



Assessment of myofascial medialization following posterior component separation via transversus abdominis muscle release in a cadaveric model

A. Majumder¹ · H. J. Miller¹ · L. M. del Campo¹ · H. Soltanian¹ · Y. W. Novitsky¹

Received: 10 December 2017 / Accepted: 17 April 2018 / Published online: 30 April 2018
© Springer-Verlag France SAS, part of Springer Nature 2018

Abstract

Purpose Posterior component separation (PCS) via the transversus abdominis release (TAR) procedure continues to gain popularity. However, neither the physiologic basis nor the extent of myofascial medialization after TAR is established. We aimed to assess both anterior and posterior rectus fascia (AF and PF) medialization following each step of the TAR procedure.

Methods Ten fresh cadavers underwent PCS via TAR. Steps included midline laparotomy (MLL), retrorectus dissection (RRD), incision of the posterior rectus sheath (IPL), transversus abdominis muscle division (TAD), and retromuscular dissection (RMD). Medial advancement of AF and PF was measured following application of 2.5, 5.0 lb, and maximal tension to the fascial edge. Values are represented as mean advancement past midline in centimeters.

Results MLL allowed advancement of 2.5, 3.7, and 4.9 cm. RRD provided advancement of 4.1, 5.9, and 7.6 cm for AF and 4.4, 6.2, and 7.5 cm for PF. IPL provided advancement of 4.2, 6.1, and 8.0 cm for AF and 4.6, 6.6, and 8.3 cm for PF. TAD provided advancement of 4.5, 6.6, and 8.6 cm for AF and 5.3, 7.5, and 9.5 cm for PF. RMD provided advancement of 5.5, 7.9, and 9.9 cm for AF and 6.9, 9.6, and 11.2 cm for PF. Overall, the complete TAR procedure provided AF advancement of 102% and PF advancement of 129%, over baseline.

Conclusions The TAR procedure provides for substantial medial advancement of both anterior and posterior myofascial components of the abdominal wall. Retromuscular dissection deep to the divided transversus abdominis muscle appears to be the key step of the procedure, allowing for effective reconstruction of very wide (≈ 20 cm) defects.

Keywords Ventral hernia repair · Posterior component separation · Transversus abdominis release · TAR · Cadaveric · Myofascial advancement

Introduction

Posterior component separation (PCS) via the transversus abdominis release procedure (TAR) [1] has found an increasing role in addressing large and complex hernia defects during open ventral hernia repair (VHR) [2–4]. The ability to manipulate the myofascial components of the abdominal wall has allowed surgeons to not only restore the position

of native abdominal wall via re-creation of the linea alba, but also create a large sublay space for the mesh reinforcement. The procedure itself is an extension of the original retrorectus Rives–Stoppa repair [5, 6] involving incision into the ventral aspect of the posterior rectus sheath following retrorectus dissection, thus allowing exposure of the transversus abdominis (TA) muscle and aponeurosis along with subsequent division along the length of the muscle and development of a retromuscular space.

Although the TAR procedure continues to gain widespread acceptance and utilization for a multitude of clinical scenarios, the exact physiologic basis of how myofascial advancement occurs and objective amounts of advancement has not been well elucidated. Given the TAR procedure provides the ability to medialize both anterior and posterior fascial components, we aimed to gain understanding on how much medialization is offered with each step. Our

Presented at: The 102nd American College of Surgeons Clinical Congress, October 2016, Washington, D.C.

✉ A. Majumder
arnab.uhhs@gmail.com

¹ Department of Surgery, University Hospitals Cleveland Medical Center, 11100 Euclid Avenue, Cleveland, OH 44106, USA

study was conceived with inspiration from the seminal paper by Ramirez et al. [7], studying anterior component separation in a cadaveric model. Similarly, we utilized a fresh cadaveric model to simulate the TAR procedure. Technical enhancements in our model allow for reliable and reproducible measurements. Our aim was to objectively evaluate the TAR procedure to delineate the physiologic basis of each step in the release as well as quantitative measurements of the myofascial medialization offered.

Methods

After obtaining IRB exemption for our study, we obtained ten fresh cadaveric torsos for testing (Anatomy Gifts Registry, Hanover, MD and UT Southwestern Medical Center, Dallas, TX). All cadavers had a BMI of 25–35, with no prior midline hernia defects and no prior midline laparotomy. Hereafter, we describe our novel apparatus which allowed for completion of each step of a complete posterior component separation via the TAR procedure while measuring advancement at each step reliably and without damage to the fascia.

