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Comparative analysis of open and robotic transversus abdominis release for ventral hernia repair

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Abstract
Background Transversus abdominis release (TAR) is a safe, effective strategy to repair complex ventral incisional hernia (VIH); however, open TAR (o-TAR) often necessitates prolonged hospitalization. Robot-assisted TAR (r-TAR) may benefit short-term outcomes and shorten convalescence. This study compares 90-day outcomes of o-TAR and r-TAR for VIH repair.
Methods A single-center, retrospective review of patients who underwent o-TAR or r-TAR for VIH from 2015 to 2016 was conducted. Patient and hernia characteristics, operative data, and 90-day outcomes were compared. The primary outcome was hospital length of stay, and secondary metrics were morbidity, surgical site events, and readmission.
Results Overall, 102 patients were identified (76 o-TAR and 26 r-TAR). Patients were comparable regarding age, gender, body mass index, and the presence of co-morbidities. Diabetes was more common in the open group (22.3 vs. 0%, $P = 0.01$). Most VIH defects were midline (89.5 vs. 83%, $P = 0.47$) and recurrent (52.6 vs. 58.3%, $P = 0.65$). Hernia characteristics were similar regarding mean defect size (260 ± 209 vs. 235 ± 107 cm^2, $P = 0.55$), mesh removal, and type/size mesh implanted. Average operative time was longer in the r-TAR cohort (287 ± 121 vs. 365 ± 78 min, $P < 0.01$) despite most receiving mesh fixation with fibrin sealant alone (18.4 vs. 91.7%, $P < 0.01$). r-TAR trended toward lower morbidity (39.2 vs. 19.2%, $P = 0.09$), less severe complications, and similar rates of surgical site events and readmission (6.6 vs. 7.7%, $P = 1.00$). In addition, r-TAR resulted in a significantly shorter median hospital length of stay compared to o-TAR (6 days, 95% CI 5.9–8.3 vs. 3 days, 95% CI 3.2–4.3).
Conclusions In select patients, the robotic surgical platform facilitates a safe, minimally invasive approach to complex abdominal wall reconstruction, specifically TAR. Robot-assisted TAR for VIH offers the short-term benefits of low morbidity and decreased hospital length of stay compared to open TAR.

Keywords Ventral incisional hernia · Posterior component separation · Transversus abdominis release · Minimally invasive · Robotic hernia repair

Ventral/incisional hernia (VIH) repair remains one of the most common operations performed by general surgeons in the United States. The frequency of VIH repair continues to increase as does cost of care despite advances in abdominal wall reconstruction techniques [1]. In the United States, use of the robotic surgical platform for minimally invasive VIH repair is increasing as well [2]. Numerous studies demonstrate the benefits of minimally invasive VIH repair

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including lower rates of surgical site infection, less postoperative pain, shorter hospital length of stay (LOS), and fewer days of lost work compared to open VIH repair [3–5]. However, novel minimally invasive approaches like robot-assisted VIH repair may increase capital costs to health systems. Therefore, it is imperative to investigate the potential value of robot-assisted VIH repair (abdominal wall reconstruction) within the context of a value-based health care delivery system.

Trends in VIH repair favor the use of primary fascial defect closure and implantation of mesh in the sublay (retromuscular and/or preperitoneal) position with wide overlap of the defect [6–10]. The anterior component separation technique facilitates closure of large abdominal wall defects, but due to the creation of fasciocutaneous flaps also increases surgical site events (SSE). Posterior component separation (transversus abdominis release or TAR) omits the creation of fasciocutaneous flaps and comparatively decreases the risk for wound morbidity and hernia recurrence [11]. A minimally invasive approach to TAR may even reduce midline tension at specific locations more effectively than open TAR, perhaps due to longer transversus abdominis muscle release [12]. To combine the benefits of a minimally invasive approach and TAR, surgeons are studying the value of the robotic surgical platform for abdominal wall reconstruction.

Robot-assisted TAR (r-TAR) is designed to replicate an open TAR (o-TAR), with the technical goals of primary fascial defect closure, mesh implantation in a sublay position with wide overlap, and minimal fixation with transfascial sutures and/or fibrin sealant. The robotic surgical platform allows these technical goals to be met using a minimally invasive approach in the hopes that r-TAR may yield lower rates of wound morbidity and shorter hospital LOS compared to o-TAR. Given the increasing adoption of robot-assisted VIH repair, specifically r-TAR, and early data supporting this technique, it is important to elucidate clinically relevant outcomes of r-TAR compared to the standard open approach early in the r-TAR learning curve. Objectives of this study were to compare o-TAR and r-TAR regarding hospital LOS and 90-day outcomes early in the r-TAR learning curve. A secondary objective was to investigate the potential value of the robotic surgical platform for complex abdominal wall reconstruction. The alternative hypothesis for this study was that hospital LOS is shorter after r-TAR compared to o-TAR.

