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Differences in midline fascial forces exist following laparoscopic and open transversus abdominis release in a porcine model

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Abstract

Introduction Posterior component separation herniorrhaphy via transversus abdominis release (TAR) permits midline reapproximation of large fascial defects. To date, no report delineates the reduction in tensile force to reapproximate midline fascia following TAR. We hypothesized that open and laparoscopic TAR would provide similar reductions in midline reapproximation forces in a porcine model.

Methods Under general anesthesia, a 20-cm midline laparotomy was created and bilateral lipocutaneous flaps were raised to expose the anterior rectus sheath. Five stainless steel hooks were placed at 1-cm intervals lateral to the midline at three locations: 5 cm above, at, and 5 cm below the umbilicus bilaterally. Baseline force measurements were taken by pulling each lateral point to midline. Laparoscopic TAR was performed unilaterally by incising the parietal peritoneum and transversus muscle lateral to the linea semilunaris. Open TAR was performed contralaterally, and force measurements were repeated. Comparisons were made to baseline and between the groups.

Results Following laparoscopic TAR, 87 % (13/15) of points showed significant reduction compared to baseline forces, whereas only 20 % (3/15) of open TAR points had significant force reductions. Compared to open TAR, three locations favored the laparoscopic approach [1 cm lateral to midline, 5 cm above the umbilicus ($p = 0.04$; 95 % CI 0.78–1.00), 2 cm lateral to midline at the umbilicus ($p = 0.04$; 95 % CI 0.80–1.00), and 1 cm lateral to midline 5 cm below the umbilicus ($p = 0.05$; 95 % CI 0.79–1.00)]. The mean length of TAR was longer for laparoscopic than open at 27.29 versus 19.55 cm ($p < 0.0001$; 95 % CI 6.46–9.02).

Conclusions Open TAR reduced midline tensile force at few locations, suggesting that the mechanism by which TAR facilitates herniorraphy may not solely be through reductions in *linea alba* tensile forces. At specific locations, laparoscopic TAR provides superior reduction in midline closure force compared to open TAR, likely as a result of a longer muscle release.

Traditional methods of hernia repair have unacceptably high recurrence rates [1, 2]. Primary open suture repair of ventral hernias with simple fascial reapproximation results in recurrence rates in excess of 60 % in long-term follow-up [3–11]. The addition of mesh alone to open repairs still results in long-term recurrence rates as high as 32 % [5, 7, 9].

In 1990, Ramirez et al. [12] described a component separation hernia repair method which permitted greater medial fascial advancement and aided in definitive abdominal wall reconstruction. Component separation methods result in a lower rate of hernia recurrence, in part,

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by reducing tension across the midline closure through the surgical division of constraining myofascial planes [13–15]. Numerous 'anterior' and 'posterior' methods of component separation have since been described.

More recently, Novitsky et al. [16] described transversus abdominis release (TAR) as a method of open PCS. Following takedown of the posterior rectus sheath, the transversus abdominis muscle and fascia are divided from costal margin through arcuate line by incising posteriorly. The avascular plane beneath the transversus muscle is then entered and bluntly dissected; laterally to the psoas, superiorly behind the xyphoid process, and inferiorly behind the pubic symphysis [17]. Utilizing TAR, Novitsky et al. [16] achieved midline fascial reapproximation in the majority of patients (recreation of the *linea alba*) and demonstrated a recurrence rate of only 4.7 % with 26-month follow-up. Despite these impressive results, no data exist about the degree to which TAR alleviates tension on the midline fascial reapproximation.

Open TAR has a reported 23.8 % rate of surgical site occurrence including seroma formation, hematoma, and surgical site infection [16]. Methods to perform a minimally invasive TAR might decrease wound morbidity, hospital stay, and postoperative pain associated with the open version of the surgery. Recently, robotic-assisted TAR has been described [18]. This is achieved by performing a retrorectus dissection, TAR, suturing the posterior rectus sheath closed in the midline, placement of polypropylene mesh in the retromuscular space, and closure of the midline abdominal wall defect. Results suggest a shorter hospital stay and less intraoperative blood loss but a steep learning curve for robotic TAR.