Measurement apparatus

We constructed an apparatus consisting of two straight metal rods (0.5" diameter) attached to the bed rails of a standard operating table with clamps. A cross rod was attached to each upright rod via right angle clamps. The cross bar was positioned parallel to the torso and so that it would extend along the length of the abdominal wall (Fig. 1). A single 1" pulley was suspended from the cross bar with fine gauge metal wire suspended across the pulley. The wire was attached to a straight metal bar (1.5"×8") with evenly spaced holes on one end and to a hook on the opposite end for attaching weight (Fig. 2). The straight bar on the end of the wire was attached to the Kocher or towel clamps with 'S' hooks spaced evenly along the midline with upper, middle, and lower attachment points along the fascia to allow for even application of tension, as well as allow for isolation of upper, middle, and lower abdominal segments (Fig. 3).

Myofascial advancement was measured by application of 2.5 and 5.0 lb. of weight to the wire of the apparatus while connected to the fascia (Fig. 4). Additionally, maximal advancement was measured, defined as the point at which no further fascial advancement occurred with increased force applied to the fascia, or with any tearing/disruption of the fascia due to increased force. Measurements of fascial advancements were taken by noting the position of the wire at the vertical junction with the pulley with fine hemostats. The difference in position of each hemostat was measured as a direct 1:1 corollary of fascial advancement as tension was

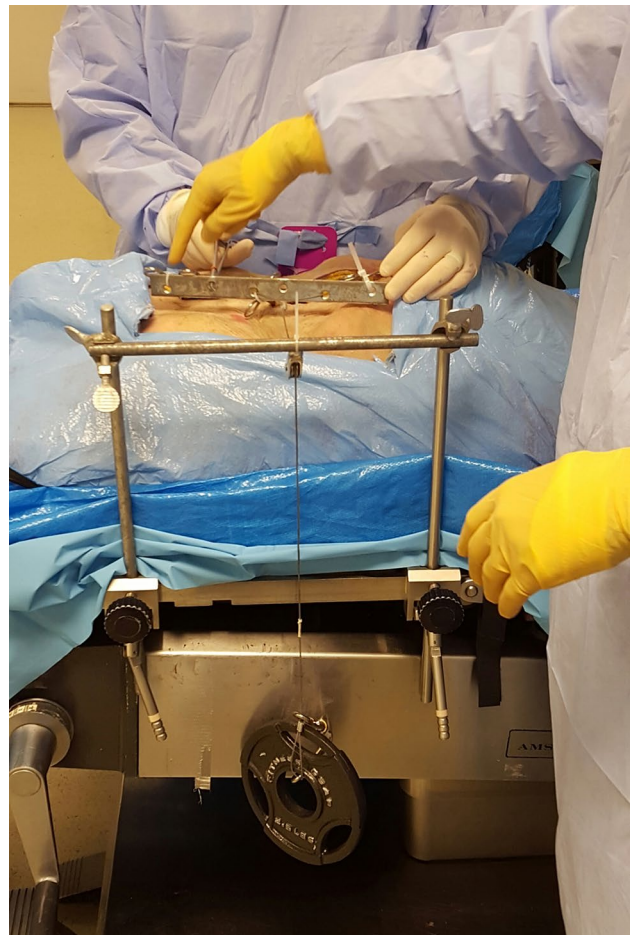


Fig. 1 Complete apparatus with pulley suspended at the level of the fascia from the cross bar, weight is applied to the fascia below

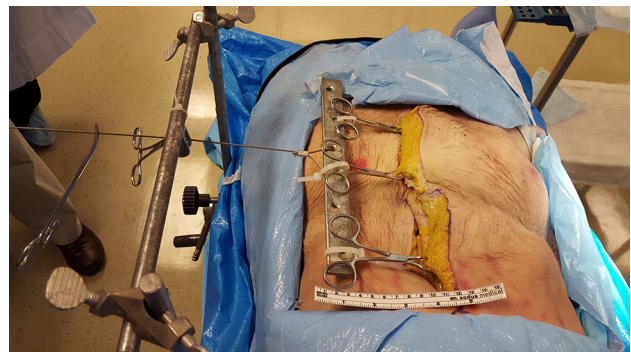


Fig. 2 View of the pulley apparatus attached to the anterior fascia following midline laparotomy with towel clamps via metal bar with evenly spaced holes

applied (Fig. 5). This eschewed more unreliable methods of measurement such as marking midline with a drawn line or suspended string, or by comparing the edge of fascia to a grid overlay.

