



# Technique: Transversus Abdominis Release

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Luis A. Martin-del-Campo and Yuri W. Novitsky

## Introduction

The goal of modern ventral hernia surgery is to restore the functionality of the abdominal wall. Therefore, tissue-based reconstruction with concurrent prosthetic reinforcement techniques has gained popularity in the past decades.

Approximately 50 years ago, Rives and Stoppa introduced retrorectus repairs [1, 2], while Wantz subsequently presented the concept of “giant reinforcement of the visceral sac” [3]. This technique has proven to be safe and effective for treating moderate-sized midline defects, but it has two significant drawbacks: limited myofascial advancement and a retromuscular plane for mesh placement that is limited by the linea semilunaris. Anterior component separation with external oblique release (see separate chapter) was initially described by Ramirez [4], but it is not our preferred approach given the need for creation of large skin flaps and its high rates of wound morbidity.

In order to attend to these limitations, posterior component separation with transversus abdominis muscle release (TAR) was developed in 2006 by Novitsky. Ever since the first presentation in 2009 and subsequent publication in 2012 [5], TAR has found an increasing role in addressing complex ventral hernia. The advantages of this technique include reapproximation of the linea alba with preservation of the neurovascular bundles to the rectus muscles and creation of a large sublay plane for prosthetic reinforcement without raising lipocutaneous flaps.

This chapter will discuss the anatomical principles, indications, technical aspects, and postoperative considerations of the TAR procedure.

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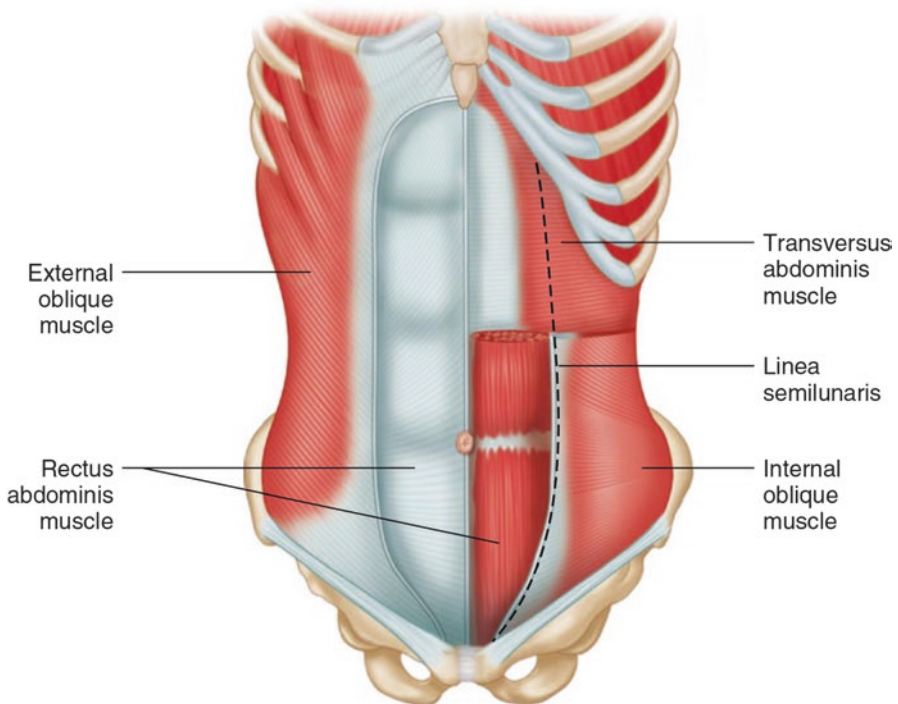
L. A. Martin-del-Campo  
University Hospitals Cleveland Medical Center, Cleveland, OH, USA

Y. W. Novitsky (✉)  
Department of Surgery, Columbia University Medical Center, New York, NY, USA  
e-mail: [yn2339@cumc.columbia.edu](mailto:yn2339@cumc.columbia.edu)

## Anatomic Basis for TAR

The transversus abdominis (TA) muscle is the ideal target for posterior component separation due to its distinctive anatomy and function. Opposed to what has been the traditional anatomic description of the TA (Fig. 18.1), the muscular portion of the TA extends medially beyond the linea semilunaris in the upper third of the abdomen and inserts in the edge of the costal margin and xiphoid process. In the lower part of the abdomen, most of the TA medial to the linea semilunaris will be aponeurotic with almost no muscle fibers. This unique feature allows the surgeon to safely divide the TA and perform retromuscular dissection without injuring the rectus muscle neurovascular bundles.