Interestingly, the transversus abdominis muscle is readily visible and divisible from within the abdominal cavity, a space familiar to any laparoscopic surgeon (Fig. 1). Laparoscopic TAR, performed intraperitoneally,

Fig. 1 Laparoscopic view of human transversus abdominis

may have the advantage of permitting reduced tension across the midline closure without the need to understand the complexities of robotic-assisted TAR which aims to reproduce the open paradigm of a retromuscular repair. Moreover, laparoscopic TAR coupled with laparoscopic defect closure and intraperitoneal mesh placement could eliminate the need for a fully open or robotic-assisted component separation while at the same time being an operation familiar to surgeons currently performing laparoscopic ventral hernia repair.

We hypothesized that laparoscopic TAR is both safe and feasible and that both open and laparoscopic TAR provide similar reductions in the midline fascial closure forces. An animate porcine model was chosen due to its similarities with human abdominal wall anatomy as well as the need for multiple force measurements being made on living tissue. Furthermore, it is amenable to typical laparoscopic instruments used in adult human laparoscopic surgery [19, 20].

Methods

The research protocol was reviewed and accepted by the Institutional Animal Care and Use Committee (IACUC) at the Penn State College of Medicine. Twenty, 40 kg female domestic pigs (*Sus scrofa domesticus*) were used in this non-survival study. For the surgical procedures, the animals were anesthetized and monitored by the veterinary staff. Anesthesia was induced by an intramuscular injection of telazol (500 µg/kg), medetomidine (70–80 µg/kg), and butorphanol (300 µg/kg). The animals were intubated and anesthesia maintained with 1–2 % isoflurane delivered in 100 % O_2 with mechanical ventilation. An IV catheter was placed in the marginal ear vein.

Neuromuscular-blocking agents and skeletal muscle relaxants were not utilized at any point during the operation to eliminate their confounding effects on midline fascial tension. End-tidal CO_2, SpO_2, respiratory rate, and pulse rate were monitored throughout the procedure. The animals were firmly stabilized across the chest and pelvis to eliminate lateral or rotational motion during force measurement.

Following the satisfactory induction of anesthesia, a 20-cm midline laparotomy was created. The *linea alba* was carefully identified and divided at its midpoint. Bilaterally, the anterior rectus fascia was exposed from 5 cm above to 5 cm below the umbilicus and from the midline to 10 cm laterally. This was accomplished by dissecting the *cutaneous trunci* muscles off of the external oblique fascia to create a large lipocutaneous flap (Fig. 2).

Force measurements across the abdominal wall were taken in the following fashion: 0 silk suture loops were
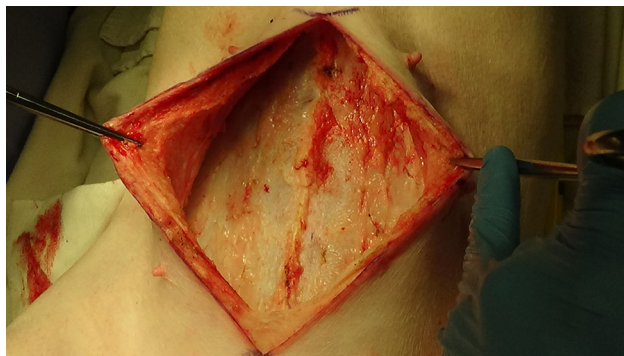
Fig. 2 Lipocutaneous flaps after removal of *cutaneous trunci* muscles bilaterally, exposing the anterior fascia

attached to steel hooks which were placed in the anterior rectus fascia at 15 locations bilaterally. Steel hooks were placed at 1-cm intervals laterally from the midline fascial incision at 5 cm above the umbilicus, at the umbilicus, and 5 cm below the umbilicus. The midline was marked from xyphoid to pubis with a reference suture (Fig. 3). A digital force gauge (BFG200N, Mecmesin, West Sussex, UK) was hooked to each of the suture loops, and measurements of the force required to pull the point to the midline were taken. Two measurements were taken at each location and in the event of discrepancy, a third measurement was taken.