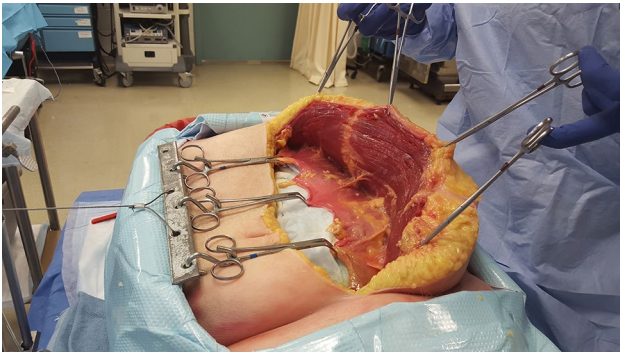


Fig. 3 Towel clamps attached to the fascia and to the cross bar with S-hooks at upper, middle, and lower abdominal segments

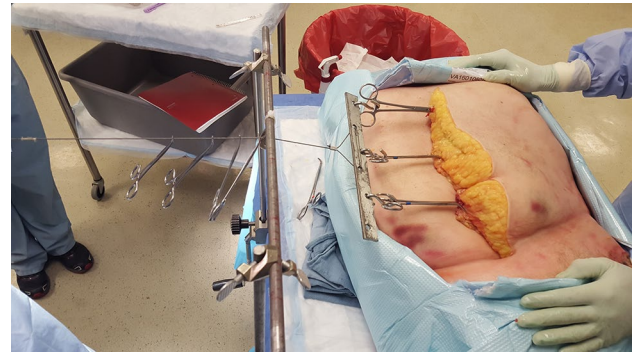


Fig. 5 Hemostats applied to the wire at each step (baseline, 2.5, 5.0 lb, and maximum tension). Difference in positions is the measured fascial advancement from baseline

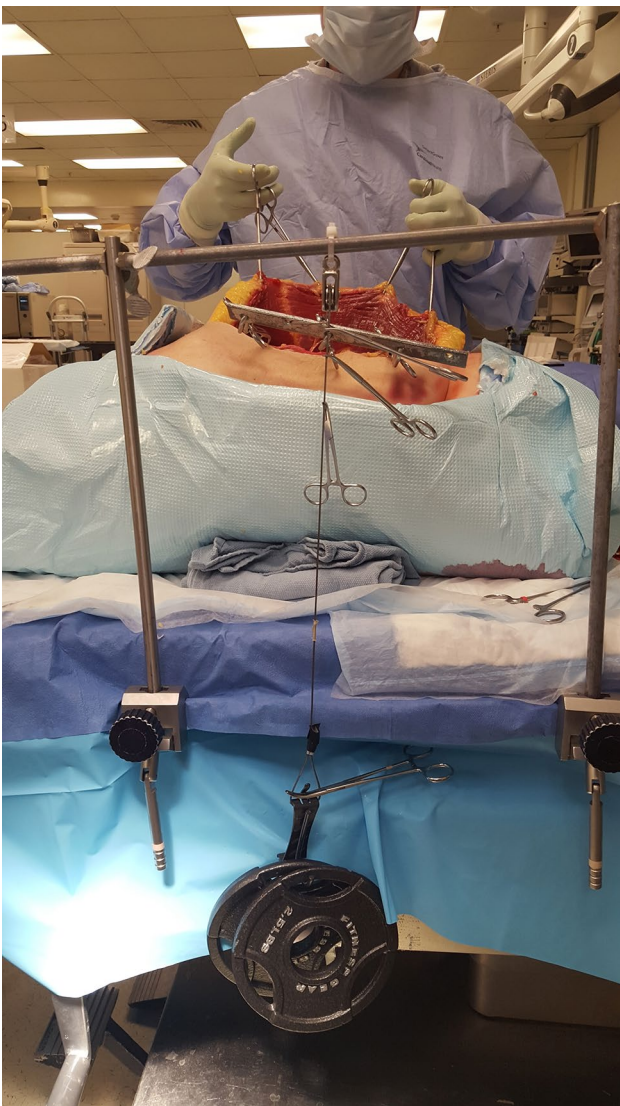


Fig. 4 Weight (5.0 lb) attached to the fascia with advancement measured with hemostats

Measurements of fascia were taken as the whole unit with all three clamps attached to the length of the fascia and then segmentally with single clamps attached to the middle of the cross bar for the upper, middle, and lower attachment points individually. All measurements were taken for each cadaver separately and data were compiled in aggregate. The values are presented as a mean advancement along with standard deviation at each step. Of note each step includes the advancement obtained from the previous step and are not incremental increases but rather aggregate ones.

