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Transversus abdominis muscle release: a novel approach to posterior component separation during complex abdominal wall reconstruction

Yuri W. Novitsky, M.D.[a,b,*], Heidi L. Elliott, M.D.[a,b], Sean B. Orenstein, M.D.[a], Michael J. Rosen, M.D.[b]

[a]*Department of Surgery, University of Connecticut Health Center, Farmington, CT, USA;* [b]*Case Comprehensive Hernia Center, University Hospitals Case Medical Center, Case Western Reserve University, 11100 Euclid Ave., Cleveland, OH 44106, USA*

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Sublay

Abstract

BACKGROUND: Several modifications of the classic retromuscular Stoppa technique to facilitate dissection beyond the lateral border of the rectus sheath recently were reported. We describe a novel technique of transversus abdominis muscle release (TAR) for posterior component separation during major abdominal wall reconstructions.

METHODS: Retrospective review of consecutive patients undergoing TAR. Briefly, the retromuscular space is developed laterally to the edge of the rectus sheath. The posterior rectus sheath is incised 0.5–1 cm underlying medial to the linea semilunaris to expose the medial edge of the transversus abdominis muscle. The muscle then is divided, allowing entrance to the space anterior to the transversalis fascia. The posterior rectus fascia then is advanced medially. The mesh is placed as a sublay and the linea alba is restored ventral to the mesh.

RESULTS: Between December 2006 and December 2009, we have used this technique successfully in 42 patients with massive ventral defects. Thirty-two (76.2%) patients had recurrent hernias. The average mesh size used was 1,201 ± 820 cm^2 (range, 600–2,700). Ten (23.8%) patients developed various wound complications requiring reoperation/debridement in 3 patients. At a median follow-up period of 26.1 months, there have been 2 (4.7%) recurrences.

CONCLUSIONS: Our novel technique for posterior component separation was associated with a low perioperative morbidity and a low recurrence rate. Overall, transversus abdominis muscle release may be an important addition to the armamentarium of surgeons undertaking major abdominal wall reconstructions.

Ventral abdominal wall hernias present a formidable and growing challenge that complicates 11% to 23% of all abdominal laparotomies.[1,2] The ability to perform a reliable, durable ventral hernia repair with low morbidity and recurrence rate has become a significant problem for today's general surgeon. Alarmingly, hernia repair failure rates range from 25% to 54% for primary suture repair, and up to 32% for open mesh repair.[3–8] The retromuscular (Rives-Stoppa) hernia repair, first described in the early 1970s, uses the space between the posterior rectus fascia and the rectus muscle, extending approximately 6 to 8 cm on either side of

* Corresponding author. Tel.: +1-216-286-6801; fax: +1-216-844-2888
E-mail address: yuri.novitsky@uhhospitals.org

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the midline.[9–11] This technique has evolved as an effective approach for open ventral herniorrhaphies.[4,12–14]

Although durable, the Rives-Stoppa technique is limited by the lateral border of the posterior rectus sheath, and thus usually is inadequate for larger abdominal wall defects.[15] As a result, several modifications on this technique have been developed. Such innovative approaches involve use of the preperitoneal space[12] or development of an intramuscular plane using a posterior component separation technique.[16] We recently developed another novel technique of posterior component separation using transversus abdominis muscle release (TAR). This modification allows for significant posterior rectus fascia advancement, wide lateral dissection, preservation of the neurovascular supply, avoids subcutaneous tissue undermining, and provides a large space for mesh sublay. Herein, we present technical details and outcomes of TAR in a series of patients undergoing complex abdominal wall reconstruction using our novel approach.

Materials and Methods

We performed a retrospective review of all patients undergoing hernia repair at the specialized hernia repair center by a single surgeon (Y.W.N.). Patients who underwent abdominal wall reconstruction using retromuscular synthetic mesh repair with TAR were identified and reviewed.

Main outcome measures included patient demographics, body mass index, number of previous abdominal surgeries, number of recurrent hernias, and number of previous hernia repairs. Perioperative data included surgical time and blood loss, mesh type and size, complications, and length of hospitalization.

Typical follow-up evaluation consisted of a physical examination at 3 to 4 weeks, 3 months, 6 months, 1 year, and then annually. Abdominal computed tomography (CT) scans were obtained routinely at 1 year and/or to delineate any abdominal discomfort.

Surgical technique

After a complete adhesiolysis via a generous midline laparotomy, the posterior rectus sheath is incised about 0.5–1 cm from its edge (Fig. 1). This typically is performed at the level of the umbilicus. The retromuscular plane then is developed toward the linea semilunaris, visualizing the junction between the posterior and anterior rectus sheaths (Fig. 2). The perforators to the rectus muscle (branches of the thoracoabdominal nerves, penetrating the lateral edge of the posterior rectus sheath) are visualized and preserved (Fig. 2). Starting in the upper third of the abdomen, about .5 cm medial to the anterior/posterior rectus sheath junction, the posterior rectus sheath is incised to expose the underlying transversus abdominis muscle (Fig. 3).