Following baseline data collection, three laparoscopic trocars were placed through the abdominal wall lateral to the *linea semilunaris*. This was done under direct visualization through the midline incision performed previously. The midline was then temporarily closed with skin staples and an occlusive drape (Incise Drape, 3 M Corporation, USA) to permit laparoscopy. Pneumoperitoneum was created utilizing a carbon dioxide insufflator (Electronic Laparoflator, Karl-Storz, Germany). Utilizing standard laparoscopic instrumentation and monopolar electrocautery, the transversus abdominis muscle was divided one
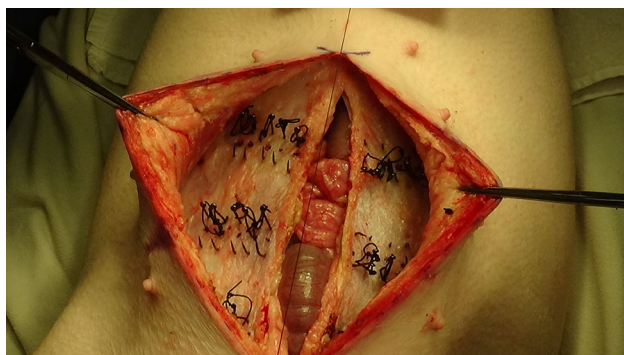
centimeter medial to the *linea semilunaris*. The division included the peritoneum, posterior investing transversalis fascia, transversus abdominis muscle belly, and anterior investing transversalis fascia (Fig. 4). Division of the transversus was carried out from above the costal margin to as far inferiorly as could be safely dissected.

Following completion of the laparoscopic TAR, the ports and occlusive drape were removed. Utilizing previously described methods, an open TAR was performed on the contralateral abdominal wall [16]. Alternate sides were used throughout the study such that an equal number of laparoscopic and open TARs were performed on the right and left sides of the abdomen.

Following the completion of the open TAR, the midline reference suture was replaced. The digital force gauge was again hooked onto each of the silk suture loops, and the measurements were repeated. At the conclusion of the procedure, all animals were euthanized and grossly examined for the adequacy of the release of the transversus abdominis muscle (uncut muscle fibers, fascial bands) as well as unintended injury to other abdominal wall structures including the *linea semilunaris*, internal oblique, external oblique, and the rectus abdominis as well as all intra-abdominal organs.

Additional measurements included the length of the skin incision, the length of the laparoscopic and open releases, and the length and width of the fascial defect and its location in relation to the xyphoid and pubis.

The force required to medialize the anterior rectus sheath before and after surgery is reported as the median (25th percentile, 75th percentile) because these data were not normally distributed. In order to meet parametric modeling assumptions, i.e., normality, the force data were log-transformed prior to analysis. A linear mixed-effects
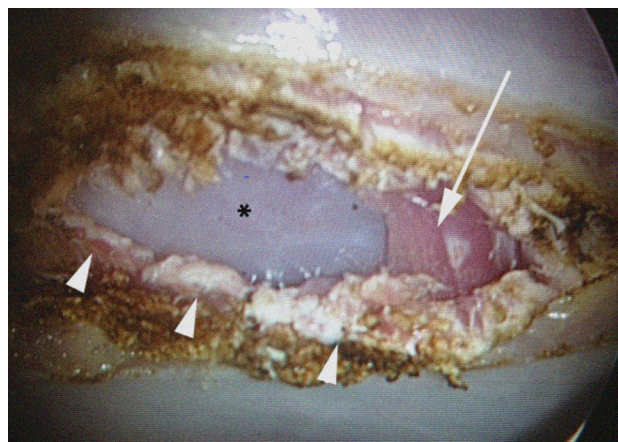

Fig. 3 Steel hooks placed at 1-cm intervals laterally from midline fascial incision at 5 cm above, at, and below the umbilicus. Midline reference suture from xyphoid to midline is seen bisecting the abdomen above the level of the fascia

Fig. 4 View of the myofascial release during laparoscopic TAR. Cut lower (lateral) edge of the transversus muscle (*arrowheads*), uncut transversus abdominis muscle fibers (*arrow*), and intact internal oblique muscle (*asterisk*) can all be seen

model was fit to the log-transformed force data to assess differences between procedure types (i.e., laparoscopic vs. open TAR), the time (i.e., pre- and post-procedure), the location (i.e., below, at, and above umbilicus), and the distance (i.e., 1, 2, 3, 4, 5 cm) [21]. The linear mixed-effects model is an extension of linear regression that accounts for the within-animal variability inherent in repeated measures designs. In this study, there were four repeated factors per animal: the procedure type, the time, the location, and the distance. For ease of interpretation, the comparisons from the linear mixed-effects model that were analyzed on the logarithmic scale were back-transformed to the original scale resulting in a ratio of geometric means with corresponding 95 % confidence intervals. All hypothesis tests were two-sided, and all analyses were performed using SAS software, version 9.4 (SAS Institute Inc., Cary, NC).

