and innervate the rectus muscles. This posterior lamina of the internal oblique aponeurosis will prove to be very important in this operation. The anterior and posterior rectus sheath then desiccate with the contralateral counterparts at the midline—the linea alba.

## Dissecting the retrorectus space

The first key step is to identify the medial aspect of the rectus abdominis muscle bilaterally. It is particularly important that the surgeon differentiates the hernia sac from the medial edge of the rectus muscle. The hernia sac can often be fibrotic and thickened. By manually pinching the rectus muscle, the surgeon can localize the medial extent. There are two different approaches (anterior and posterior) for getting into the retrorectus space (Fig. 2). The *anterior approach* has the primary advantage of remaining extraperitoneal throughout the dissection. After fully mobilizing the hernia sac laterally, cranially, and caudally back to the edge of the hernia defect (i.e., the medial edge of the rectus muscles), an anterior fasciotomy is performed at the medial-most edge of the anterior rectus sheath for the length of the hernia defect but not cranial or caudal to the defect. Note that continuity of an intact rectus sheath and the linea alba with the contralateral anterior sheath should be maintained cranially and caudally to the defect whenever the rectus sheath/linea alba is still intact. This fasciotomy permits visualization of the medial-most fibers of the rectus abdominis muscle. One of the limitations of the anterior approach is that the hernia sac may tend to be deeply invested in the medial 1–2 cm of the anterior rectus fascia; this can result in the anterior fasciotomy occurring a bit more lateral to the linea alba on the anterior rectus fascia. Thus, when the anterior rectus fascia is transected, this 1–2-cm length of the medial most anterior rectus fascia will not be available for use in closure of the midline fascia, which can compromise the eventual reconstruction of a linea alba in larger defects. Dissection under the medial fibers of the rectus abdominal muscle, which is retracted anterolaterally, allows exposure of the retrorectus space. The retrorectus space is filled with fine areolar tissues, and blunt, gentle finger dissection is usually all that is required to separate the posterior surface of the rectus abdominal muscles from the anterior surface of the posterior rectus sheath (Fig. 2a). Small perforator vessels from the epigastric artery supplying the posterior rectus sheath should be cauterized. On occasion, the most medial 1–2 cm of this space is obliterated by reaction due to prior sutures passed transmurally through the medial aspect of the rectus fascia and muscle to close the original incision. This fibrous reaction is more prominent if there have been several attempts at prior herniorrhaphy, especially if a meshed prosthesis was used previously.

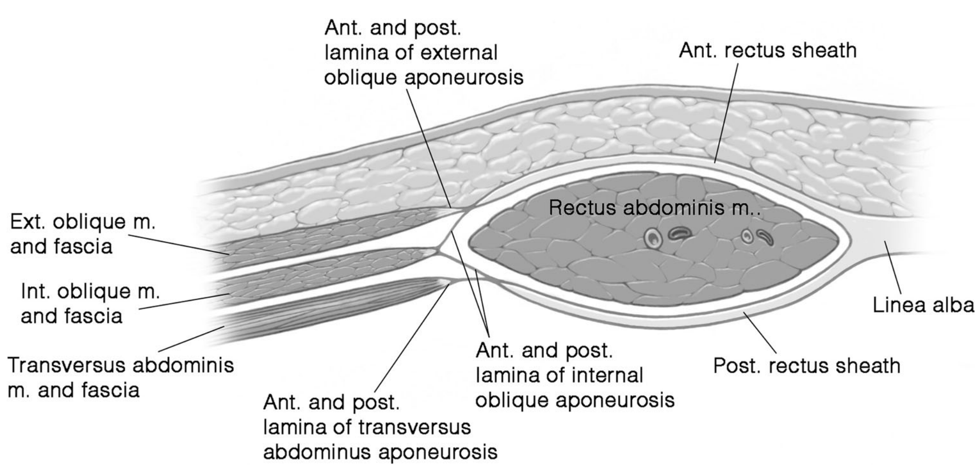



**Fig. 1** Normal anatomy of the anterior abdominal wall. Note especially the formation of the anterior and posterior rectus sheaths