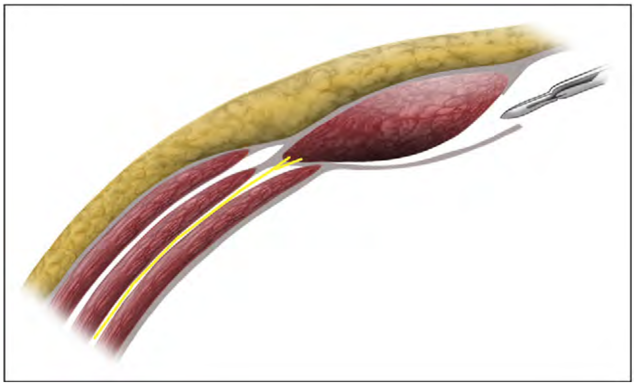

Figure 1 The retromuscular space is developed by incising the posterior rectus sheath and dissecting the rectus abdominis muscle from the underlying rectus sheath.

The muscle then is divided along its entire medial edge using electrocautery (Fig. 3). 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. This step allows entrance to the space between the transversalis fascia and the divided transversus abdominis muscle. This space is contiguous with the retroperitoneum and can be extended laterally to the psoas muscle, if necessary. Superiorly, the subxyphoid space is developed as previously described.[16,17] The retromuscular dissection plane can be extended cephalad to the costal margins and dorsal to the sternum by sweeping the peritoneum/transversalis fascia off the diaphragm (Fig. 4). Inferiorly, the space or Retzius (anterior to the urinary bladder) is entered to expose the pubis symphysis and both Cooper ligaments (Fig. 5). Below the arcuate line of Douglas, only transversalis fascia and peritoneum are medialized. This dissection results not only in the creation of a large retromuscular space beyond the linea semilunaris but also allows for significant medial advancement of the posterior rectus sheaths (Fig. 6). The steps of the release are shown in sequence in Fig. 7. Once a similar release is performed on both sides, the posterior rectus sheaths are reapproximated in the midline with a running monofilament suture (Fig. 8A). In rare instances when the anterior rectus sheath cannot be reapproximated, the gap could be bridged with remnants of the hernia sac or absorbable mesh. The mesh is placed as a sublay in the retromuscular space (Fig. 8B) and secured with full-thickness, transabdominal sutures using a Reverdin needle.[12,16] In addition, the inferior edge of the mesh is secured to both Cooper ligaments using 2 to 4 interrupted monofilament sutures. Closed suction drains are placed on top of the mesh. The anterior rectus sheaths then are reapproximated in the midline to restore the linea alba ventral to the mesh (Fig. 9).

Results

Between December of 2006 and December 2009, we used the TAR technique in 42 patients with complex ventral

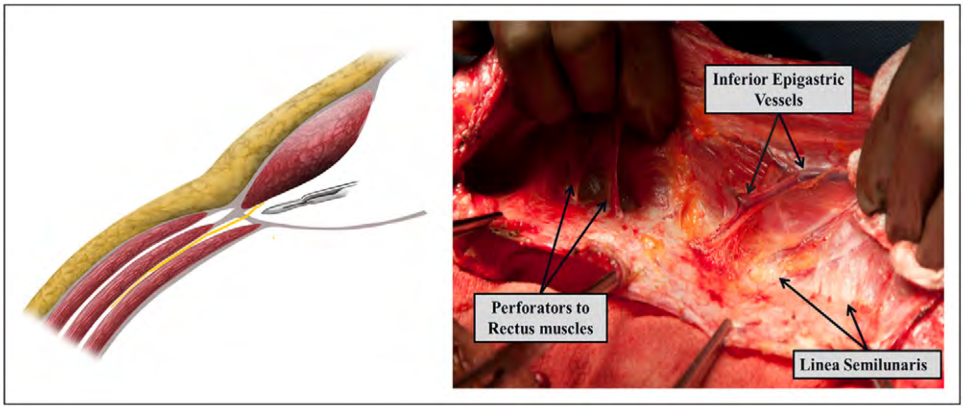

Figure 2 The posterior rectus sheath is incised about 0.5–1 cm medial to the anterior/posterior rectus sheath junction to expose the underlying transversus abdominis muscle. Note the perforator nerves that are preserved during retromuscular dissection and subsequent posterior component release.