Results

All 20 animals underwent both open and laparoscopic TAR as described above. There were no intraoperative complications as a result of either anesthesia or the operative technique, and all procedures were carried out to completion. The average operative time to complete the TAR in an open fashion was 13.6 min (SD 3.17 min) while laparoscopic was 15.5 min (SD 3.12 min), which was not statistically different. The mean fascial defect created was 49.75 cm^2 (SD 10.31 cm^2). The mean distance from the fascial defect to the xyphoid and to the pubis was 11.15 cm (SD 1.67 cm) and 11.08 cm (SD 1.06 cm), respectively. The mean distance from the midline to the TAR for the laparoscopic technique was 7.93 cm (SD 1.23 cm), while for the open technique the mean distance was 3.62 cm (SD 0.87 cm). The mean length of the release was significantly longer for laparoscopic than open TAR at 27.29 cm (SD 2.62 cm) and 19.55 cm (SD 1.06 cm), respectively (p value < 0.0001; 95 % CI 6.46–9.02) (Fig. 5).

There was no difference in baseline forces between the two sides prior to undergoing laparoscopic or open TAR. The greatest forces were measured preintervention at the points most lateral to the midline. Following laparoscopic TAR, the majority of points measured (13 of 15) showed a statistical reduction in force except for 5 cm lateral to the midline both above and below the umbilicus (Table 1). However, for open TAR only 1 cm lateral to the umbilicus, and 1 and 2 cm lateral to midline below the umbilicus resulted in a statistically significant reduction in force (Table 2). Even at points with a statistically significant reduction in force, the absolute reduction was modest, with the highest reduction being at 5 cm lateral to the umbilicus after laparoscopic TAR (median force prior to TAR
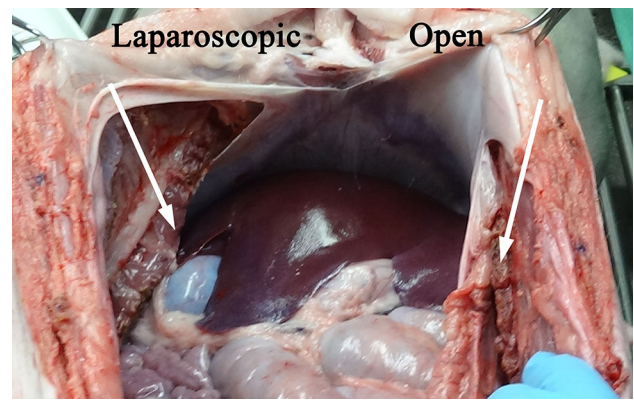

Fig. 5 Picture at necropsy showing extent of dissection with laparoscopic TAR extending much further caudad over the top of the liver than open PCS with TAR on the contralateral side. *Arrows* showing lateral cut edge of transversus bilaterally

13.19 N, median force post-TAR 11.98 N). When comparing laparoscopic to open TAR, three locations were statistically significant in favor of laparoscopic TAR. These were at 1 cm lateral to midline above the umbilicus (p = 0.0455; 95 % CI 0.78–1.00), 2 cm lateral to midline at the umbilicus (p = 0.0412; 95 % CI 0.80–1.00), and 1 cm lateral to midline below the umbilicus (p = 0.0460; 95 % CI 0.79–1.00) (Table 3).

There were no injuries to the bowel or other abdominal viscera identified. In all cases, the transversus had been completely transected throughout the length of the release. There were no cases where the internal oblique had been transected, but there were four cases with thermal artifact on the internal oblique in the laparoscopic TAR group.

Discussion

For many surgeons, the pillars of ventral herniorrhaphy technique are reapproximating the fascial defect (using component separation techniques when appropriate) and wide mesh reinforcement of the closed defect [22]. To accomplish these goals, some authors advocated primary closure of the hernia defect during laparoscopic repair [23]. Many have noted technical difficulty with such closures for fascial defects above 8 cm, primarily due to tension across the midline [24].

This series successfully demonstrated that laparoscopic TAR is feasible in a porcine model and results in a decrease in midline tension. Laparoscopically, the decrease from baseline was similar to that seen with open TAR. The longer release afforded by the laparoscopic approach resulted in greater reductions in midline tensile forces is some locations when compared to open TAR.