Procedure

We began with a midline laparotomy (MLL) and measurement of baseline myofascial advancement. Functionally this was a measurement of fascial elasticity rather than true advancement. Following MLL we proceeded with retrorectus dissection (RRD) as during a Rives–Stoppa ventral hernia repair. This involved incision into the posterior rectus sheath approximately 1 cm from the medial edge of the rectus muscle, which was then carried along the length of the entire abdominal wall. The retrorectus plane was then developed towards the linea semilunaris, ending just medial to the perforators to the rectus abdominis (Fig. 6). Once complete, we incised the ventral aspect of the posterior rectus sheath, specifically the posterior lamina of the internal oblique aponeurosis (IPL), exposing the underlying transversus abdominis muscle and aponeurosis (Fig. 7). The following step, transversus abdominis division (TAD) involved isolation and division of the exposed transversus abdominis fibers following IPL, however the muscle was not fully release from the underlying transversalis fascia/peritoneum (Fig. 8). The final step was retromuscular dissection (RMD), which involved developing the plane deep to the transversus abdominis from the underlying transversalis fascia and peritoneum beginning lateral to the point of division in the previous step, thus resulting in complete separation of anterior and posterior fascial components (Fig. 9). Myofascial

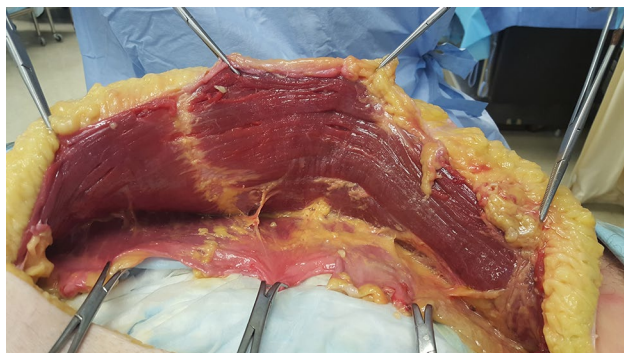


Fig. 6 Completed retrorectus dissection in fresh cadaver



Fig. 7 Posterior lamina of internal oblique (ventral aspect of posterior rectus sheath) is incised following retrorectus dissection

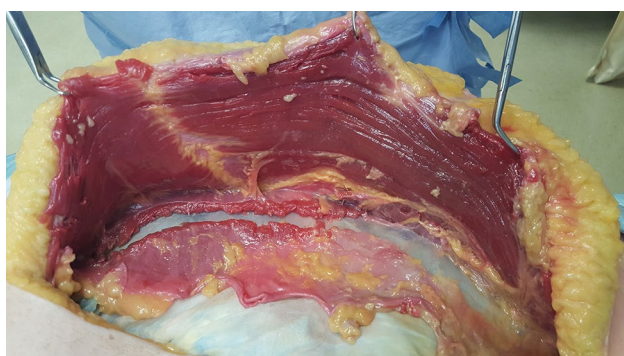


Fig. 8 Complete division of the transversus abdominis muscle along its length

advancement was measured after each step including upper, middle, and lower regions of the abdomen.

Results

Fascial advancement following MLL alone, with an average of 2.5 ± 0.2 , 3.7 ± 0.9 , and 4.9 ± 0.8 cm of medial myofascial advancement with application of 2.5, 5.0 lb, and maximal



Fig. 9 Retromuscular dissection of transversus abdominis muscle from underlying peritoneum/transversalis fascia

tension, respectively. This represents a baseline not recorded in previous experiments but establishes a baseline for both anterior and posterior fascia for comparison as the TAR procedure is carried out. All values are subsequently represented are for 2.5, 5.0 lb, and maximal tension, respectively.

Anterior fascia

Following RRD we obtained 4.1 ± 0.8 , 5.9 ± 1.3 , and 7.6 ± 1.1 cm of medial advancement for the anterior fascia. With IPL, we saw a small incremental increase of 0.1, 0.2, and 0.4 cm to 4.2 ± 0.9 , 6.1 ± 1.1 , and 8.0 ± 1.2 cm of advancement. TAD offered incrementally more (0.3, 0.5, and 0.6 cm) advancement of 4.5 ± 0.9 , 6.6 ± 1.2 , and 8.6 ± 1.4 cm. Finally, RMD offered the largest incremental increase (1.0, 1.3, and 1.3 cm) to 5.5 ± 0.7 , 7.9 ± 1.0 cm, and a maximum of 9.9 ± 1.5 cm of myofascial advancement (Table 1). The range of maximal anterior fascial advancement following completed TAR was 8.0–12.3 cm across cadavers. The average maximum anterior myofascial advancement following each step of the TAR procedure is shown in Fig. 10.

Ultimately compared to midline laparotomy, RRD resulted in a 55% maximal increase for anterior fascial medialization compared to 63% (+8% from RRD) for IPL, 76% (+13% from IPL) for TAD, and a maximum of 102% (+26% from TAD) following RMD and the completed TAR procedure.