The horizontal fibers of the TA help maintain intra-abdominal pressure and contribute to the tone of the lateral abdominal wall. Division of the TA releases some of the circumferential tension on the abdominal wall, but complete lateral retromuscular dissection after TA division is the key step that permits dissociation of the anterior fascia from the remaining posterior fascia. Our study in cadavers shows that the end result of these maneuvers is approximately 10 cm of myofascial advancement for the anterior sheath and just over 11 cm for the posterior layer. This advancement for both layers allows restoration of linea alba plus giant reinforcement of the visceral sac [6].



**Fig. 18.1** Transversus abdominis muscular and aponeurotic extension medial to the semilunar line

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## Indications

The most common scenario for TAR is large midline defects ( $\sim 10$  cm), but it has shown to be very useful in complex locations such as subcostal, subxiphoid, flank, parastomal, suprapubic, and donor site hernias after flap-based (TRAM) breast reconstruction [7, 8]. With the introduction of minimally invasive techniques for TAR [9], our current practice is to offer an open approach to patients with a predicted hostile abdomen and contaminated scenarios and those who require removal of mesh or large soft tissue excision and also for very large defects ( $>20$  cm).

Although there are no absolute contraindications for TAR, patients with previous preperitoneal/retromuscular repair and those with history of severe necrotizing pancreatitis can be particularly challenging. TAR has been described as an option for recurrences after anterior component separation techniques [10], but it should not be performed simultaneously with anterior component separation as this would create lateral abdominal wall instability and bulging.

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## Preoperative Considerations

We require all patients to have non-contrast-enhanced abdomen and pelvis CT to identify and outline every abdominal wall defect, to define intra-abdominal anatomy, and to reveal occult intra-abdominal pathology. Preoperative optimization according to our enhanced recovery pathway for ventral hernia repair (Table 18.1) has proven to be invaluable to maximize surgical outcomes [11]. As long as the patient does not develop obstruction or other indication of emergent repair, elective cases are delayed until preoperative optimization goals are met.

Smoking cessation for at least 4 weeks is mandatory, and patients with recent tobacco use are tested before the operation. Diabetes control needs to be optimized ( $\text{HbA1c} < 7.5\%$ ), and patients are selectively screened for obstructive sleep apnea. All patients undergo nasal swab screening for MRSA and routinely receive decolonization with mupirocin ointment the night before surgery.

Nutritional counseling includes preoperative weight loss for all obese patients, but in our practice a BMI of  $45 \text{ kg/m}^2$  is considered as the upper limit for elective abdominal wall reconstruction. All patients are given arginine/ornithine and omega-3 supplementation drinks three times per day for 5 days before the day of operation. This strategy has been shown to improve healing and minimize wound complications.

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## Technical Aspects

The patient is placed in supine position. The abdomen is prepped from the nipples to mid-thigh and laterally to the posterior axillary lines.