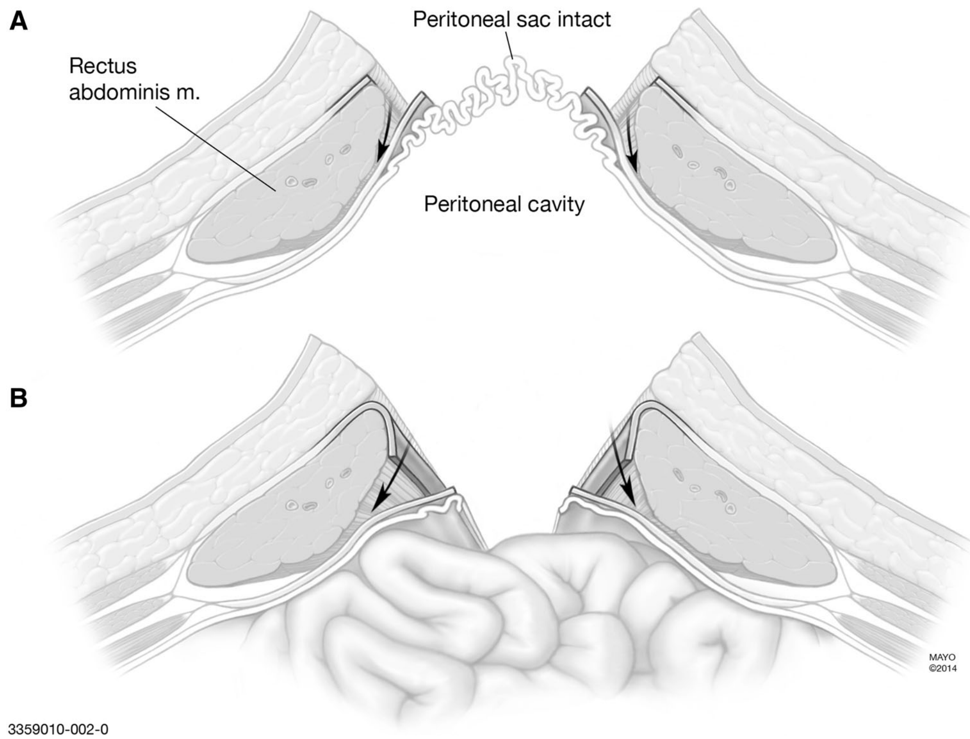



**Fig. 2** Approaches to the retrorectus space. **a** Anterior extraperitoneal approach with an incision along the medial aspect of the anterior rectus sheath; note the peritoneum is intact. **b** Posterior approach with incision (intraperitoneally) of the posterior rectus sheath's insertion to the anterior rectus sheath; note the peritoneum (hernia sac) has been opened

The *posterior approach* to the retrorectus space (Fig. 2b) is easier and is utilized when you are intraperitoneal because of the need for adhesiolysis, release of incarcerated bowel, removal of prior mesh, etc. Two of the authors of this review (MJR and YWN) almost always use this approach, while the others (WOG and MGS) try to stay extraperitoneal whenever possible. The posterior approach to the retrorectus space is performed by incising the medial-most edge of the posterior rectus sheath at the medial-most edge of the rectus abdominis muscle. As mentioned previously, it is important to differentiate the hernia sac from the rectus abdominis muscle. The edge of the transected posterior rectus sheath is grasped with clamps and retracted medially and posteriorly, allowing easy lateral dissection of the retrorectus space (Fig. 3). The posterior approach assures a more complete preservation of the anterior rectus fascia during the fasciotomy but requires an intraperitoneal approach.

Some hernia surgeons perform an "alternating approach" of getting into the retrorectus space by using the anterior approach on one side and the posterior approach on the other side. The authors acknowledge this possibility, but see very few situations where this is necessary.

## Dissection of the retrorectus space

Once the retrorectus space is entered, special care is needed to preserve the superior/inferior deep epigastric vessels, which run anterior to the transversus abdominis fascia along the posterolateral surface of the rectus abdominis muscles, and to preserve the delicate lower thoracic intercostal and lumbar nerves, which perforate the lateral-most aspect of the posterior rectus sheath. These nerves perforate the posterior lamina of the internal oblique aponeurosis) to innervate segmentally the rectus muscles (Figs. 3, 4a); note, the nerves do not enter the rectus muscle lateral to the retrorectus space, but perforate through the posterior lamina in the lateral part of the retrorectus space. If you dissect the retrorectus space all the way to the lateral-most border of the rectus muscle, you will transect or injure these delicate nerves and denervate the rectus muscle which will result in weakness of the abdominal wall musculature. Therefore, these nerves should be protected throughout the operation, and denervation of the rectus abdominis muscle should be avoided. This retrorectus space extends from several centimeters cranial to the costal margin (yes, the rectus muscles insert 4–6 cm cranial to the costal margin) and caudally down to the pubis, pubic tubercles, and medial aspect of the inguinal ligament (Fig. 5). Cranial to the cranial extent of the hernia defect (if the hernia defect does not extend up to the xiphoid) and caudal to the caudal extent of the defect (provided the caudal extent of the hernia does not extend down to the pubis), the retrorectus spaces on each side do not communicate with one another, because the posterior rectus sheath combines with the anterior rectus sheath to form the linea alba. Placement of the prosthesis across the midline cranial and caudal to this hernia defect requires transection of the insertion of the

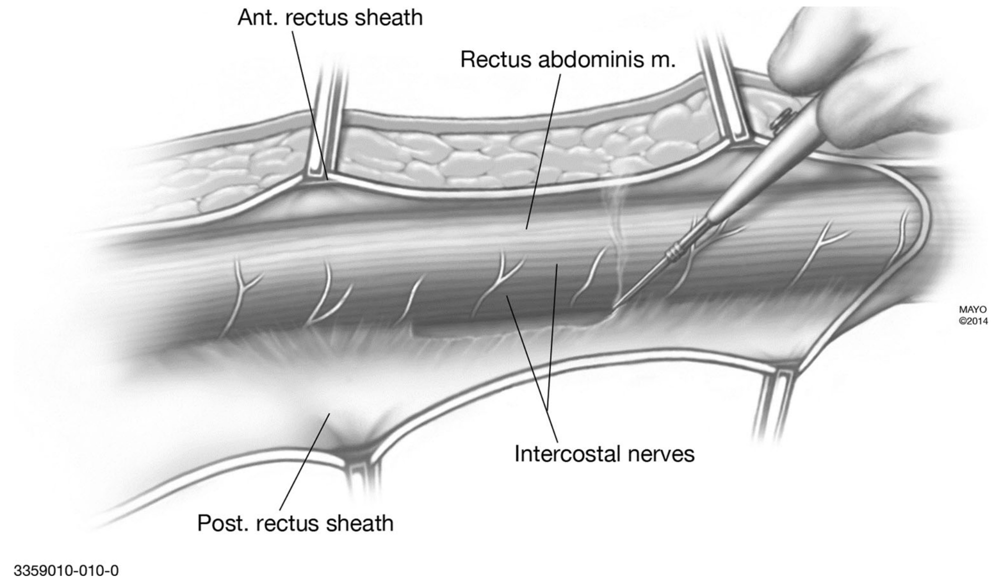



**Fig. 3** Lateral view of developing the retrorectus space but preserving the intercostal (thoracic) nerves. The anterior rectus sheath attached to the rectus muscle is retracted anteriorly while the posterior rectus sheath is retracted medially

medial- most aspect of the posterior rectus sheath with the posterior surface of the anterior rectus sheath, thereby allowing continuity between the retrorectus spaces across the midline posterior to the still-continuous anterior rectus sheath/linea alba/contralateral anterior rectus sheath cranial and caudal to the hernia defect.