Measurement of anterior myofascial advancement following the completed TAR procedure for upper, middle, and lower segments are as follows. For the upper segment, final advancement after RMD (completed TAR) demonstrated 5.0 ± 0.8 , 6.4 ± 0.9 , and 7.9 ± 1.3 cm of anterior advancement. For the middle segment, following RMD, we obtained 6.7 ± 1.4 , 9.2 ± 1.2 , and 11.0 cm of advancement. And in the lower segment, we found 5.9 ± 1.3 , 7.8 ± 1.3 , and 9.0 ± 1.7 cm of anterior advancement.

Table 1 Anterior fascial advancement (mean ± standard deviation)

Operative step	2.5 lb	5.0 lb	Max
Midline laparotomy (MLL) (cm)	2.5 ± 0.2	3.7 ± 0.9	4.9 ± 0.8
Retrorectus dissection (RRD) (cm)	4.1 ± 0.8	5.9 ± 1.3	7.6 ± 1.1
Incision of posterior lamella of IO (IPL) (cm)	4.2 ± 0.9	6.1 ± 1.1	8.0 ± 1.2
TA muscle division (TAD) (cm)	4.5 ± 0.9	6.6 ± 1.2	8.6 ± 1.4
Retromuscular dissection (RMD) (cm)	5.5 ± 0.7	7.9 ± 1.0	9.9 ± 1.5

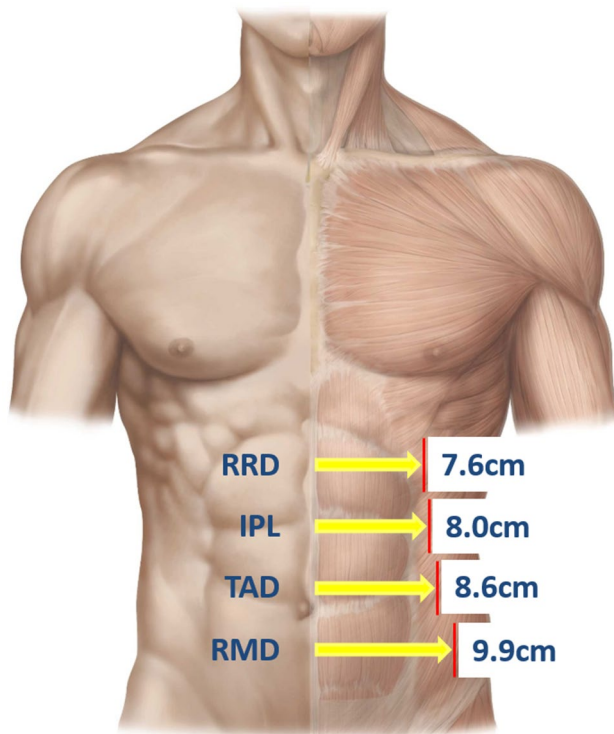


Fig. 10 Anterior fascial advancement following each step of the TAR procedure

Posterior fascia

Similar to the trends seen for anterior fascia, RRD provided 4.4 ± 0.9, 6.2 ± 1.1, and 7.5 ± 1.8 cm of advancement for the posterior fascia. IPL demonstrated a similar small incremental advantage of +0.2, +0.4, and +0.8 cm to 4.6 ± 1.2, 6.6 ± 1.5, and 8.3 ± 1.9 cm of advancement. TAD again provided an incrementally larger (+0.7, +0.9, and +1.2 cm)

Table 2 Posterior fascial advancement (mean ± standard deviation)

Operative step	2.5 lb	5.0 lb	Max
Midline laparotomy (MLL) (cm)	2.5 ± 0.2	3.7 ± 0.9	4.9 ± 0.8
Retrorectus dissection (RRD) (cm)	4.4 ± 0.9	6.2 ± 1.1	7.5 ± 1.8
Incision of posterior lamella of IO (IPL) (cm)	4.6 ± 1.2	6.6 ± 1.5	8.3 ± 1.9
TA muscle division (TAD) (cm)	5.3 ± 1.5	7.5 ± 1.8	9.5 ± 2.2
Retromuscular dissection (RMD) (cm)	6.9 ± 1.8	9.6 ± 2.0	11.2 ± 2.7

increase to 5.3 ± 1.5, 7.5 ± 1.8, and 9.5 ± 2.2 cm of maximal advancement. Finally, the largest incremental increase (+1.6, +2.1, and +1.7 cm) was seen with RMD with a 6.9 ± 1.8, 9.6 ± 2.0, and 11.2 ± 2.7 cm of myofascial medialization (Table 2). The range of maximal posterior fascial advancement following completed TAR was 9.1–15.0 cm across cadavers. The average maximum posterior fascial advancement following each step of the TAR procedure is shown in Fig. 11.