hernia defects. There were 32 (76%) women with a mean age of 52.1 years. The average body mass index was 39 $\pm$ 13 kg/m^2 (range, 23–69 kg/m^2). The average defect size was 366 $\pm$ 120 cm^2 (range, 160–660 cm^2). Thirty-two (76.2%) patients had recurrent hernias with an average number of previous repairs of 2.9 (range, 1–8). Thirty (71.4%) patients had chronically incarcerated hernias. Thirteen (25%) patients had diabetes and 3 (7%) were smokers. All procedures were performed in the absence of contamination with use of a macroporous, unprotected synthetic mesh. The average surgical time was 235 minutes (range, 138–400 min). The average estimated blood loss was 310 mL (range, 100–660 mL). There were no intraoperative blood transfusions. The average mesh size used was 1,201 $\pm$ 820 cm^2 (range, 600–2,700 cm^2). There were no major intraoperative complications. The average length of hospitalization was 5.1 days (range, 3–15 d). There were no perioperative mortalities.

Postoperative wound complications occurred in 10 (24%) patients. Seven of those were minor superficial infections that responded to antibiotic therapy alone. There were 3 (7%) major wound infections requiring surgical debridement in 2 patients. One patient was an elderly diabetic man who developed necrotizing wound infection 2 weeks postoperatively. His wound was debrided and treated with vacuum-based dressing. He went on to have an uneventful recovery. Another patient who required creation of skin flaps for closure developed a flap necrosis requiring surgical debridement. Importantly, given tremendous prior tissue loss, her linea alba was not restored entirely ventral to the mesh. She had a prolonged course of local wound care that culminated in the need for removal of a small central portion of the exposed mesh. The resultant wound developed a good granulation base and was treated with a skin graft. Abdominal imaging did not reveal any residual infection and/or recurrence at a 24-month follow-up evaluation.

The median follow-up period was 26.1 months (range, 2–42 mo), and 36 patients (86%) had a follow-up period of 12 months or longer. In addition to physical examination, an abdominal CT scan was obtained in 30 (71%) patients. No patient developed any lateral bulging or laxity. There have been 2 (4.7%) recurrences. One recurrence was detected on a CT scan performed for an unrelated indication that revealed an asymptomatic defect superior to the mesh placement. The patient was treated with observation and has remained asymptomatic. Another patient had discomfort

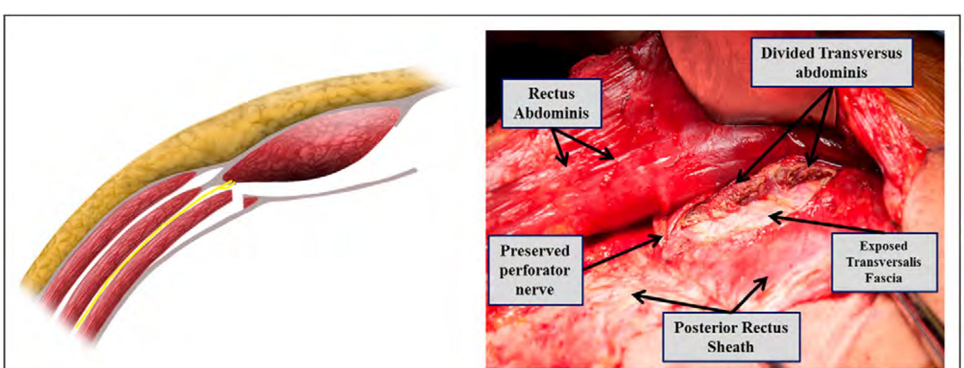

Figure 3 Division of the posterior rectus fascia just medial to the linea semilunaris and perforator nerves followed by division/release of the transversus abdominis muscle along its entire medial edge.