Methods

After Institutional Review Board approval, a single-center, retrospective review of consecutive patients who underwent elective o-TAR or r-TAR at a large urban university hospital between January 2, 2015 and August 30, 2016 was conducted using prospectively collected data. Patients were excluded if they underwent open or robot-assisted Rives-Stoppa retromuscular repair or unilateral TAR, required anterior component separation, had mesh placed in a location other than the sublay position, or required concomitant takedown of an enterostomy and/or colostomy. Patients who required an emergent VIH repair were excluded as well. Those who needed other concomitant procedures (e.g., cholecystectomy) at the time of VIH repair were included in the analysis.

All operations were performed by one minimally invasive fellowship-trained surgeon who leads a comprehensive hernia program and has experience with o-TAR and advanced robot-assisted procedures including but not limited to inguinal and ventral hernia repair. This series represents the first 26 r-TAR cases performed by the operating surgeon. Surgical trainees participated in all operations to varying degrees based on clinical experience. The da Vinci® Si robotic platform (Intuitive Surgical, Sunnyvale, CA) was used for the first four r-TAR operations, while the da Vinci® Xi robotic platform (Intuitive Surgical, Sunnyvale, CA) was used to assist in all subsequent r-TAR operations.

The technique for TAR includes enterolysis, dissection of the posterior rectus sheath to the linea semilunaris, incision of the posterior lamina of the internal oblique fascia approximately 2 cm medial to the linea semilunaris and neurovascular bundles revealing transversus abdominis muscle, transection of the transversus abdominis muscle in its entirety, dissection of the transversus abdominis muscle off the transversalis fascia (posterior component separation), and separation of the peritoneum from overlying fascia extending from the diaphragm to space of Retzius and laterally to the retroperitoneum and psoas muscle. In addition, dissection of the myopectineal orifice assures identification and reduction of groin hernia or cord lipoma when present. Once wide dissection of the peritoneum is performed, the posterior rectus sheath is approximated in a running fashion using either #2-0 polydioxanone suture (PDS® II, Ethicon Inc., Somerville, NJ) for o-TAR or #2-0 absorbable barbed suture (V-Loc™ 90, Medtronic Inc., Minneapolis, MN) for r-TAR. A large-sheet mesh is placed in the retromuscular/preperitoneal position, oriented most often in a diamond configuration, and secured using transfascial #0 polydioxanone sutures (PDS® II, Ethicon Inc., Somerville, NJ) and/or fibrin sealant (TISSEEL®, Baxter Healthcare Corp., Deerfield, IL). After the hernia sac is resected, the anterior rectus sheath is approximated using a 4:1 suture-to-wound-length ratio and short-stitch technique with either #0 polydioxanone suture (PDS® II, Ethicon Inc., Somerville, NJ) for o-TAR or #0 absorbable barbed suture (V-Loc™ 180, Medtronic Inc., Minneapolis,

MN) for r-TAR. In o-TAR, excess or at-risk subcutaneous tissue and skin are resected. Closed suction drain(s) is/are placed into the retromuscular/preperitoneal space. Wounds are closed in layers with rapidly absorbable suture and sealed with topical skin adhesive (DERMABOND®, Ethicon Inc., Somerville, NJ).

Inpatient management was similar between the two groups. Preoperatively, all patients were prepped with chlorhexidine gluconate and isopropyl alcohol then draped with Ioban 2 Antimicrobial Incise Drapes (3 M, St. Paul, MN) using sterile technique. Antibiotics were administered according to Surgical Care Improvement Project (SCIP) guidelines. Both sequential compression devices and chemoprophylaxis were used for prevention of venous thromboembolism according to American College of Chest Physicians guidelines [13]. Intra- and postoperatively, patients were managed according to an enhanced recovery pathway designed to minimize excess fluid administration, assess peak/plateau airway pressures prior to extubation, limit use of narcotics, and control pain with epidural analgesia, acetaminophen, non-steroidal anti-inflammatory medications, and gabapentin, ensure early ambulation through physical therapy, start protein-enhanced nutrition early, and initiate a bowel regimen. Epidural use as an outcome metric was defined as successful catheter placement preoperatively and effective catheter function for analgesia postoperatively. Patients who remained intubated postoperatively due to high peak/plateau airway pressures or complex medical condition were treated with a specific paralytic protocol and once extubated, managed using the standardized enhanced recovery pathway.