Compared to midline laparotomy, RRD resulted in a 53% maximal increase for posterior fascial medialization compared to 69% (+16% from RRD) for IPL, 94% (+25% from IPL) for TAD, and a maximum of 129% (+35% from TAD) following RMD and the completed TAR procedure.

Similar to the anterior fascia, we documented posterior myofascial advancement following completion of the TAR procedure for upper, middle, and lower segments. In the upper segment, we demonstrated 8.1 ± 2.3, 10.1 ± 2.1, and 11.1 ± 2.6 cm of anterior advancement after RMD (completed TAR). The middle segment evidenced 10.7 ± 2.0, 12.8 ± 1.6, and 14.0 ± 1.7 cm of posterior advancement. Finally, for the lower segment, we found 9.4 ± 1.8, 11.5 ± 1.9, and 12.3 ± 2.0 cm of posterior sheath advancement.

Discussion

The use of posterior component separation via the transversus abdominis release procedure has been increasingly utilized to provide myofascial advancement and wide sublay space for mesh placement during complex open ventral hernia repair [2, 8–11]. Despite the trend in utilization of this technique, the mechanism by which it provides myofascial advancement is poorly understood. A clearer grasp of how the fascial components of the abdominal wall contribute to

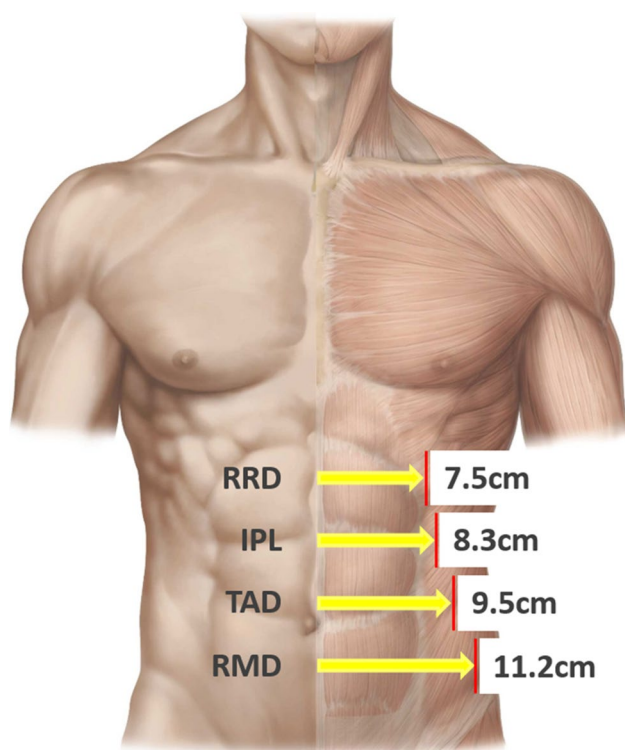


Fig. 11 Posterior fascial advancement following each step of the TAR procedure

the tone of the abdomen allows surgeons insight on how best to manipulate these anatomic structures to provide the most ideal hernia repair. The importance of such findings becomes abundantly clear when considering that the goal of functional and restorative hernia repair remains fascial closure, more specifically restoration of the linea alba. To facilitate this, the TAR procedure consists of a series of operative maneuvers beginning from laparotomy to eventual division and reflection of the transversus abdominis muscle off the underlying peritoneum/transversalis fascia, to provide this medial myofascial advancement. Our study reveals that although midline laparotomy followed by a retrorectus dissection alone provide a large amount of initial medialization, the critical step in the TAR procedure is extensive retromuscular dissection into the lateral retroperitoneum following division of the transversus abdominis muscle allowing for upwards to 10 cm of myofascial medialization.

At the outset, we demonstrate that midline laparotomy (MLL) itself allows for approximately 5 cm of maximal advancement beyond midline. Although surprising, it is important to note that with minimal tension applied (2.5 lb) this value drops by 50% to only 2.5 cm. However, the 5 cm value should be interpreted with caution, as this amount of advancement required a high degree of force applied to the fascia, effectively contradicting the principles of ‘tension-free’ hernia repair. Of note, during the initial conception of

our study we had intended to measure this maximal tension objectively, however due to the difficulty in obtaining reliable Newton measurements for force, this was eschewed. Interestingly, however, the finding of 2.5 cm of fascial advancement after MLL with minimal tension indicates that approximately 5 cm wide hernias could be amenable to repairs without any component separation.