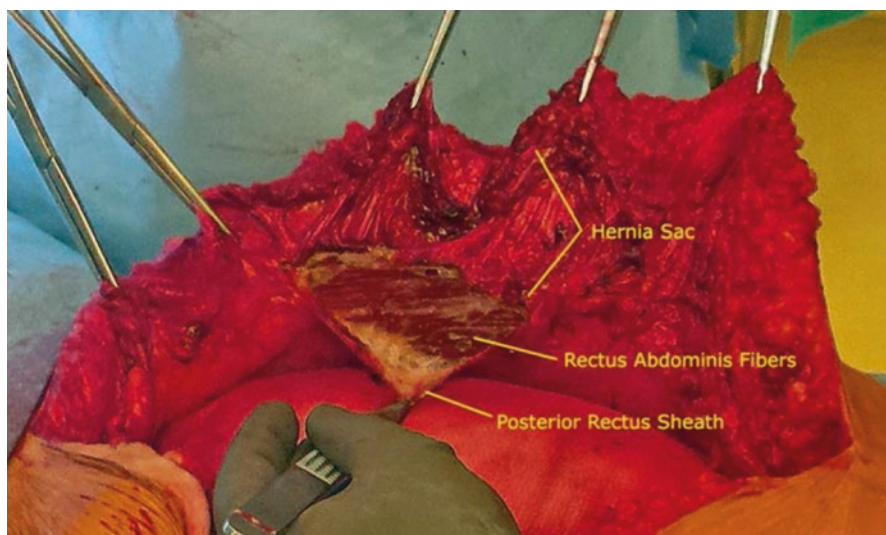
*Incision:* Unless additional soft tissue resection is planned, most cases will be addressed through a midline laparotomy. After careful access to the abdominal

**Table 18.1** Enhanced recovery after surgery pathway for ventral hernia repair

<b>Preoperative</b>	Weight loss counseling
	Diabetic control (HbA1C < 8%)
	Smoking cessation ( $\geq 4$ week)
	OSA screening
	IMPACT preoperative nutrition shake
	MRSA screening
<b>Perioperative</b>	SQ Heparin 5000 $\times$ 1 dose + SCDs
	po Alvimopan 12 mg $\times$ 1 dose
	po Gabapentin 100–300 mg $\times$ 1 dose
	First-generation cephalosporin + vancomycin for positive MRSA screen
<b>Intraoperative</b>	
<i>Pain control</i>	Minimization of narcotics/paralytics
	Intraoperative TAP block: 20 mL liposomal bupivacaine diluted to 200 mL (100 mL per side)
<b>Postoperative</b>	
<i>Pain control</i>	IV Hydromorphone PCA: 0.2 mg q 6–10 min, no breakthrough dose; no basal rate; stopped on POD 2 once on clears
	po Oxycodone 5–10 mg q 4 h PRN started once off IV PCA
	po Acetaminophen 650 mg q 6 h scheduled started immediately post-op
	po Gabapentin 100–300 mg tid started on POD 1
	IV/po Diazepam 5 mg q 6 h PRN: 2.5 mg dose for patients >65 years old; hold for OSA patients, sedation, or any respiratory compromise
	po NSAIDs 600–800 mg po q 6–8 h PRN: hold for renal dysfunction; can use IV Toradol 15–30 mg q 6 h
<i>Intestinal recovery</i>	No routine nasogastric tube placement
	NPO except meds on operative day only
	Scheduled diet advancement: POD 1, limited clears (<250 mL/shift); POD 2, clear liquids ad lib; POD 3, regular diet
	po Alvimopan 12 mg bid until discharge or POD 7
<i>Fluids</i>	Fluid conservative strategy: LR at 100 mL/h on operative day; D5 $\frac{1}{2}$ NS at 75 mL/h on POD 1; heplock IVF on POD 2

cavity is obtained, complete lysis of adhesions from the anterior abdominal wall is obtained to protect the viscera during the release and to facilitate medialization of the posterior components. Meticulous dissection is required to avoid injury to the bowel and preserve the peritoneum as much as possible. Interloop intestinal adhesions are selectively lysed in patients with a history of obstructive symptoms. The falciform ligament is routinely freed in proximity to the liver to keep it in continuity with the posterior layers while allowing for placement of a towel that will protect the entire visceral contents extending from the hiatus to the pelvis and laterally to the gutters.