Patient characteristics included age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status class, smoking history, and the presence of diabetes mellitus, hypertension, chronic obstructive pulmonary disease (COPD), coronary artery disease (CAD), chronic kidney disease (CKD) including dialysis, inflammatory bowel disease (IBD), and immunosuppression status. Abdominal hernia characteristics were determined by preoperative examination and computed tomography (CT), classified according to the modified Ventral Hernia Working Group grade, then confirmed by intraoperative measurement in all cases [14]. Hernia-specific metrics included defect size, type, and location. Intraoperative data were reviewed for Centers for Disease Control wound class, epidural analgesia used, operative time, fascial closure method, mesh type and size, method of mesh fixation, estimated blood loss, drain use, and conversion.

The primary outcome metric, hospital LOS, was defined as the difference in time between the date of index operation and the date of hospital discharge. Secondary outcome metrics included 90-day complications, hernia-related reoperation, morbidity, and mortality. Postoperative morbidity was categorized according to the Clavien-Dindo classification system and Comprehensive Complication Index (CCI®, University of Zurich, Zurich, Switzerland) [15, 16]. Surgical site events (SSE) were defined as surgical site infection (SSI), surgical site occurrence (SSO), and surgical site occurrence requiring procedural intervention (SSOPI). An SSI included cellulitis, non-healing wounds, skin-related complications, and/or prolonged wound drainage. An SSO was defined as hernia recurrence, fascial dehiscence, hematoma/seroma, or development of enterocutaneous fistula. Any SSO that required procedural intervention such as opening a wound, placing a drain, or reoperation qualified as a SSOPI. Concomitant procedures were defined as any non-hernia-related operations performed at the time of VIH repair. For example, an inguinal hernia repaired at the time of VIH repair was not considered a concomitant procedure; however, a cholecystectomy was defined as a concomitant procedure.

Sample size was determined based on available patients with an estimated mean difference in hospital LOS of 3 days (standard deviation of 5 days) between the o-TAR and r-TAR cohorts. Assuming a mean difference in LOS of at least 3 days with a standard deviation of 5 days this study required a minimum of 26 patients in each cohort to reject the alternative hypothesis that LOS is longer after o-TAR with power of 80%. Descriptive statistics were performed, categorical variables were compared using Fischer's exact test, and continuous variables were analyzed with Student's t test or Mann–Whitney U test as appropriate with alpha set at 0.05. Grubb's test to detect outliers was employed for the primary measure. Outcomes were assessed using an intent-to-treat model. Data are reported as proportions, mean and standard deviation, or median with range and 95% CI. Calculations were performed using QuickCalcs software (GraphPad Software Inc., La Jolla, CA).

Results

In all, 102 patients (76 o-TAR and 26 r-TAR) were analyzed after accounting for inclusion/exclusion criteria. No patient in the r-TAR group required conversion to an open approach. Patients were comparable regarding age, gender, BMI, the presence of co-morbidities, and hernia characteristics though diabetes was more common in the open group (Table 1). Most hernia defects were midline (89.5 vs. 83%, $P = 0.47$) and recurrent (52.6vs. 58.3%, $P = 0.65$). Hernia characteristics were similar regarding mean defect area, width, and length, the type, and area of mesh used, and the need for mesh removal. A similar proportion of patients in each group received perioperative