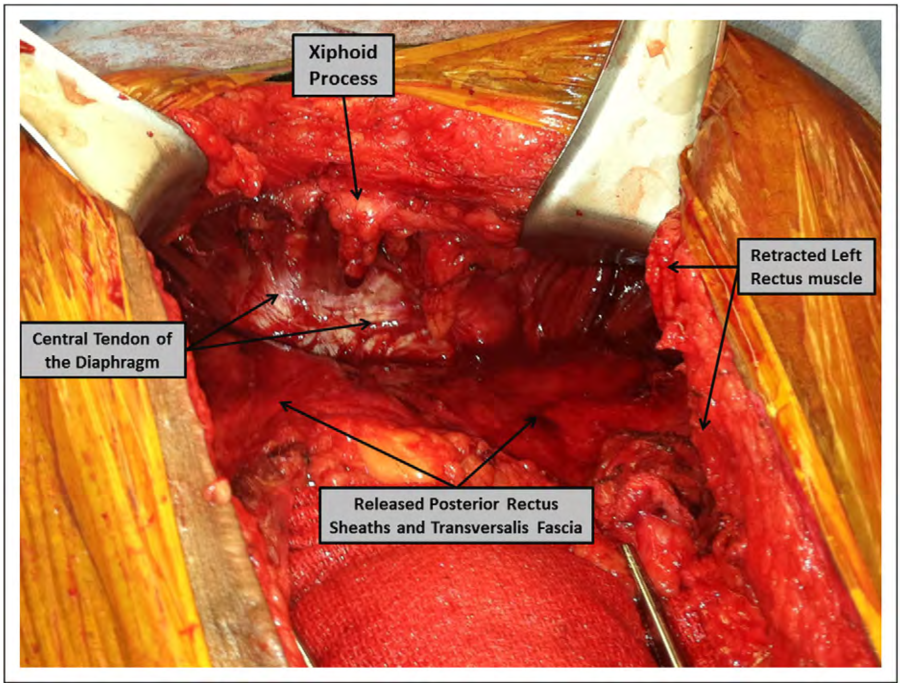

Figure 4 Subxiphoid and retrosternal dissection with exposure of the middle leaflet of the central tendon of the diaphragm. Note the extension of the dissection plane well above the costal margin. This dissection is of particular importance to repairs of subxiphoid (post-sternotomy) and subcostal hernias.

and was found to have a lateral recurrence that was treated with a laparoscopic repair and remained well at a 1-year follow-up evaluation.

Comments

The ideal surgical approach to the difficult ventral hernia repairs remains to be elucidated. Complex abdominal problems continue to present a significant technical challenge with high perioperative morbidity, frequent repair failures, and negative effects on patient quality of life.[18] Similarly to others, we believe that the goal of any herniorrhaphy should be restoration of a functional abdominal wall with autologous tissue repair strengthened by reinforcement with a durable mesh.[18] Our novel TAR technique allows for safe and reliable medial fascia advancement and large retromuscular space dissection in the complex patient undergoing major abdominal wall reconstruction.

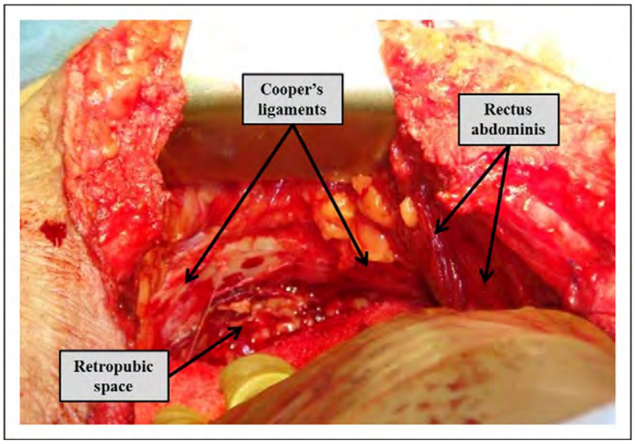

Figure 5 Retromuscular dissection of the space of Retzius and exposure of the pubis and both Cooper ligaments.

Myofascial advancement during component release was described as the most physiological reconstruction of large abdominal wall defects.[18] It is based on mobilization and medial advancement of the abdominal wall musculature and accompanying fascia to obliterate the hernia defect using autologous tissue. As first described by Ramirez et al,[19] incision of the posterior rectus sheath and external oblique aponeurosis allows for significant medialization of the rectus muscles and primary closure of the midline hernia defect. This technique reportedly bridges the fascial gap of defects up to 20 cm at the waistline. It is important to mention that all patients in that series had posterior rectus sheath release. In fact, it was the only release in 70% of those patients and it was reported that it was the posterior rectus sheath release that provided the most medial advancement of all components of the anterior abdominal wall.[19] Although widely used today, among the major drawbacks of the traditional anterior component separation technique are extensive skin flaps, difficulties with suprapubic and/or subxyphoid defects, and the absence of a reliable space for prosthetic reinforcement, resulting in up to 30% recurrence and 26% to 42% wound infection rates.[16,20,21]

The retromuscular Rives-Stoppa hernia repair affords sublay placement of mesh while avoiding a large subcuta-