*Retrorectus dissection:* An incision is created in the posterior rectus sheath close to its medial edge. It is critical that the fibers of rectus abdominis are clearly visualized to avoid mistakenly entering the subcutaneous plane (Fig. 18.2). The retromuscular plane is then developed toward the linea semilunaris with constant traction on the anterior fascia using Kocher clamps or Richardson retractors under the rectus

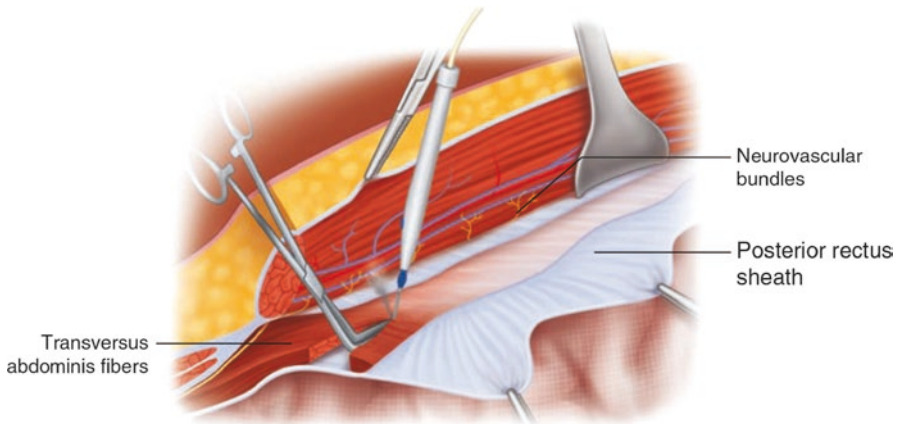


**Fig. 18.2** Incision of the posterior rectus sheet in its medial-most portion. The correct location can be confirmed by visualizing fibers of the rectus muscle

muscle, combined with countertraction with multiple Allis clamps on the medial edge of the posterior layer. The plane can be dissected using blunt instruments in combination with monopolar energy to divide the fine areolar tissue and small perforating branches of the epigastric artery. The lateral limit of this mobilization is the perforators to the rectus muscle just medial to linea semilunaris. The retrorectus plane is extended cephalad toward the costal margin while preserving the attachments of the falciform ligament to the posterior rectus sheath, as they will be useful for closure of the posterior layers.

Caudally, 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, the preperitoneal plane must be entered to allow dissection to the space of Retzius and exposure of the pubis symphysis and Cooper's ligaments. True access to the preperitoneal plane at this level will facilitate dissection and prevent injury to the epigastric vessels.

*Division of the TA:* Once the limits of the traditional Rives-Stopppa repair have been reached, the division of the transversus abdominis and subsequent posterior component separation are undertaken. Our preferred area to expose the TA is the upper abdomen, where the posterior rectus sheath will be incised just medially to the perforating neurovascular bundles to identify the underlying fibers of the TA. If this incision is created too medially, the muscle fibers may be difficult to visualize, and peritoneum may be cut. Similarly, if this step is done in the lower abdomen, the muscular portion of the TA is more lateralized in those areas and, as a result, more difficult to identify properly. 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. 18.3** Division of the transversus abdominis muscle fibers is performed medial to the neurovascular bundles to the rectus muscle

The division of the TA muscle itself is then undertaken (Fig. 18.3), ideally starting in the upper third of the abdomen where medial fibers of the transversus abdominis muscle are easiest to identify and separate from the underlying transversalis fascia. The use of a right-angled dissector helps to avoid penetrating the underlying transversalis fascia and peritoneum. This release allows entrance to the space between the transversalis fascia and the divided transversus abdominis muscle (pre-transversalis plane).

*Lateral dissection:* After division of the TA, the plane deep to it is developed in the medial to lateral direction. We usually accomplish this by providing traction on the TA with a right-angled dissector, countertraction in the posterior layer with Allis clamps and gentle use of the Kittner dissector. Bleeding at this point should alert to the possibility of erroneous entry into the intramuscular plane, and it should be noted that the correct retromuscular plane is posterior to the ribs. If fenestrations occur, they can be sutured with 2-0 Vicryl running or figure-of-eight sutures. This is done in the transverse direction to avoid tension on the suture lines.

The transition from the pre-transversalis/preperitoneal plane into the retroperitoneum is often defined by visualization of retroperitoneal fatty tissue. The lateral edge of the psoas muscle is used as safety landmark for the lateral extent of the retroperitoneal dissection. A transversus abdominis plane (TAP) block is performed during TAR by directly accessing the TAP plane through the cut edge of the transversus abdominis muscle to improve pain control, reduce narcotic use, and shorten hospital stay [12].