The cranial aspect of this space is developed by dividing the insertion of the posterior rectus sheath into the junction of the anterior rectus sheath/linea alba. Cranially, this plane is just superficial to the falciform ligament. Importantly, the continuity of the anterior rectus fascia bilaterally with the linea alba is maintained in continuity cranial and caudal to the defect. As the dissection continues to the xiphoid process, the posterior insertion of the posterior rectus sheath with the xiphoid can be incised. This provides access to a fatty triangle that extends cephalad in a substernal plane. If the defect is particularly close to the xiphoid process and more mesh overlap is necessary, the peritoneum posteriorly can be swept off to expose the central tendon of the diaphragm.

Caudally, this dissection plane often involves entering the space of Retzius. Key landmarks in this area involve identification of the inferior epigastric vessels. These vessels in essence lead to the major vascular structures of the pelvis. By dissecting initially medially exposing first the pubis and pubic tubercle, then Cooper's ligament, and only then laterally to the cord structures, one avoids inadvertent injury to the key pelvic anatomy. In women, the round ligament is divided routinely, and in men, the spermatic cord is dissected carefully and deperitonealized.

The lateral border of the retrorectus space is a very important area when performing a posterior component separation. This area is bound by the division of the internal oblique aponeurosis into an anterior and a posterior lamina (Fig. 4a–c). The anterior lamina joins the external oblique aponeurosis to form the anterior rectus sheath, while the posterior lamina joins the transversus abdominis aponeurosis to form the posterior rectus sheath. The thoracic and lumbar nerves perforate this posterior lamina of the internal oblique aponeurosis about 1 cm medial to the lateral border of the rectus muscle to innervate the rectus muscles. Protecting this landmark is crucial to the next step of the operation.

## The posterior components separation

### Getting into the plane between the transversus abdominis fascia/aponeurosis, and the internal oblique muscle cranially

To enter the plane between the internal oblique aponeurosis and the transversus abdominis muscle and fascia which provide the access to the transversus abdominis muscle, the posterior lamina of the internal oblique aponeurosis is incised just medial to the entry of the intercostal nerves as they enter the rectus muscle posteriorly (Fig. 4a–c). *This is the first trick to starting the posterior component separation*. This maneuver is best started as far cranial to the umbilicus as possible, which will be an area where there are still underlying muscle fibers of the transverse abdominis muscle. This area of transition of the posterior lamina of the internal oblique fascia allows safe exposure and visualization of the most medial fibers of the transverse abdominis muscle and avoids inadvertent entry into the peritoneal cavity (Figs. 4a–c, 6a). Three layers separate the