In analyzing the steps of the TAR procedure, we demonstrated increasing incremental advancement beginning with retrorectus dissection (RRD) and ending with retromuscular dissection (RMD). RMD proved to be the most important of the steps, providing a maximum 102% increase in myofascial advancement for the anterior fascia and 129% for the posterior fascia. Incrementally, RMD also provided the largest progressive increase of 26% for anterior fascia and 35% for posterior fascia when comparing each step to the one prior. Although incision of the posterior lamina of internal oblique and transversus abdominis division both serve to release some of the circumferential ‘hoop’ tension generated by the transversus abdominis muscle, each provided only incremental advancement. In other words, without RMD the full potential of this maneuver is not realized. Following TAD, the muscle is completely free from its medial insertion, however it remains in intimate contact with both the overlying internal and external oblique muscle along with the underlying transversalis fascia and peritoneum. Thus, until this retromuscular separation occurs, the transversus muscle is not truly released and continues to provide some circumferential tension on the anterior fascia via its interaction with the underlying layers. Thus, beyond doubt, the RMD remains the critical step in the TAR procedure and our data provide confirmation of this key concept.

Objective measurements of medialization showed approximately 10 cm of myofascial advancement for the anterior sheath and just over 11 cm for the posterior sheath. Interestingly, both the maximal values and standard deviation seen in posterior sheath advancement was larger than that seen in the anterior sheath. This may be reflected in the fact that the portion of the posterior sheath lateral to the division of TAM consists only of peritoneum and transversalis fascia, whereas the anterior sheath effectively consists of the remaining components of the abdominal wall. The elasticity of the posterior layers likely allowed for further medialization and a wider range of values seen. Indeed, in a single cadaver we saw a maximum of 15 cm of posterior sheath advancement. This advancement is critical when considering the importance of recreating the visceral sac. Such large posterior sheath advancement allows for exclusion of the peritoneal contents from contact with mesh placed as a sublay, especially without the need for bridging meshes. Ultimately, the added mobility of the posterior sheath offered by TAR is an important finding. Resultant complete restoration of the visceral sac allows for its reinforcement with a giant

synthetic mesh without concerns for mesh contact with the abdominal viscera.

Clinically however, the mobility of the posterior sheath is ultimately less consequential, as anterior fascial closure remains the goal of reconstructive hernia repair. Interestingly, although RRD offered up to 7.5 cm of advancement implying the ability to close defects up to 15 cm, we do not advocate such narrow mesh overlap, effectively confined to the rectus sheath, in patients with such wide defects. Our data suggest that substantial advancement is obtained from RRD alone, and thus Rives–Stoppa remains an important tool in the technical armamentarium of hernia surgeons. Importantly however, the completed TAR procedure allows anterior myofascial advancement of approximately 10 cm per side which should allow for closure of defects up to 20 cm wide. Large published series, including those from our group, have indeed demonstrated the ability to close defects 20 cm wide and as large as 36 cm [8, 9, 12]. We believe the ability to create complete dissociation of the anterior fascia from the remaining posterior fascia following TAD limits the lateral tension experienced by the anterior fascia from the TAM in its native position. As stated before, RMD serves dual functions with the primary being myofascial advancement, but also creating a well vascularized bilaminar plane for mesh placement. Although beyond the scope of this paper, the benefit of sublay positioning of mesh offered by TAR has been well studied [8, 12, 13]. In light of these findings, when choosing a reconstructive technique for large ventral hernias with associated loss of domain, the TAR procedure remains an effective option both in terms of tissue advancement and optimal space for mesh placement.

Despite the benefits in simulating operative conditions in our novel cadaveric model, certain limitations are certainly important to acknowledge. The use of cadavers, although fresh, ultimately cannot replicate the true character of live, perfused tissues in a patient. Thus, while the trends noted in myofascial release at each step may be valid, the absolute numerical values of medialization should be interpreted with caution. Secondly, the cadavers used in this model did not have hernias. Given the scarcity of fresh cadavers without prior midline laparotomy, attempting to source those with hernias would effectively be prohibitive to carrying out the study in a timely manner. Additionally, attempts to standardize hernia widths if such cadavers could be obtained would further increase the constraints on available specimens. Due to these limitations, we elected to utilize cadavers without hernias knowing that the absolute numbers again, may not be reflective of those encountered in patients with hernia defects. Finally, although we intended to measure the actual force required for ‘maximal’ tension to obtain the advancement seen, we were unable to reliably measure this. This may be an opportunity for further investigation building on the foundations of this model.