*Inferior dissection:* After exposure of Cooper's ligaments and pubis, the dissection is extended laterally across the entire myopectineal orifice. In women, the round ligament is divided routinely. In men, the spermatic cord is identified and separated from the peritoneum in a fashion similar to a laparoscopic inguinal hernia repair.

If inguinal or femoral hernias were identified, the dissection can be extended to expose at least 5 cm of the distal psoas muscle with subsequent prosthetic coverage of the myopectineal orifice. For this step, our preference is to use a separate preformed synthetic mesh with no fixation.

*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 for hernias that extend superiorly. This step is easier after dissection is completed on both sides.

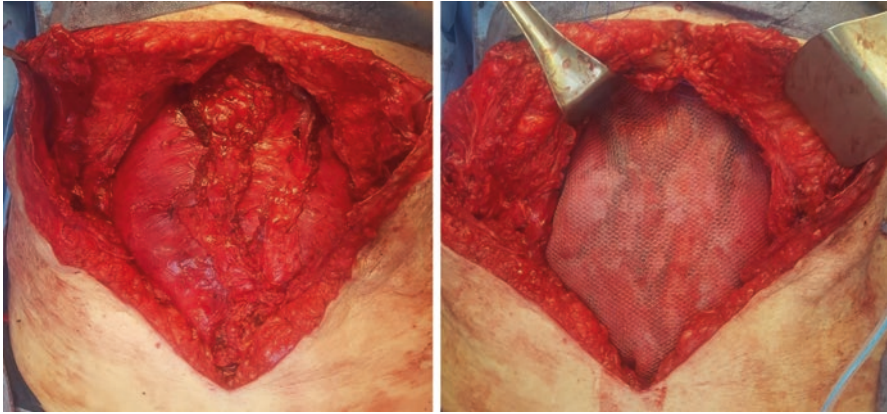
To prevent recurrent herniation off the superior edge of the dissection, the linea alba is maintained in continuity ventral to the mesh for at least 5 cm by dividing the insertion of the posterior rectus sheaths into the linea alba. This is accomplished by cutting the insertion of each posterior sheath in the cranial direction about 0.5 cm lateral to the linea alba with subsequent reconnection of the plane between posterior rectus sheath, preperitoneal space, and posterior rectus sheath. These planes can be easily connected using a cutting lineal stapler being careful not to staple the linea alba itself.

For the majority of mid and upper abdominal defects, cephalad dissection to the retrosternal space is critical to minimize superior/subxiphoid recurrences. First, the linea alba is divided to the xiphoid process, and then, posterior insertion of the posterior rectus sheath into the xiphoid process is also incised. 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 followed by complete division of the uppermost fibers of the transversus abdominis muscle just off the lateral edge of the xiphoid, making sure not to create an iatrogenic Morgagni hernia by injuring diaphragm fibers. In order to provide adequate mesh overlap, the retromuscular plane can be extended to expose the upper aspect of the central tendon of the diaphragm.

*Closure of posterior layers:* This step is critical to avoid visceral contact with the mesh and to prevent intraparietal herniation. Reapproximation of posterior rectus sheaths is performed from the cephalad and caudal ends separately with running 2-0 Vicryl or PDS suture. In rare circumstances, this will not be possible and buttressing with omentum, Vicryl or biologic mesh can be done. The countable towel is removed shortly before completing the posterior layer closure. The intraperitoneal contents will be isolated afterward.

We routinely irrigate the visceral sac with approximately two liters of saline in all clean cases. Antibiotic pressurized pulse lavage significantly reduces the bioburden, and it is our preference in clean-contaminated and contaminated cases since it could potentially prevent prosthetic contamination [13].

*Mesh placement:* The mesh is placed in the retromuscular space based on the principle of “giant reinforcement of the visceral sac” (Fig. 18.4). For hernias that extend inferiorly, we secure the mesh to the Cooper’s ligaments to ensure mesh overlap in the retropubic space. This is typically done with one interrupted suture on each of the Cooper’s ligament, passing the tail through the mesh so that the knots will be tied at the dorsal surface of the mesh. Superiorly, the mesh could be secured



**Fig. 18.4** Closure of the posterior layer and mesh implantation to obtain giant reinforcement of the visceral sac

with interrupted sutures around the xiphoid process and 4–5 cm off the edge of the mesh to provide with large superior overlap. We minimize/avoid lateral fixation, only using it selectively for lateral defects and cases where the linea alba cannot be completely reapproximated.