While minimally invasive forms of TAR including robotic and laparoscopic preperitoneal TARs have both

Table 1 Median force required to medialize anterior rectus sheath before and after laparoscopic TAR

Location	Force in Newtons prior to TAR Median (25th Pctl, 75th Pctl)	Force in Newtons after TAR Median (25th Pctl, 75th Pctl)	Ratio of geometric means (95 % CI) [p value]
Above umbilicus			
1 cm*	4.26 (3.85, 4.91)	3.24 (2.84, 3.81)	0.79 (0.71–0.89) [<0.001]
2 cm*	5.61 (5.31, 6.83)	5.48 (4.29, 5.83)	0.89 (0.79–1.00) [0.04]
3 cm*	8.29 (7.16, 9.34)	7.11 (6.10, 7.68)	0.86 (0.77–0.97) [0.01]
4 cm*	11.08 (9.39, 12.51)	10.05 (8.21, 11.36)	0.89 (0.79–0.99) [0.04]
5 cm	14.86 (12.39, 16.39)	13.24 (11.14, 14.63)	0.90 (0.80–1.00) [0.06]
At umbilicus			
1 cm*	3.63 (3.03, 4.14)	2.83 (2.06, 3.58)	0.79(0.72–0.86) [<0.001]
2 cm*	5.46 (4.71, 6.18)	4.65 (3.79, 5.39)	0.83 (0.77–0.91) [<0.001]
3 cm*	7.60 (6.48, 8.54)	6.63 (5.69, 7.61)	0.87 (0.80–0.95) [0.002]
4 cm*	10.26 (8.88, 11.25)	9.63 (7.66, 10.28)	0.90 (0.83–0.99) [0.02]
5 cm*	13.19 (11.94, 14.55)	11.98 (11.15, 13.09)	0.90 (0.83–0.98) [0.02]
Below umbilicus			
1 cm*	3.38 (3.00, 3.75)	2.61 (1.90, 3.03)	0.74 (0.67–0.81) [<0.001]
2 cm*	5.33 (4.69, 5.88)	4.58 (3.85, 4.96)	0.81 (0.74–0.89) [<0.001]
3 cm*	7.10 (6.69, 8.40)	6.58 (5.59, 7.74)	0.86 (0.78–0.94) [0.001]
4 cm*	9.29 (8.69, 11.36)	8.81 (7.24, 10.41)	0.87 (0.79–0.95) 0.003]
5 cm	12.60 (11.76, 14.41)	12.18 (10.30, 13.56)	0.94 (0.86–1.03) [0.18]

TAR transversus abdominis release

* Statistically significant difference

Table 2 Median force required to medialize anterior rectus sheath before and after open PCS with TAR

Location	Force in Newtons prior to TAR Median (25th Pctl, 75th Pctl)	Force in Newtons after TAR Median (25th Pctl, 75th Pctl)	Ratio of geometric means (95 % CI) [p value]
Above umbilicus			
1 cm	4.1 (3.24, 5.30)	3.86 (2.96, 5.03)	0.92 (0.81–1.04) [0.18]
2 cm	5.68 (4.66, 8.24)	5.44 (4.40, 7.51)	0.92 (0.81–1.05) [0.23]
3 cm	7.78 (6.40, 11.63)	6.89 (6.05, 9.44)	0.92 (0.81–1.04) [0.17]
4 cm	10.18 (8.25, 13.81)	9.34 (8.26, 12.94)	0.94 (0.83–1.07) [0.33]
5 cm	13.24 (10.48, 19.91)	12.16 (10.20, 16.91)	0.92 (0.81–1.04) [0.18]
At umbilicus			
1 cm*	3.71 (2.85, 4.49)	3.23 (2.70, 4.10)	0.85 (0.75–0.97) [0.01]
2 cm	5.76 (4.15, 6.68)	5.60 (4.06, 6.16)	0.93 (0.82–1.05) [0.23]
3 cm	7.46 (5.90, 9.11)	7.38 (5.56, 8.49)	0.91 (0.80–1.03) [0.14]
4 cm	9.84 (8.54, 12.13)	9.54 (7.86, 11.24)	0.91 (0.80–1.03) [0.14]
5 cm	12.63 (10.64, 16.61)	12.25 (10.00, 15.55)	0.93 (0.82–1.06) [0.27]
Below umbilicus			
1 cm*	3.76 (2.81, 4.28)	3.09 (2.28, 3.63)	0.80 (0.69–0.93) [0.004]
2 cm*	5.56 (4.55, 6.80)	5.06 (3.99, 5.74)	0.83 (0.71–0.96) [0.01]
3 cm	8.16 (5.98, 10.33)	7.19 (5.98, 8.56)	0.87 (0.75–1.01) [0.06]
4 cm	10.13 (8.33, 14.10)	9.59 (7.88, 10.94)	0.87 (0.75–1.01) [0.06]
5 cm	13.65 (10.51, 16.68)	12.70 (10.15, 14.05)	0.89 (0.77–1.05) [0.13]