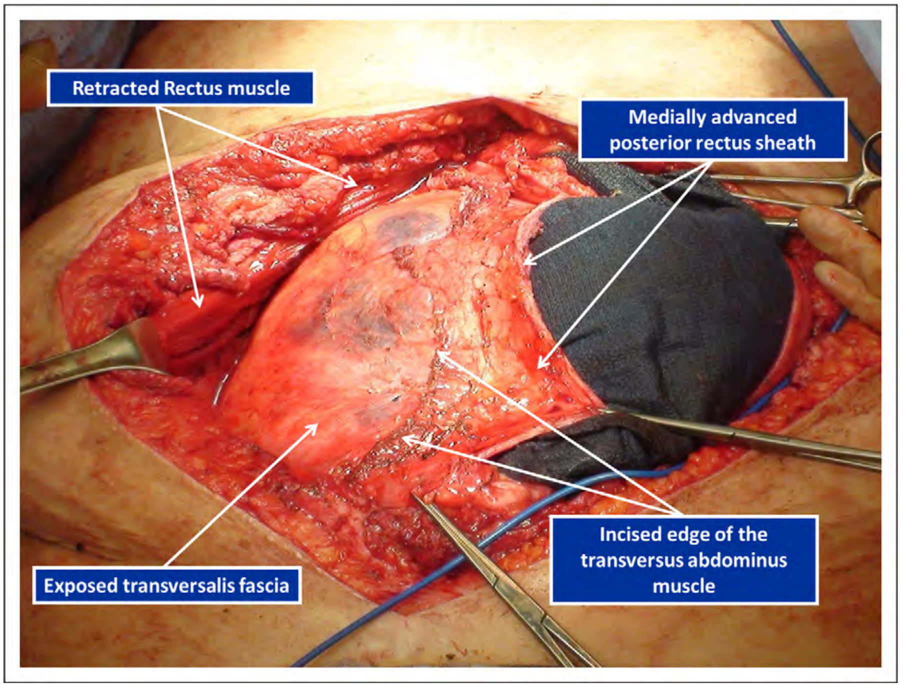

Figure 6 Transversus abdominis muscle release allows for posterior component separation with entrance to the space between the transversalis fascia and the divided transversus abdominis muscle. This sublay space is sufficient for significant prosthetic reinforcement of a visceral sac.

neous flap dissection. By developing the space between the posterior rectus fascia and the rectus muscle, this technique allows for mesh placement that extends approximately 6 to 8 cm on either side of the midline.[9,10] The original technique, as described by Stoppa et al,[15] also incorporates approximation of the posterior rectus sheath. In fact, in 2004, given its superior track record, this approach was proclaimed to be the gold standard for open ventral hernia repair by the American Hernia Society. Although durable, the Rives-Stoppa technique is limited by the lateral border

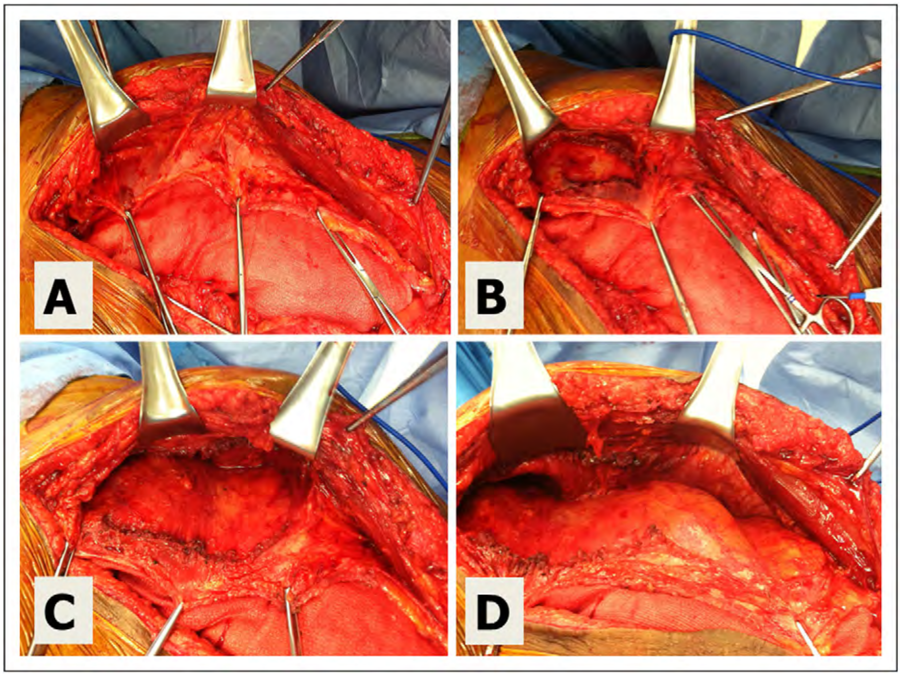

Figure 7 Sequential steps of the TAR technique: (A) exposure of the posterior rectus fascia; (B) incision of the posterior rectus sheath and the underlying transversus abdominis muscle; (C) further division of the posterior sheath/transversus abdominis with development of the lateral space; and (D) dissection caudal to the arcuate line of Douglas toward the space of Retzius.