Conclusions

Posterior component separation via the TAR procedure provides a substantial amount of medial advancement of both anterior and posterior myofascial components of the abdominal wall. The critical step in providing this advancement is retromuscular dissection deep to the transversus abdominis muscle following its division. In our cadaveric model at the end of the TAR, over 11 cm of posterior sheath advancement is obtained allowing for restoration of the visceral sac. Additionally, 10 cm of medial advancement is seen for the anterior myofascial component allowing for reconstruction of linea alba for defects as wide as 20 cm along with providing a large sublay space for mesh reinforcement. Our experiments confirm the suitability of the TAR procedure for reliable abdominal wall reconstructions of very large defects.

Funding No external funding was used for this study.

Compliance with ethical standards

Conflict of interest AM, HJM, LMD, and HS declare no conflict of interest. YWN declares conflict of interest (consultant for C.R. Bard, Inc, Intuitive Surgical, and Cooper Surgical, Inc.) not directly related to the submitted work.

Ethical approval Ethical approval was also exempt as this again was a non-living tissue study.

Human and animal rights This study was IRB exempt as it was with non-living tissue.

Informed consent No consent was needed as the cadavers had consented to tissue donation for their respective provides.

References

1. Novitsky YW, Elliott HL, Orenstein SB, Rosen MJ (2012) Transversus abdominis muscle release: a novel approach to posterior component separation during complex abdominal wall reconstruction. *Am J Surg* 204:709–716. <https://doi.org/10.1016/j.amjsurg.2012.02.008>
2. Jones CM, Winder JS, Potochny JD, Pauli EM (2016) Posterior component separation with transversus abdominis release. *Plast Reconstr Surg* 137:636–646. <https://doi.org/10.1097/01.prs.0000475778.45783.e2>
3. Petro CC, Orenstein SB, Criss CN et al (2015) Transversus abdominis muscle release for repair of complex incisional hernias in kidney transplant recipients. *Am J Surg*. <https://doi.org/10.1016/j.amjsurg.2014.08.043>
4. Petro CC, Como JJ, Yee S et al (2015) Posterior component separation and transversus abdominis muscle release for complex incisional hernia repair in patients with a history of an open abdomen. *J Trauma Acute Care Surg* 78:422–429. <https://doi.org/10.1097/TA.0000000000000495>
5. Stoppa R, Petit J, Abourachid H et al (1973) Original procedure of groin hernia repair: interposition without fixation of Dacron

- tulle prosthesis by subperitoneal median approach. *Chirurgie* 99:119–123
6. Rives J, Pire JC, Flament JB et al (1985) Treatment of large eventrations. New therapeutic indications apropos of 322 cases. *Chirurgie* 111:215–225
 7. Ramirez OM, Ruas E, Dellon AL (1990) “Components separation” method for closure of abdominal-wall defects: an anatomic and clinical study. *Plast Reconstr Surg* 86:519–526
 8. Novitsky YW, Fayeziadeh M, Majumder A et al (2016) Outcomes of posterior component separation with transversus abdominis muscle release and synthetic mesh sublay reinforcement. *Ann Surg*. <https://doi.org/10.1097/SLA.0000000000001673>
 9. Appleton ND, Anderson KD, Hancock K, Scott MH, Walsh CJ (2016) Initial UK experience with transversus abdominis muscle release for posterior components separation in abdominal wall reconstruction of large or complex ventral hernias: a combined approach by general and plastic surgeons. *Ann R Coll Surg Engl* 99(4):265–270. <https://doi.org/10.1308/rcsann.2016.0241>
 10. Espinosa-de-los-Monteros A, Avendano-Peza H, Novitsky YW (2016) Abdominal closure after TRAM flap breast reconstruction with transversus abdominis muscle release and mesh. *Plast Reconstr Surg Glob Open* 4:e1014. <https://doi.org/10.1097/GOX.0000000000001014>
 11. Krpata DM, Blatnik J, Novitsky YW, Rosen MJ (2012) Posterior and open anterior components separations: a comparative analysis. *Am J Surg* 203:318–322. <https://doi.org/10.1016/j.amjsurg.2011.10.009> discussion 322.
 12. Pauli EM, Wang J, Petro CC et al (2014) Posterior component separation with transversus abdominis release successfully addresses recurrent ventral hernias following anterior component separation. *Hernia*. <https://doi.org/10.1007/s10029-014-1331-8>
 13. Timmermans L, De Goede B, Van Dijk SM et al (2014) Meta-analysis of sublay versus onlay mesh repair in incisional hernia surgery. *Am J Surg* 207:980–988. <https://doi.org/10.1016/j.amjsurg.2013.08.030>