PCS posterior component separation, *TAR* transversus abdominis release

* Statistically significant difference

been performed, this version has not (to the best of our knowledge) been performed in a human [18]. Our goal was to develop an MIS operation that provided the offloading of tension at the midline by TAR, but obviated the need for a complex preperitoneal dissection required by an open, robotic, or laparoscopic preperitoneal approach. Using the

Table 3 Comparison of geometric means, laparoscopic TAR versus open PCS with TAR

Location	Ratio of geometric Means (95 % CI)	p value (95 % CI)
Above umbilicus		
1 cm*	0.88 (0.78–1.00)	0.05
2 cm	0.93 (0.82–1.05)	0.23
3 cm	0.93 (0.82–1.06)	0.27
4 cm	0.98 (0.86–1.10)	0.69
5 cm	1.02 (0.90–1.15)	0.81
At umbilicus		
1 cm	0.90 (0.81–1.01)	0.06
2 cm*	0.89 (0.80–1.00)	0.04
3 cm	0.94 (0.85–1.05)	0.27
4 cm	0.99 (0.89–1.10)	0.88
5 cm	0.97 (0.87–1.08)	0.61
Below umbilicus		
1 cm*	0.89 (0.79–1.00)	0.05
2 cm	0.94 (0.84–1.06)	0.30
3 cm	0.94 (0.84–1.06)	0.32
4 cm	0.95 (0.86–1.07)	0.41
5 cm	1.01 (0.90–1.13)	0.91

TAR transversus abdominis release, *PCS* posterior component separation

* Statistically significant difference in favor of laparoscopic TAR

technique we have described, midline closure may be facilitated by the midline force reduction provided by laparoscopic TAR. The majority of locations (13/15) measured showed a statistically significant reduction in midline force in our series. The two locations that failed to show significance were those most distant to the umbilicus (5 cm above and 5 cm lateral). These points represent the equivalent of a 10 cm × 10 cm wide fascial defect. It should be noted that all locations were measured as individual data points, without the advantage of the force reduction that would have been afforded by superior or inferior fascial closure stitches that would have been placed in a standard fascial closure.

In contrast, the only three points that were significantly reduced after open TAR were 1 cm lateral to the umbilicus and below the umbilicus at 1 and 2 cm laterally. The mechanism by which the laparoscopic approach afforded a greater number of significant reduction points compared to baseline remains unclear. One readily apparent difference is that the mean length of the release achieved by laparoscopic TAR was 27.29 cm compared to only 19.55 cm for open TAR. The longer release achieved by laparoscopic TAR is a result of the superior surgical access to the entire length of the transversus abdominis muscle. In order to

achieve a similar release by an open approach, a larger midline fascial incision would have been required to provide adequate visualization and access. Although we could have extended the incision form xyphoid to pubis in order to permit a longer release on the open TAR side, we elected not to do so as this more accurately mimics our current practice of restricting the extent of the midline incision. This is done to minimize the risk of recurrence, surgical site occurrences, and overall morbidity from a longer incision that would be required to provide a longer open release. Whether the pneumoperitoneum played any part in the difference is unclear. Although we did dissect laterally on the open TAR side, we did not formally dissect laterally on the laparoscopic side. It is possible that the pneumoperitoneum dissected the plane to some extent. However, we deemed this unlikely as the planes seemed largely intact during necropsy.