Table 1 Preoperative and operative characteristics of o-TAR and r-TAR patients

	o-TAR ($n = 76$)	r-TAR ($n = 26$)	P value
Demographics			
Mean age ± SD (years)	54.6 ± 14	52.4 ± 12.9	0.48
Male (%)	46	33.3	0.35
Mean BMI ± SD (kg/m^2)	32.1 ± 7	33.4 ± 9	0.47
Past abdominal operation (%)	98.7	100	1.00
Co-morbidities			
Median ASA class	3	3	1.00
Chronic kidney disease (%)	10.5	0	0.13
Coronary artery disease (%)	13	4.3	0.29
COPD (%)	10.5	25	0.09
Diabetes (%)	22.3	0	0.01
Dialysis (%)	0	0	1.00
Hypertension (%)	65.8	66.7	1.00
IBD (%)	2	2	1.00
Immune (%)	5.2	4.2	1.00
Nicotine use (%)	13	0	0.11
Median modified VHWG grade	2	2	0.49
Hernia characteristics			
Midline (%)	89.5	83	0.47
Recurrent (%)	52.6	58.3	0.65
Epidural used (%)	68	59	0.35
Mean hernia area ± SD (cm^2)	260 ± 209	235 ± 107	0.55
Mean hernia width ± SD (cm)	13.7 ± 5.9	12.3 ± 3	0.26
Mean hernia length ± SD (cm)	17.1 ± 7.1	18.5 ± 5.1	0.35
Operative details			
Median CDC wound class	1	1	1.00
Concomitant procedure (%)	16	0	<0.01
Mean operative time ± SD (min)	287 ± 121	365 ± 78	<0.01
Mesh details			
Mesh used (%)	100	100	1.00
Mean mesh area ± SD (cm^2)	713 ± 498	759 ± 119	0.65
Mesh type (%)			
Permanent synthetic	65.4	92.4	0.01
Absorbable synthetic	12	3.8	0.45
Hybrid (synthetic/biologic)*	17.3	3.8	0.11
Biologic	5.3	0	0.57
Mesh removed (%)	13	8.3	0.72
Fixation details			
Fixation used (%)	100	100	1.00
Fixation type (%)			
Sutures only	67.1	0	<0.01
Fibrin sealant only∝	18.4	92.3	<0.01
Sutures and fibrin sealant	14.5	7.7	0.51
Fascia closed (%)			
Absorbable monofilament	100	100	1.0
Running stitch	100	100	1.0
Drain(s) used (%)	96.1	84.6	0.07
Complication, intraop (%)	3.9	0	1.0

Table 1 continued

	o-TAR ($n = 76$)	r-TAR ($n = 26$)	P value
Conversion (%)	0	0	1.0

o-TAR open transversus abdominis release; *r-TAR* robot-assisted transversus abdominis release; *SD* standard deviation; *BMI* body mass index; *ASA* American Society of Anesthesiologists; *COPD* chronic obstructive pulmonary disease; *IBD* inflammatory bowel disease; Immune, immunosuppressed; *VHWG* Ventral Hernia Working Group; *CDC* centers for disease control

* Zenapro® Hybrid hernia repair device (Cook Biotech Inc., Bloomington, IN)

∝ TISSEEL® (Baxter Healthcare Corp., Deerfield, IL)

epidural analgesia, with a goal of continuing epidural analgesia postoperatively for at least 24 h. Epidural analgesia was permitted up to 5 days postoperatively as needed for pain management.

Average operative time was longer in the r-TAR cohort (287 ± 121 vs. 365 ± 78 min, $P < 0.01$) despite most patients receiving mesh fixation with fibrin sealant alone (18.4 vs. 91.7%, $P < 0.01$). Again, this series represents the first 26 r-TAR cases performed by the operating surgeon and perioperative team. The first four r-TAR cases were performed with the assistance of the da Vinci® Si robotic platform which takes longer to dock and re-dock due to platform limitations and need for patient repositioning. If these first four r-TAR cases were excluded from analysis, mean operative time of r-TAR was no longer statistically different (287 ± 121 vs. 338 ± 49 min, $P = 0.06$). Twelve o-TAR patients (16%) underwent concomitant procedure at the time of VIH repair. Concomitant procedures included enterectomy ($n = 3$), cholecystectomy ($n = 2$), partial colectomy ($n = 2$), spleen-preserving distal pancreatectomy ($n = 1$), hysterectomy ($n = 1$), radical nephrectomy ($n = 1$), liver biopsy ($n = 1$), and closure of gastrostomy ($n = 1$).

There was no significant difference between groups in overall morbidity, mortality, or complication profile (Table 2). Overall, o-TAR trended toward higher morbidity (39.2 vs. 19.2%, $P = 0.09$) compared to r-TAR. Both procedures exhibited similarly low rates of SSI, SSO, and SSOPI. In the o-TAR group, 30 patients (39.4%) suffered 34 complications. In the r-TAR group, five patients (19.2%) suffered 5 complications out to 90 days postoperatively (Table 3).