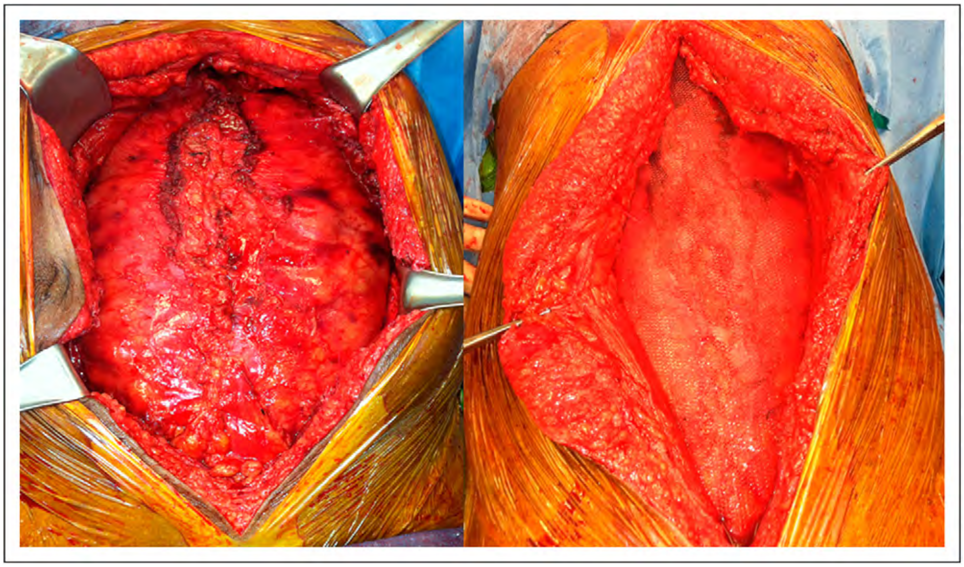

Figure 8 Both medialized posterior rectus sheaths are reapproximated in the midline (left panel), and the mesh is placed in the retromuscular space (right panel). It is fixated to the abdominal wall with transabdominal sutures.

of the posterior rectus sheath, and thus inadequate for larger ventral hernias. In those instances, the space afforded by dissection within the rectus sheath will not allow for sufficient fascia medialization and/or sufficient mesh coverage of the hernia defect. Therefore, several modifications of the classic Rives-Stoppa technique have been described. Although, multiple techniques using the intraperitoneal, preperitoneal, and interparietal spaces have been reported,[4,12,14,16,22] all have significant shortcomings that are addressed by the TAR approach.

The TAR technique described herein is an extension of the retromuscular Rives-Stoppa repair to the posterior component separation technique. There are 3 main advantages to this approach. First, transversus abdominis muscle release results in significant medial mobilization of the posterior rectus sheath. Second, it allows for extensive lateral dissection in a potentially unlimited space between the transversus muscle and the underlying transversalis fascia/peritoneum. Finally, it avoids disruption of the nerves and blood supply to the rectus abdominis and anterolateral abdominal wall skin. Overall, the TAR technique allows not only for a relatively tension-free repair with a large mesh but also myofascial reconstruction dorsal and ventral to the mesh, potentially restoring the native biomechanics of the abdominal wall.

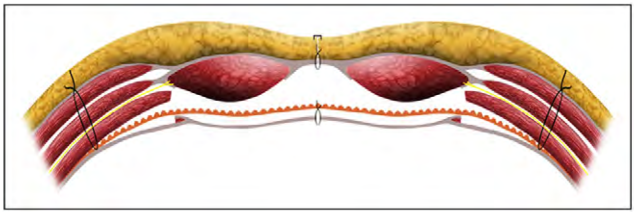

Figure 9 The anterior rectus sheaths then are reapproximated in the midline ventral to the mesh to re-create the linea alba.

The key component to the TAR technique is the release of the transversus abdominis muscle itself. The main function of this muscle, in conjunction with the internal oblique, is to act as a "corset" by creating hoop tension around the abdomen. The synergistic action of the transversus and the posterior fibers of the internal oblique produce this tension throughout the thoracolumbar fascia.[23] As the transversus is activated, it draws the abdominal wall inward, and therefore increases the intra-abdominal pressure.[24] As a result, we postulated that by dividing the transversus abdominis we would be able to release the circumferential tension, thus providing for an increase of the abdominal cavity and significant medial advancement of the posterior rectus fascia. In addition, TAR also afforded medial advancement of the anterior rectus sheath/rectus muscles allowing us also to reapproximate the anterior rectus sheath in all but one patient. Although the exact degree of fascial advancement is difficult to assess, our experience shows that the TAR release affords 8 to 12 cm of advancement per side in most patients. In this fashion, we believe we are able to restore a anatomy of the anterior abdominal wall and provide a dual layer of fascial closure to facilitate repair and minimize mesh infections. To date, no patient has experienced any deleterious effects of a transversus abdominis muscle division.