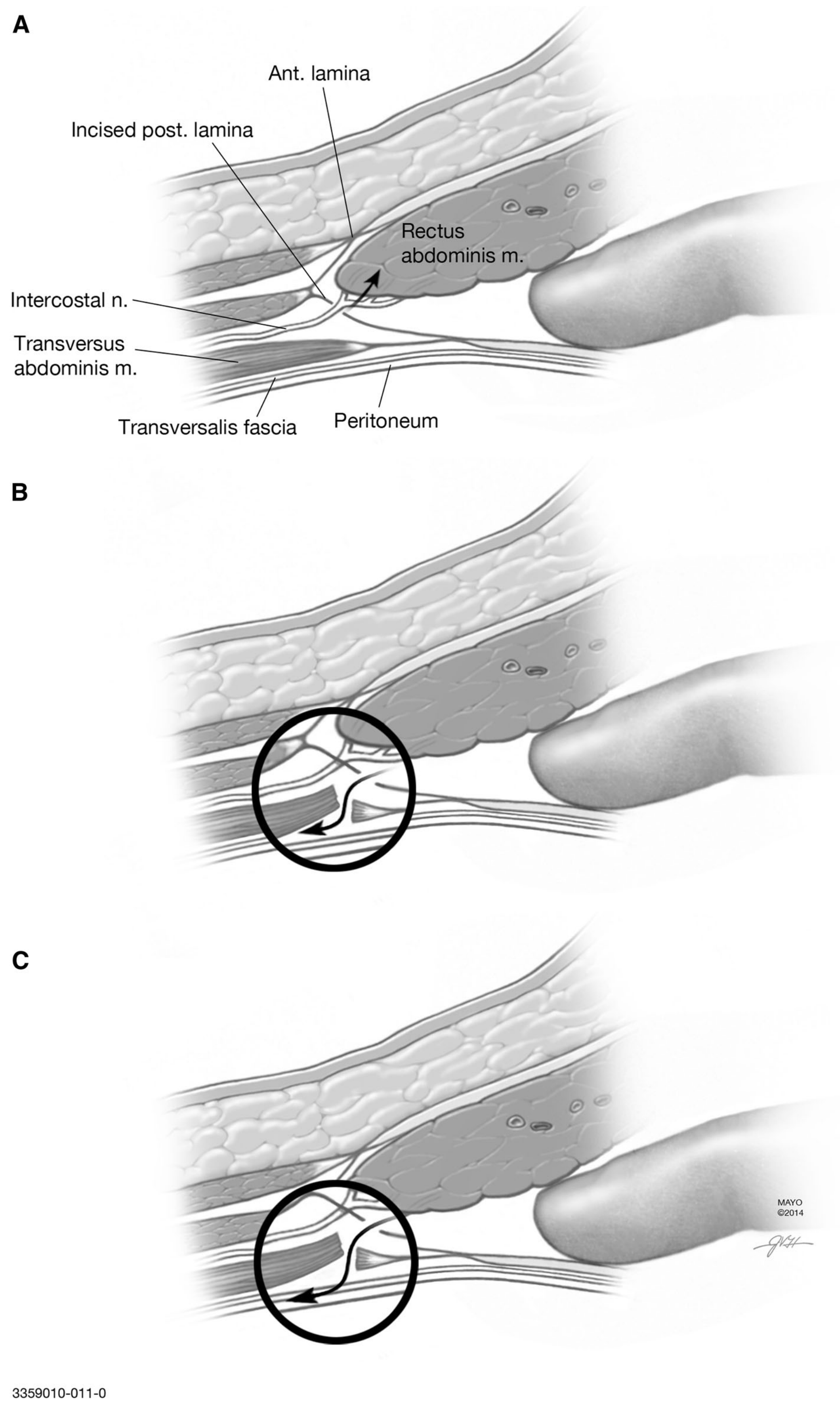



**Fig. 4** Development of retrotransversus muscle plane. **a** Note the anatomic location of the intercostal nerves penetrating the posterior lamina of the internal oblique muscle but within the retrorectus plane. **b** Transversus abdominis release (TAR). This internal lamina of the internal oblique muscle is transected just medial to the nerves and then, **c** the underlying transversus abdominal muscle is carefully transected to enter the plane posterior to the transversus abdominis muscle laterally

plane between the transverse abdominis muscle from the peritoneal cavity. In order from superficial to deep, these layers are: transversal is abdominis fascia, areolar preperitoneal tissues (when present), and the peritoneum. The areolar preperitoneal tissues are virtually absent cranial and medial to the semicircular line but are quite prominent caudal and lateral to the semicircular line. Therefore, development of the posterior component separation is best performed using a different technique cranial and caudal to the semicircular line.

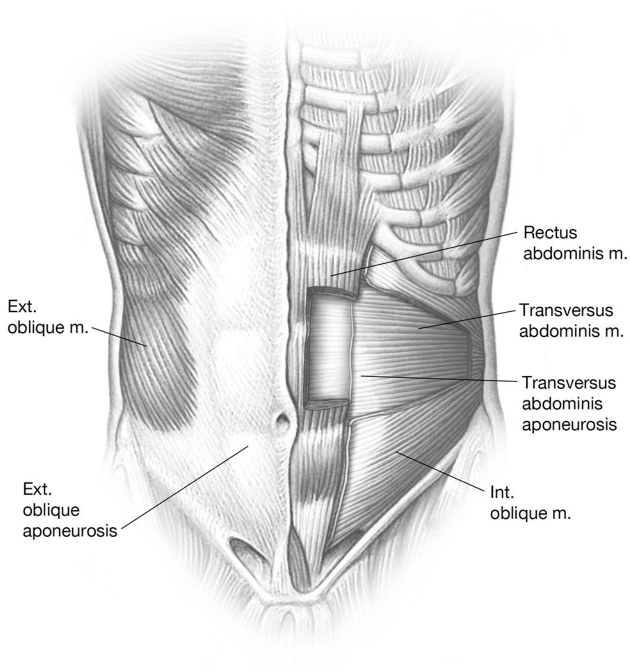



**Fig. 5** Direction and extent of muscle groups of the anterior abdominal wall. Note the cranial insertion of the rectus abdominis muscles cranial to the costal margin and the medial extent of the transversus abdominis muscles

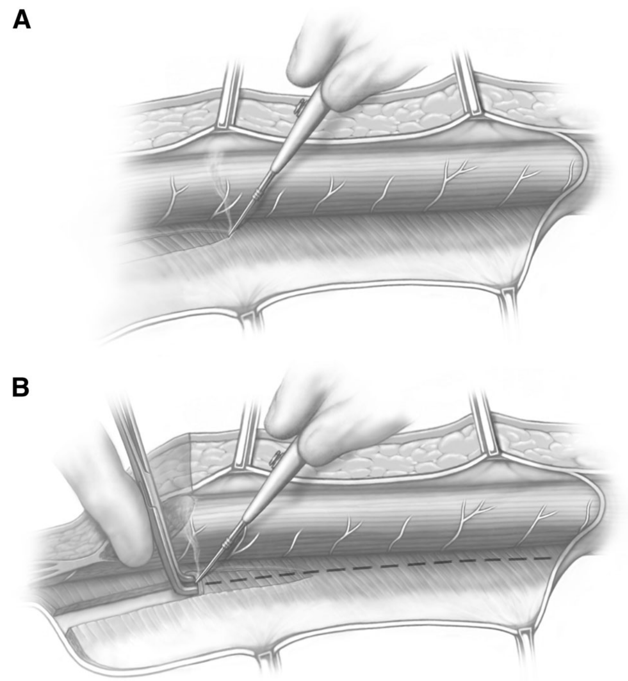



**Fig. 6** Techniques for safe transection of the transversus abdominis muscle (TAR) cranially. **a** First, the posterior lamina of the internal oblique muscle is transected medial to the perforating intercostal nerves exposing the underlying transversus abdominis muscle. **b** In this region, the posterior aspect of the transversus abdominis muscle is very adherent to its posterior fascia; the transversus abdominis muscle can be transected using a care spreading technique with a clamp as far cranially (and caudally) as possible

### Transverse abdominis (muscle) release (TAR)

Near the xiphoid process, there are few to no muscular fibers or any noticeable transversus aponeurosis. Just caudally and laterally in the upper abdomen, the muscular part of the transversus abdominis muscle is much more prominent and extends medially behind the lateral extent of the rectus abdominis muscle immediately posterior to the posterior lamina of the internal oblique muscle. The medial extent of the fibers of the transversus abdominis muscle extend less far medially as one moves caudally. At the level of the umbilicus, almost no muscle fibers of the transversus abdominis muscle extend as far medially as the lateral border of the rectus muscle, and further caudally, only the transversalis abdominis aponeurosis without any preperitoneal fat persists (Fig. 5).