The vast majority of prosthetic reinforcements in our series are done using synthetic mesh [14]. Mid-weight, macroporous polypropylene is usually preferred; reserving heavy-weight polypropylene for cases where the linea alba cannot be reapproximated and for lateral defects. We strongly discourage the use of light-weight monofilament polyester for abdominal wall reconstruction due to the potential of recurrence from central mesh failure [15]. Our experience with biologic mesh has been somewhat disappointing [16], and a recent multicenter experience demonstrated biologic mesh to be an independent predictor of wound complications and recurrences in a comparative series with matched synthetic repairs [17].

*Linea alba reconstruction:* We routinely place closed suction drains over the mesh after open TAR. The combination of muscle releases and component separation performed in this operation will allow for medial advancement of the rectus abdominis.

Linea alba reapproximation is performed with running PDS suture, with occasional use of interrupted figure-of-eight. After resection of hernia sac, redundant soft tissue, and attenuated skin, closure of superficial layers is performed with selective use of subcutaneous drains.

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## Postoperative Care

A minority of patients might experience an increase of pulmonary plateau pressure above 6 mmHg and will need to stay intubated, at least overnight. Those patients with increase in plateau airway pressures >11 mmHg are kept paralyzed for 24 h



postoperatively. Abdominal compliance usually improves within 12–24 h postoperatively, and pulmonary physiology returns to baseline allowing for safe extubation [18].

All patients are kept NPO on postoperative day 1, and diet is advanced according to the patient's status and the enhanced recovery pathway schedule (Fig. 18.1). Alvimopan is given twice a day and is stopped after the first bowel movement. Patient-controlled analgesia is maintained for the first 1–2 days with adjunctive use of oral acetaminophen and gabapentin. Drains are usually kept in place until the output is <30–50 cm<sup>3</sup> per day. Most patients will wear an abdominal binder at least during the first week.

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## Outcomes

As experience with TAR is expanding, a wealth of outcome data is now available in the literature. In a nonrandomized study published in 2012 [19], 55 cases of TAR were compared to 56 traditional anterior component separation cases looking for differences in wound morbidity and repair durability. Hernia characteristics were similar between groups, but the mean operative time was significantly reduced in the TAR group (228 min vs 285 min). Midline reapproximation was equally feasible in both groups. Wound complications were significantly reduced when TAR was the procedure of choice (25.4% vs 48.2%, *p* 0.01), and this significance remained even after adjusting for differences in demographics between groups. There appeared to be a trend for lower hernia recurrence rate in the TAR group (3.6% vs 14.3%), but this was not statistically significant (*p* 0.09). This study was able to demonstrate one of the benefits TAR, since it allows preservation of the abdominal wall blood supply by avoiding creation of the skin flaps that are typically needed in the traditional anterior component separation.

The largest experience with TAR to date was published in 2016, when 428 consecutive repairs using synthetic mesh were reported [14]. The complex hernia population that was addressed by TAR in this study included a large proportion of obese patients (68%) with a mean BMI of 34.4 kg/m<sup>2</sup> (range 20–65). Patients would frequently present with comorbidities, DM (21%), COPD (12%), and active smoking status (7%), and usually had several previous abdominal surgeries (mean 3.9, range 1–19). The majority of patients in this study had a clean wound, but clean-contaminated and contaminated scenarios were also included (28% and 8%, respectively).

Although the mean postoperative stay in this study was 6.1 days, this has been successfully reduced to 4 days after implementation of the aforementioned enhanced recovery pathway for ventral hernia. Surgical site events were present in 18.7% of cases, and although overall surgical site infection incidence was 9.1%, it was only 6.7% for clean cases. Multivariate analysis revealed age, hernia width, and wound class III to be predictors for surgical site infection. No mesh explantation was required. The most common systemic complication after TAR was UTI (6.8%), followed by DVT/PE (6.3%) and pneumonia (1.2%).