One less apparent difference between the two techniques is the mechanism of dissection and transversus abdominis release. In the traditional open TAR technique, the transversus muscle belly and its investing fascial layers are divided just lateral to the medial insertion on the posterior rectus sheath [16]. This is in contrast to the laparoscopic approach utilized here whereby the transversus muscle, investing fascia, and peritoneum were divided more laterally in an effort to facilitate identification and avoid injury to the *linea semilunaris*. It is possible that by releasing the transversus further laterally results in greater reductions when compared to the more medial release of the open TAR.

Open TAR has favorable recurrence rates but shares the morbidities associated with any large open abdominal surgery (surgical site occurrences, prolonged hospital stay, and postoperative pain and narcotic use). The marriage of TAR with a minimally invasive approach could offer the advantages of decreased recurrence rates with the benefits of laparoscopic surgery including decreased wound morbidity, pain, and hospital stays. Surgeons who are familiar with traditional laparoscopic intraperitoneal onlay mesh herniorrhaphy could adopt this laparoscopic TAR technique due to the fact that it is performed intraperitoneally utilizing readily identifiable abdominal wall landmarks. The purpose of laparoscopic TAR we have described here is to provide reduction in midline tension for primary defect closure, followed by a traditional intraperitoneal onlay mesh placement that many laparoscopic surgeons favor. The intraperitoneal onlay mesh would ideally cover both the midline defect as well as the peritoneal and muscular defects created by the laparoscopic TAR. The mesh would only need to cover the peritoneal defect with minimal overlap, as this release does not represent a full-thickness defect to the abdominal wall. In this case, the mesh is only creating a barrier between the viscera and

exposed muscle of the cut transversus. Alternatively, the peritoneal defects could be closed either with suture, or laparoscopic tacking devices. Whether primary fascial closure provides an advantage over traditional intraperitoneal onlay mesh (bridged) repair remains unclear. A recent multicenter retrospective review showed no difference in patients who underwent primary fascial closure or bridged repair with regard to recurrence, SSI, seroma, reoperation, or readmissions [25]. The authors did note that further study is needed to further evaluate the benefits in terms of pain, patient satisfaction, cosmesis, and function. Our goal was to develop an operation that can be done without a robot, but still provides the advantages of both a TAR and a minimally invasive intraperitoneal operation. The surgeon can close the midline should they believe the patient would benefit from primary defect closure, and this approach may aid them in doing so.

One of the limitations of this study is the use of a porcine model. Although the pig abdominal wall does have all three lateral muscles (external oblique, internal oblique, and transversus abdominis) as well as the rectus abdominis, the pig abdomen differs in the following ways: The transversus abdominis is thicker and lies somewhat more medial as it approaches the costal margin cephalad than it does in humans; additionally, the pig abdomen has the *cutaneous trunci* muscle which lies directly below the skin and subcutaneous tissue and on top of the external oblique and rectus abdominis muscles anteriorly. In our study, this was dissected free from the anterior abdominal wall in order to more closely resemble the human abdomen. Although a porcine model does not perfectly mimic the human abdomen, it has been used in numerous other studies looking at the effects of component separation on abdominal compartment syndrome, laparoscopic trocar placement and closure, and alterations of pneumoperitoneum by neuromuscular blockade [26–28].

Further investigation is needed to fully understand the changes in midline tension that were demonstrated in this study. While at this time we do not fully understand if the amount of reduction in midline tension after open TAR contributes to long-term recurrence, we have shown that laparoscopic TAR is feasible, provides a significant decrease in midline tension, and may provide an answer for patients who previously could not be provided a laparoscopic herniorrhaphy with primary fascial defect closure.

Finally, we caution surgeons looking to adopt this or any technique involving component separation or muscle release that a firm knowledge of abdominal wall anatomy, the indications for release, and the potential risks are essential for the success of any durable repair. The long-term consequences of TAR are not known. The largest series of patients in the literature consist of 428 patients, of which 347 had at least 1-year follow-up (mean 31 months) [29]. In that series, there was a 3.7 % recurrence rate. Longer-term, prospective data are needed to make any conclusions on the consequences of TAR; however, these results are encouraging. While we are proposing a simpler method for division of the muscle, such an undertaking should be approached with caution. The procedure carries both the risk of long-term abdominal wall destabilization, as well as immediate lateral hernia formation should the release be performed incorrectly, leading to a full-thickness defect. With this in mind, the need to close the midline defect should be weighed against the inherent risks of either procedure.

Compliance with ethical standard

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