Once the posterior lamina of the internal oblique aponeurosis is transected cranially (Fig. 6a), the medial-most muscle fibers of the transversus abdominis muscle can be visualized covered by a thin, almost unappreciable fascia. This part of the muscle and posterior fascia are very adherent to the underlying peritoneumin their medial extent. *Here is the second trick to the posterior component separation.* The muscle fibers and fascia of the transversus abdominis muscle can be separated from the underlying thin posterior transversus abdominis fascia and peritoneum with a right angle clamp. But, this separation requires a careful spreading action under the muscle fibers of the transversus abdominis muscle; thus, careful, gentle dissection allows for a controlled transection of the transversus abdominis muscle (Fig. 6b). Attempting to transect this muscle without prior dissection posteriorly risks transecting inadvertently both the posterior transversus abdominis fascia and the underlying peritoneum, leading to extrusion of the bowel through the site of the peritoneotomy and into this now retrorectus/preperitoneal plane; this protrusion of intra-abdominal fat/bowel interferes with visualization, jeopardizing exposure, and placing the bowel at risk of injury. On occasions, transecting the posterior, thin-layered fascia of the transversis abdominis muscle to expose the peritoneum will facilitate the dissection caudally (Fig. 4c). This maneuver is often not necessary and even the authors of this review differ in the importance of transecting this fascia. The peritoneum needs to be kept intact to serve as an autogenous barrier between the viscera and the prosthetic material to be placed in this plane. Starting the transection of the transversus abdominis muscle as far cranially as possible where these muscle fibers are prominent and progressing caudally aids markedly this part of the component separation. If a peritoneotomy is made during the dissection process, it is important to confirm you have begun your release as lateral as possible. If so, complete the transverse abdominis transection and then reapproximate the peritoneum with a running absorbable suture. If the closure is not secure, we use a piece of polyglycolic acid mesh as an underlay patch. Continuity of the peritoneum must be restored, because when the muscle paralysis of the anesthetic is reversed, the subsequent increased intra-abdominal pressure will cause the bowel to herniate posterior to the prosthesis into the retrorectus space through the peritoneal defect. Another tip is that if you attempt to develop this preperitoneal plane by transecting the posterior rectus sheath too far medially, the plane will be very difficult and almost impossible to develop, because the posterior fascia of the transversalis muscle disappears as the transversalis aponeurosis joins the posterior lamina of the internal oblique to form the posterior rectus sheath. Therefore, the muscle release of the posterior sheath should be as far laterally as possible, without damaging the intercostal nerves. Take your time during this part of the procedure; this is possibly the most important and most difficult part of the entire operation.

## Extending the extraperitoneal plane laterally and cranially

Once the transversus abdominis release is completed, the lateral edge of the divided muscle can be grasped with a Kocher or Allis clamp and retracted anteriorly. Further lateral dissection follows. The lateral dissection occurs deep to the transversus abdominis muscle and is usually very easy to do. The intercostal neurovascular bundles run superficial to the transversus abdominis muscle and deep to the internal oblique muscle. Thus, they are avoided as one dissects laterally. If excessive bleeding is encountered, it is likely that the dissection is occurring in the wrong plane in between the transversus abdominis and internal oblique muscle. *Here is the third trick.* The surgeon's hand can then be used to bluntly but carefully dissect the plane and release the transversalis muscle fascia or aponeurosis (depending on how far cranially you are) from the underlying peritoneum laterally (Fig. 7b). The space thus created is contiguous with the retroperitoneum and can be extended laterally to the mid axillary line and if necessary, even more posteriorly to the lateral edge of psoas muscle. This space can be extended cranially to above the costal margin and join the central tendon of the diaphragm in the midline.

## Extending the extraperitoneal plane caudally

Creating this preperitoneal plane caudally involves several tricks to facilitate the dissection. From just cranial to the umbilicus and caudally, there are usually no muscle fibers of the transverse abdominal muscle, only the transversalis aponeurosis (the "tendon" of the transversus abdominis muscle, Figs. 5, 7a). This aponeurosis lies directly anterior to the peritoneum (Fig. 4c). The space between the transversalis aponeurosis and peritoneum can usually be dissected with a blunt technique while maintaining the integrity of the underlying peritoneum. Dissection of this plane to allow a safe, caudal transection of the transversalis abdominis aponeurosis as one moves more caudally can be difficult, because the transversus abdominus aponeurosis and the underlying peritoneum are both thin and adherent. There are two approaches. One favored by two of the authors (MJR, YWN) involves a careful transection of only the transversus abdominis muscle and then dissecting the pre-peritoneal space caudally using a spreading clamp technique (Fig. 7a). Another trick (#4) used by the other two authors (WOG, MGS) is to start laterally and dissect medially with a sweeping motion of the surgeon's hand. Starting cranially where the transversus abdominal muscle and fascia have been transected and dissected laterally off the peritoneum, the surgeon can begin far laterally and sweep bluntly caudally and medially with the fingers to get behind the transversalis aponeurosis but anterior to the peritoneum (Fig. 7b). This maneuver from lateral to medial allows a more safe, controlled (and easy) separation of the transversus abdominis aponeurosis off of the underlying thin peritoneum and making the caudal transection of the transversalis aponeurosis quite easy. The concept of a lateral to medial mobilization is facilitated by the presence of the more areolar preperitoneal space laterally where there is much more preperitoneal fat. Some surgeons free the intraperitoneal space between the undersurface of the anterior abdominal wall from the underlying viscera by all adhesions because of worry about injuring bowel adherent to the peritoneum when creating the preperitoneal plane. This maneuver requires a wide intraperitoneal access, and the authors differ on the necessity of this maneuver; two of the authors (MJR and YWN) perform this maneuver routinely, while the other two (WOG and MGS) only do this when intraperitoneal access is necessary because of prior recent or recurrent small bowel obstruction from adhesions.

When the hernia is situated in the lower abdomen, some surgeons suggest that it might be easier to start the dissection in the space of Retzius, dissect laterally, and then move cranially, maintaining the concept of lateral to medial dissection; the authors, however, do not use this technique often.