After a mean follow-up of 31.5 months, the recurrence rate was 3.7%, most of which can be attributed to central mesh failure with polyester or to herniations

outside the edges of the prosthetic reinforcement (subxiphoid, suprapubic, lateral). Among those who recurred, repair was obtained either laparoscopically (IPOM) or with an onlay technique. The favorable wound morbidity observed in this study probably highlights the benefits of using rapidly integrated macroporous polypropylene mesh in a retromuscular space that provides bilaminar fascial coverage.

A particular challenging repair is often needed in kidney transplant recipients, in whom defect size, location, presence of an allograft, and multiple comorbidities and immunosuppression are all significant obstacles for a repair. We recently reported the safety and efficacy of TAR in this special population; 11 kidney transplant recipients who underwent incisional hernia repair using this technique were analyzed, most of whom had a previous attempted repair (73%) [7]. There were two cases of superficial surgical site infection that resolved with antibiotics. One patient developed skin necrosis that required debridement. After a mean follow-up of 12 months, only one patient developed a lateral recurrence, which during revisional surgery was found to be bulging and not a true hernia. Although a biologic mesh was used in two cases, this study again demonstrated how the use of a macroporous synthetic mesh in a sublay position can be safe and effective for such unique (immunosuppressed) patient population.

Repairing incisional hernias in patients with underlying inflammatory bowel disease can be problematic, since extensive surgical history and impaired healing are almost universal in this group of patients. Our retrospective analysis of 32 patients with IBS that underwent TAR for incisional hernias [20] found that 34% of patients developed a surgical site event, while 18.4% had a surgical site infection. Nevertheless, there were no intestinal complications, and after a mean follow-up of approximately 3 years, there were only three recurrences. Therefore, TAR displayed a favorable wound morbidity and durability profile in this series of complex hernias in difficult patients.

Experience with TAR has been replicated in other centers across the USA, where a series of 37 consecutive patients was recently published [21]. Similarly, patients often had defects with several previous abdominal procedures as well as attempted repairs. Almost 90% of the patients in this series had a clean wound, and the majority of these repairs was done using synthetic mesh (81.1%). Surgical site infection occurred in 5.4% of patients, and there was only one recurrence after a mean follow-up of 21 months. Similar results have been published in the UK [22], where a series of 12 patients has found anecdotal wound morbidity and no recurrences have been observed. Introduction of TAR has ignited changing practice patterns of hernia in many centers around the world. In Mexico, Espinosa de los Monteros et al. have progressively transitioned from anterior component separation to TAR for many of their complex ventral hernia repairs [23]. Similarly, promising reports from Russia [24] and Romania [25] suggest that the technique can be reproducible.

In order to address the concerns surrounding the potential impact that releasing the transversus abdominis would have in the abdominal wall physiology, we performed a CT-based analysis of the preoperative and postoperative morphology of the abdominal wall in 25 patients who underwent TAR and 25 who had a laparoscopic ventral hernia repair without defect closure (bridged repair) [26]. Development

of compensatory hypertrophy of the rectus abdominis and both external and internal obliques was observed only in the TAR group, reinforcing the importance of reconstruction of the linea alba. It is probably the combination of a functional midline restoration and the compensatory hypertrophy that has allowed for significant improvements in postoperative abdominal wall function, as demonstrated by dynamic evaluation and quality-of-life indicators [27].

### Conclusions

The transversus abdominis release technique has found an increasing role in addressing complex ventral hernia. TAR allows reconstruction of the linea alba and creation of a large sublay plane for prosthetic reinforcement without raising lipotaneous flaps or injury to the neurovascular bundles.

Ever since its first description, data from the USA and many other countries have shown it to be a versatile, safe, and durable repair. Deep understanding of the surgical anatomy related to the abdominal wall and this procedure are paramount to prevent injury and offer a durable repair. Outcomes for elective cases can be maximized by adhering to perioperative optimization and managing patients according to our enhanced recovery pathway for ventral hernia.

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