The importance of this dual-layer fascial closure should be emphasized. Although variations on the classic Rives-Stoppa technique may omit closure of the posterior rectus sheath (PRS), we, along with others,[4,13,14] do not advocate this practice for several reasons. First, closure of the PRS avoids herniation of the intra-abdominal viscera between the mesh and the abdominal wall layers. Second, it negates the need for costly composite meshes because there is no exposure of the abdominal viscera to mesh that is placed extraperitoneal. Finally, although the importance of PRS closure for durability of the repair is unknown, we believe this step might provide some additional strength to the reconstruction of the abdominal wall. If it is impossible to close the PRS, we use the omental fat, a hernia sac, or a Vicryl mesh as a bridge between fascial edges.

In patients with large ventral hernias, the importance of achieving a wide lateral mesh overlap of the defect is critical. In fact, based on the principles of Stoppa, we aim for a "giant prosthetic reinforcement of a visceral sac."[15] Although the precise degree of necessary mesh overlap remains unknown, we and others believe that mesh extension of at least 8 to 10 cm beyond the hernia defect is paramount for a durable repair.[22] Similar to the Rives-Stoppa principles, we aim to address the disease of "herniosis" by reinforcing most if not all of the abdominal wall in patients with large ventral defects.[15] By using the retromuscular approach we were able to develop this largely underused space even in instances of recurrence. The posterior rectus sheath is entered easily from the midline and can be extended from the xiphoid and costal margin cephalad to the pubis and Cooper ligaments caudally. Continuing laterally, we were able to gain maximum prosthetic overlap by dividing the transversus abdominis and developing the space between the muscle and its fascia. The lateral extent of this dissection could be performed to expose lateral edges of both psoas muscles. In addition, in contrast to the traditional anterior component separation techniques, we were able to expand the dissection plane to the subcostal/subxiphoid area cranially as well as to the spaces of Retzius and Bogros inferiorly. This allows a very large sublay mesh placement necessary to achieve adequate reinforcement of any defect during abdominal wall reconstruction. The average mesh size of more than 1,200 cm^2 used in our series is a testament to the extent of the retromuscular space our approach affords.

One other key advantage of dissection in the space between the transversus abdominis muscle and its underlying fascia is that we avoid the neurovascular bundles that supply the rectus abdominis muscles. The rectus abdominis is innervated by the thoracoabdominal nerves T7 to T12, whereas blood supply is derived from the superior and inferior epigastric arteries, as well as the lower 6 intercostal arteries. Cadaveric studies have shown that these nerves pass inferomedially between the internal oblique and transversus abdominis muscles before entering the lateral border of the rectus sheath.[25] In addition, the lateral cutaneous nerve branch of T12, as well as the ilioinguinal and iliohypogastric (L1), both enter the space between the internal oblique and transversus abdominis via the lateral border of the transversus muscle. These nerves, along with the ventral primary rami of the inferior 6 thoracoabdominal nerves (T7–T12) innervate the anterolateral abdominal wall skin and musculature.[26] Previously described posterior component separation with intramuscular dissection sacrifices those nerves and likely leads to rectus muscle atrophy.[16] Although the exact clinical significance of preserving these neurovascular bundles remains unclear, denervation has been suggested to predispose to abdominal wall bulging and laxity.[22] Importantly, the TAR technique avoids disrupting or injuring these nerves by dissecting in a different anatomic plane. The fact that none of our patients experienced this phenomenon may be owing to avoidance of the anatomic plane with the neurovascular bundles.

One final advantage of posterior component release in general, and the TAR technique in particular, is avoidance of skin flaps usually performed during traditional anterior component release. Wound morbidity and flap necrosis rates have been reported to be as high as 75%.[27] Given such a high surgical site occurrence rate, many surgeons have abandoned the use of synthetic meshes during anterior component separation procedures in favor of biological meshes. The avoidance of skin flaps in our technique has resulted in minimizing significant surgical site events and allowed us to use single layer synthetic mesh in most of our patients.

Conclusions

Herein we presented our novel technique of abdominal wall reconstruction using a transversus abdominis muscle release. This approach is a modification of a posterior component separation and is an adjunct to the traditional retromuscular repair of Rives-Stoppa. It was associated with low perioperative morbidity and a low-recurrence rate in our challenging group of patients. The advantages of this approach include the ability for extensive lateral extension of the retromuscular plane beyond the lateral edge of the rectus sheath while avoiding nerves/vascularity of the lateral intermuscular planes, as well as significant medial advancement of both the posterior rectus sheaths. Our technique also allows for subsequent medialization of rectus muscles, and re-creation of the linea alba ventral to the mesh. Such reconstruction not only provides for durable repair but may facilitate restoration of physiological properties of the repaired abdominal wall as well. Overall, we advocate that transversus abdominis muscle release should be an important addition to the armamentarium of surgeons performing complex abdominal wall reconstructions.