Once the medial dissection is finished, the lateral dissection progresses to the retroperitoneum. Out laterally, blunt dissection will expose the lateral edge of the psoas muscle. The further caudally, the easier is this dissection; once in the pelvis, the plane is very easily dissected bluntly sweeping posterior to the posterior peritoneum to expose

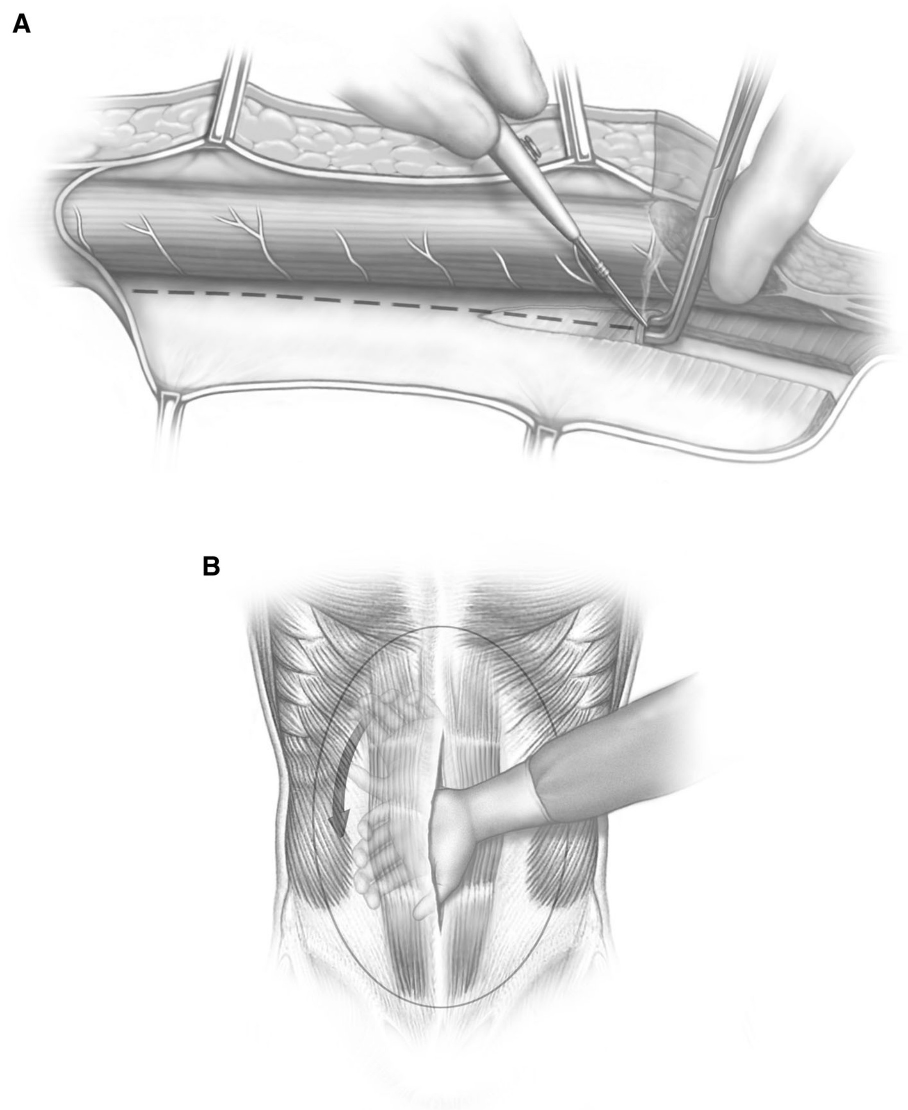



**Fig. 7** Dissection of preperitoneal space caudally. **a** The transversus abdominis aponeurosis is transected very carefully and the pre-peritoneal space dissected caudally using a spreading clamp technique. Note, as one proceeds caudally, the muscle fibers of the transversus abdominus disappear. **b** Lateral to medial dissection of the appropriate plane caudally. Note, the plane posterior to the transversus abdominis fascia and aponeurosis more laterally is entered more easily because of pre-peritoneal fat. By a sweeping motion of the surgeon's hand from lateral to medial, the space posterior to the transversus abdominal fascia laterally and the aponeurosis more medially will easily separate to allow a safe, controlled medial transection of the transversus abdominis aponeurosis as one proceeds caudally

Cooper's ligament and eventually the pubis. These bony structures will serve as potential points of fixation for suturing the caudal extent of the mesh prosthesis. The same dissection is performed on the contralateral side, unless unilateral mobilization is all that is needed (this situation would be unusual).

## Potential difficulties in dissecting this space

Many patients requiring a posterior component separation have had prior ventral hernia repairs or laparotomies involving transmural sutures (or incisions) through the rectus muscles and/or the lateral muscles. These sutures would have passed through the retrorectus and retro transversus abdominis space making this usually very easy dissection more difficult because of the associated scarring. Careful, thoughtful dissection allows transection of the sutures or the scarred suture or incisional paths. In contrast, prior wide, full dissection of this space or prior placement of a prosthetic material in this retrorectus/preperitoneal space may jeopardize a safe dissection and probably precludes the ability to create a preperitoneal plane, thereby causing the surgeon to change plans in prosthetic placement in this region.

## Reapproximation of the medial edge of the posterior rectus sheath

At this point, the retrorectus/lateral preperitoneal space has been mobilized. The posterior rectus sheath has also been "released". Whether you have accomplished this mobilization by the anterior (extraperitoneal approach) or posterior (intraperitoneal approach), the next step is to reapproximate the medial edges of the posterior rectus sheath medially; note, the posterior rectus sheaths should be reapproximated quite easily without tension after this posterior component separation. Note, the hernia sac should not be excised, but rather is reduced posterior to the reapproximation of the posterior rectus sheaths to serve as further autogenous tissue between the viscera and the prosthesis. If you have entered the peritoneal cavity, the edges of the peritoneum can be resewn together before reapproximating the posterior rectus sheath anteriorly. By reapproximating the posterior rectus sheath, the retrorectus/retroperitoneal place is defined, an element of fascial support of the midline hernia defect is established, and the intraperitoneal viscera is kept away from contact with the prosthesis by a layer of autogenous tissue. In the very rare instance where the posterior rectus sheath (or the remnants of the transversus abdominis aponeurosis) and peritoneum cannot be reapproximated, an inlay of polyglycolic acid mesh can be used to bridge the defect.

### Placement of the prosthesis, lateral fixation

The benefit of this retrorectus/preperitoneal mobilization is the wide, very large surface area for transgrowth through the meshed prosthetic material. Choice of prosthetic material varies with the patient. Because such an extensive abdominal wall reconstruction is used most often for massive incisional hernias, most herniologists would use a meshed prosthesis—possibly a polypropylene of light or medium weight with large pore size—or for a robust male, especially if a laborer or a high performance-type athlete, a heavy weight, small pore polypropylene; ePTFE does not allow transgrowth or substantive tissue incorporation and thus would not be our choice.

Next, the mesh is positioned in this space. Two of the authors (MJR and YWN) use no or few sutures and will often use a fibrin glue type fixation, relying on the wide placement and intra-abdominal pressure posteriorly to keep the mesh in place. The other two authors (WOG and MGS) use suture fixation by transmural sutures (Figs. 8, 9). The easiest technique for suture fixation involves making stab wounds in the skin directly over the lateral-most extent of the retrorectus/preperitoneal space. A horizontal mattress suture of a #1 polydioxanone is placed through the lateral-most part of the mesh. A suture passer, such as a Carter-Thomason (Cooper Surgical, Pleasanton, CA) or the less sharp disposable EndoClose™ (Covidien, Inc., Mansfield, MA), is then passed percutaneously through the stab wound and through the abdominal musculature into the retrorectus/preperitoneal space; placing a metal malleable posterior to the site of entry into this space can prevent the suture passer from entering the peritoneum or injuring the surgeon's fingers. We prefer the EndoClose™ over the

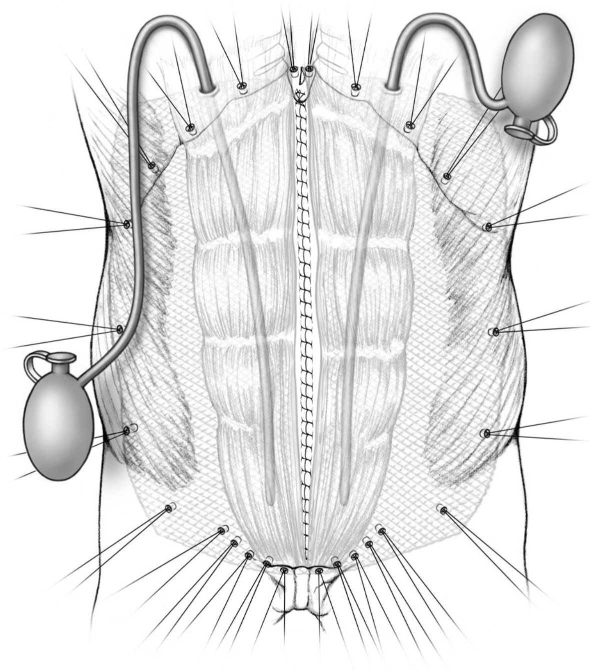
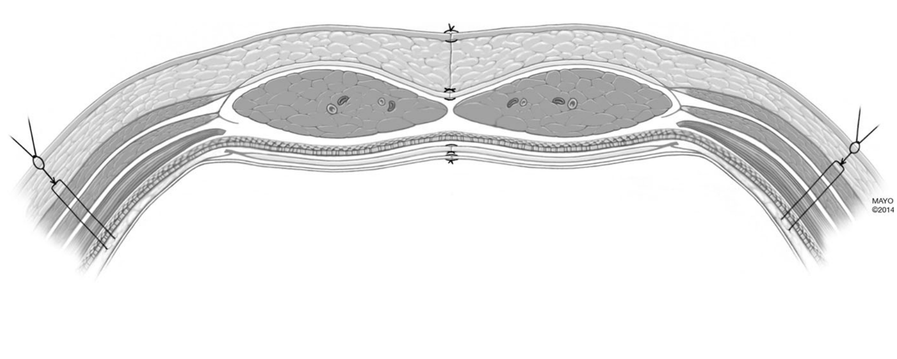


**Fig. 9** Final view of the extent of the prosthesis sewn cranially to distal sternum, and caudally to the pubis and Cooper's ligaments and extends cranial to the costal margin behind rectus abdominis muscles. Note the sublay of mesh posterior to the site of the transversus abdominis release

**Fig. 8** Transverse view of the placement and lateral extent of the prosthesis in a retrorectus and laterally a retrotransversus abdominis retroperitoneal plane



Carter-Thomason passer, because the Carter-Thomason can more easily injure underlying fingers of the less experienced surgeon. One end of the suture is grabbed and the stab wound is pulled out. The same maneuver is performed through the same stab wound but by directing the suture passer about 1.5–2 cm away on the anterior abdominal wall musculature, such that when the two ends of the suture are tied, the knot rests stably on the anterior surface of the musculofascial abdominal wall laterally. The location of these sutures are important to "off weight" the midline closure. By placing the mesh under physiologic tension, it also allows for closure of the midline without buckling of the mesh. As stated above, the need for this lateral fixation is believed important by two of the authors (WOG, MGS) but not the other two authors (MJR, YWN) of this review.