References

1. Mudge M, Hughes LE. Incisional hernia: a 10 year prospective study of incidence and attitudes. Br J Surg 1985;72:70–1.
2. Cassar K, Munro A. Surgical treatment of incisional hernia. Br J Surg 2002;89:534–45.
3. Paul A, Korenkov M, Peters S, et al. Unacceptable results of the Mayo procedure for repair of abdominal incisional hernias. Eur J Surg 1998;164:361–7.
4. Wheeler AA, Matz ST, Bachman SL, et al. Retrorectus polyester mesh repair for midline ventral hernias. Hernia 2009;13:597–603.
5. Burger JW, Luijendijk RW, Hop WC, et al. Long-term follow-up of a randomized controlled trial of suture versus mesh repair of incisional hernia. Ann Surg 2004;240:578–83; discussion, 83–5.

6. Korenkov M, Sauerland S, Arndt M, et al. Randomized clinical trial of suture repair, polypropylene mesh or autodermal hernioplasty for incisional hernia. Br J Surg 2002;89:50–6.
7. de Vries Reilingh TS, van Goor H, Charbon JA, et al. Repair of giant midline abdominal wall hernias: "components separation technique" versus prosthetic repair: interim analysis of a randomized controlled trial. World J Surg 2007;31:756–63.
8. Flum DR, Horvath K, Koepsell T. Have outcomes of incisional hernia repair improved with time? A population-based analysis. Ann Surg 2003;237:129–35.
9. Stoppa RE. The treatment of complicated groin and incisional hernias. World J Surg 1989;13:545–54.
10. Rives J, Pire JC, Flament JB, et al. [Treatment of large eventrations. New therapeutic indications apropos of 322 cases]. Chirurgie 1985; 111:215–25.
11. Wantz GE. Giant prosthetic reinforcement of the visceral sac. The Stoppa groin hernia repair. Surg Clin North Am 1998;78:1075–87.
12. Novitsky YW, Porter JR, Rucho ZC, et al. Open preperitoneal retrofascial mesh repair for multiply recurrent ventral incisional hernias. J Am Coll Surg 2006;203:283–9.
13. Iqbal CW, Pham TH, Joseph A, et al. Long-term outcome of 254 complex incisional hernia repairs using the modified rives-Stoppa technique. World J Surg 2007;31:2398–404.
14. Mehrabi M, Jangjoo A, Tavoosi H, et al. Long-term outcome of rives-Stoppa technique in complex ventral incisional hernia repair. World J Surg 2010;34:1696–701.
15. Stoppa R, Petit J, Abourachid H, et al. [Original procedure of groin hernia repair: interposition without fixation of Dacron tulle prosthesis by subperitoneal median approach]. Chirurgie 1973;99:119–23.
16. Carbonell AM, Cobb WS, Chen SM. Posterior components separation during retromuscular hernia repair. Hernia 2008;12:359–62.
17. Conze J, Prescher A, Klinge U, et al. Pitfalls in retromuscular mesh repair for incisional hernia: the importance of the "fatty triangle". Hernia 2004;8:255–9.
18. Breuing K, Butler CE, Ferzoco S, et al. Incisional ventral hernias: review of the literature and recommendations regarding the grading and technique of repair. Surgery 2010;148:544–58.
19. Ramirez OM, Ruas E, Dellon AL. "Components separation" method for closure of abdominal-wall defects: an anatomic and clinical study. Plast Reconstr Surg 1990;86:519–26.
20. Girotto JA, Chiaramonte M, Menon NG, et al. Recalcitrant abdominal wall hernias: long-term superiority of autologous tissue repair. Plast Reconstr Surg 2003;112:106–14.
21. Espinosa-de-los-Monteros A, de la Torre JI, Marrero I, et al. Utilization of human cadaveric acellular dermis for abdominal hernia reconstruction. Ann Plast Surg 2007;58:264–7.
22. Rosen MJ, Fatima J, Sarr MG. Repair of abdominal wall hernias with restoration of abdominal wall function. J Gastrointest Surg 2010;14: 175–85.
23. Bogduk N, Twomey TL. Clinical Anatomy of the Lumbar Spine. 2nd ed. Philadelphia, PA: Churchill Livingstone; 1991.
24. Wirhed R. Athletic Ability and the Anatomy of Motion. London, UK: Wolfe Medical Publications, Ltd; 1984.
25. Hammond DL, Ackerman L, Holdsworth R, et al. Effects of spinal nerve ligation on immunohistochemically identified neurons in the L4 and L5 dorsal root ganglia of the rat. J Comp Neurol 2004;475: 575–89.
26. Moore K. Clinically Oriented Anatomy. 5th ed. Philadelphia, PA: Lipincott William & Wilkins; 2006.
27. Harth KC, Blatnik JA, Rosen MJ. Optimum repair for massive ventral hernias in the morbidly obese patient–is panniculectomy helpful? Am J Surg 2011;201:396–400.