### Fixation of the mesh cranially and caudally

Cranially, the mesh should extend cranial to the costal margin posterior to the rectus muscle, but more laterally, the mesh passes posterior to the external oblique, internal oblique, and transversus abdominis muscles (Fig. 9). The mesh can also be sewn to the edge of the costal margin if fixation seems less secure. The mesh should extend 5–8 cm posterior to the sternum/xiphoid cartilage onto the center tendon of the diaphragm. Two of the authors (WOG, MGS) also place two sutures (#1 polypropylene) through the distal sternum (and not through the xiphoid cartilage whenever possible) to allow further fixation of the mesh. If the cranial aspect of the hernia defect is greater than 5–8 cm caudal to the xiphoid, the fixation sutures need not go through the sternum provided the midline linea alba is stable and intact, and there are at least 5 if not 8 cm of true underlay.

Caudally, the mesh is best sewn to Cooper's ligament, the pubic tubercle, and the ipsilateral half of the pubis using a #1 polypropylene (Fig. 9). The number of sutures to these bony structures varies with local conditions and with the patient and their lifestyles and work; we tend to place more sutures for the physically active individuals to assure a stable caudal fixation. These sutures are passed into the bone and not just the periosteum, and then through the mesh. We have tried some of the other devices for bony fixation, but they tend to pull out very easily; we specifically do not use a laparoscopic tacker, which in our experience does not provide a stable, durable fixation. Rarely in robust, husky men with big bones, a bone drill is needed to create a pathway for the suture—but with "force"; usually these sutures can be placed without need of a bone drill. If concerns are present about a stable lateral fixation, the mesh can be sewn to the anterior superior iliac spine with #1 polypropylene; because of the bulk of the iliac bone, we often need a skin incision to expose the anterior surface of the iliac crest in men; placement of the fixating suture then usually does require use of a bone drill.

When the caudal extent of the hernia defect is 5–8 cm cranial to the pubis, it may not be necessary to fix the mesh to the pubis and Cooper's ligament, provided there is 5–8 cm of underlay and the overlying caudal midline abdominal wall is stable and intact.

## Medialization of the rectus muscles

Prior to reapproximating the medial edges of the anterior rectus sheath to restore a neo-linea alba, we tend to place two, large diameter, closed-suction drains on the anterior surface of the mesh and bring them out through the abdominal wall cranially (and not caudally through the less clean inguinal region) (Fig. 9). Timing of removal of these drains varies with their output and, quite frankly, varies amongst the authors.

Next, the anterior rectus sheaths are sutured together with a running #1 polydioxanone suture. The transverse abdominis (muscle) release (of the lateral "pull" of the transverse abdominis muscle) allows for medialization of the rectus muscle ipsilaterally in most patients; the extent of medialization varies between individuals and the laxity of their abdominal wall. We expect usually at least 4 cm and often 8 cm ipsilaterally. In the more unusual situation when the anterior rectus sheaths cannot be approximated due to a large, more fixed original hernia defect, the mesh prosthesis will need to serve as a bridging or patch underlay repair. In this situation, the medial edge of the anterior rectus sheath maybe sewn to the prosthesis in an attempt to fix the medialized extent of the sheath to the mesh. Importantly, the soft tissues of the skin/subcutaneous complex and rectus muscles are medialized to cover the prosthesis. When the defect requires this bridging mesh, we do not use a lightweight polypropylene mesh; also, we use a subcutaneous drain anterior to the bridging mesh to try to prevent a fluid collection or seroma between the anterior aspect of the mesh and the subcutaneous fat.

The subcutaneous tissue is closed with a running 2-0 polyglycolic acid suture and the skin either with a subcuticular absorbable suture or with skin suture and an incisional wound vac system [12]. The stabs are closed with one of the skin adhesives (Dermabond, Ethicon, Inc.).

## Benefits of the posterior components separation

There are four main advantages of the posterior components separation technique over the anterior components separation. First, unlike the anterior components separation in which all or at least some of the perforators (blood vessels supplying the subcutaneous tissues and skin from the deep epigastric vessels) are transected, the development of the retrorectus/preperitoneal plane preserves all of these perforators, thus maintaining the blood supply to the skin and minimizing wound complications that are common after the anterior components separation described by Ramirez et al. [6]. Second, the retrorectus/lateral retromuscular plane allows for a very wide and large surface area of sublay for tissue transgrowth, which is substantially greater than for the typical Rives-Stoppa retrorectus repair. Third, the prosthesis of the posterior components separation serves as an underlay of the area of the transverse abdominis release. In addition, there is one report showing that this posterior components separation using a very wide prosthetic sublay can even be used in patients who have had a prior anterior components separation [13]. Fourth, the prosthesis is totally extraperitoneal (intramural, and not intraperitoneal as with a laparoscopic repair) in a space that anteriorly (rectus muscle medially and transversus abdominis muscle/aponeurosis laterally) and posteriorly (peritoneum) are well vascularized (unlike the subcutaneous fat with an onlay repair).

We first published our experience with posterior component separation versus anterior component separation and found a 50 % decrease in wound morbidity with the posterior approach [14]. Subsequently, we reported on a series of posterior component separations with particular attention to the technical aspects of the procedure [11]. We have also reported our outcomes in the setting of transplant patients [15], reconstruction of open abdomen patients after trauma [16], and patients undergoing repair of prior failed anterior component separations [13]; the outcomes have been very acceptable as outlined in these reports. We have found this procedure to be reproducible in a many different scenarios dealing with patients requiring abdominal wall reconstruction in whom the medial aspects of the rectus muscle could not be approximated by a retrorectus repair alone. We believe that adherence to the technical aspects described in this manuscript are key to obtaining long term success with this approach.

**Compliance with ethical standards**

**Conflict of interest** WOG and MGS declare no conflict of interest. MJR: declares conflict of interest not directly related to the submitted work: W. L. Gore. YWN: declares conflict of interest not directly related to the submitted work: C. R. Bard, LifeCell, Cooper Surgical.

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