The alternative hypothesis was that hospital LOS was shorter after r-TAR compared to o-TAR. Median hospital LOS was 3 days shorter after r-TAR (3 days, range 2–10 days, 95% CI 3.2–4.3) compared to o-TAR (6 days, range 2–34 days, 95% CI 5.9–8.3). Mean hospital LOS without adjusting for outliers in each cohort was significantly shorter after r-TAR (7.1 ± 5.4 vs. 3.8 ± 1.5 days, $P < 0.01$). One patient in the o-TAR group had a hospital stay of 34 days and one patient in the r-TAR group had a LOS of 10 days. Using Grubbs' test, these data points (34 days and 10 days) were considered outliers (o-TAR Z score 3.29, $P = 0.05$; r-TAR Z score 2.8, $P = 0.05$). Repeat analysis excluding these outliers confirmed a significantly shorter mean hospital LOS after r-TAR (6.7 ± 4.3 vs. 3.5 ± 0.9 days, $P < 0.01$).

Discussion

This study represents one of the larger single surgeon experiences of r-TAR to date. Based on a patient-centered approach, r-TAR decreased mean hospital LOS by 3 days compared to o-TAR, which was statistically and clinically significant. Despite longer operative times in the r-TAR group, a significantly shorter hospital LOS after r-TAR may translate to patient-centered value. As experience with r-TAR grows and the learning curve is overcome, operative times will decrease and likely approach o-TAR operative times in similar patients. Should that occur, in conjunction with appropriate training, the overall value of r-TAR may be solidified in terms of quality outcomes, shorter convalescence, patient satisfaction, and cost savings. Several recent studies support this concept, that a minimally invasive approach to TAR yields shorter hospital LOS compared to open abdominal wall reconstruction in similarly complex patients while potentially reducing overall hospital costs [17, 18]. Initial studies such as this should prompt further investigation into the value proposition of robot-assisted VIH repair and complex abdominal wall reconstruction, specifically TAR. Future studies may reveal the probable benefits of less postoperative pain, similar or improved long-term hernia recurrence, and lower overall costs to health systems and payers.

The shorter hospital LOS in the r-TAR cohort may be due to multiple factors including less postoperative pain, which was not assessed objectively in this study, patient bias related to a minimally invasive approach, or patient selection bias. Patient bias about pain is difficult to control, but all patients were counseled that regardless of approach, postoperative pain should be expected. Means to minimize patient bias regarding postoperative pain comprised use of an abdominal binder while hospitalized, an enhanced

Table 2 Complication profile of o-TAR and r-TAR Patients

	o-TAR ($n = 76$)	r-TAR ($n = 26$)	P value
Morbidity (%)	39.4	19.2	0.09
Complication type (%)			
Intraoperative	5.3	0	0.57
Postop, 90 days	30.2	19.2	0.32
Median Clavien-Dindo	2	1	0.69
95% CI	1.7–2.5	0.2–3.8	
Median CCI®	20.9	8.7	0.70
95% CI	15.9–27.7	0.1–37.7	
SSE (%)			
SSI	2.6	3.8	1.00
SSO	0	0	1.00
SSOPI	2.6	3.8	1.00
Readmission (%)	6.6	7.7	1.00
Mortality (%)	0	0	1.00

CCI® was calculated at 90 days postoperatively

o-TAR open transversus abdominis release, *r-TAR* robot-assisted transversus abdominis release; *CI* confidence interval, *SSE, CCI®* comprehensive complication index, *SSI* surgical site event, *SSI* surgical site infection, *SSO* surgical site occurrence, *SSOPI* surgical site occurrence requiring procedural intervention

Table 3 Postoperative complications of o-TAR and r-TAR Patients

	o-TAR ($n = 76$)	r-TAR ($n = 26$)	Clavien-Dindo class
Urologic (*n*)			
Urinary retention	6	2	I
Urinary tract infection	1	0	II
Acute kidney failure	1	0	IVa
Cardiovascular (*n*)			
Arrhythmia	4	0	II
SIRS	2	0	II
Pulmonary embolism	1	0	IVa
Dialysis graft thrombosis	1	0	IIIa
Stroke (ischemic)	1	0	IVa
Acute anemia	2	0	II
Respiratory (*n*)			
Atelectasis	5	0	II
ARDS	2	1	IVa
Respiratory failure	1	0	IVa
Pneumonia	2	0	II
Gastrointestinal (*n*)			
Postoperative ileus	1	1	I
Malnutrition	1	0	II
Pancreatic pseudocyst	1	0	I
Wound (*n*)			
SSI, superficial	1	0	I
SSI, deep	1	0	II
SSO, hematoma	0	1	IIIa

o-TAR open transversus abdominis release, *r-TAR* robot-assisted transversus abdominis release, *CCI®* comprehensive clinical index, *SIRS* systemic inflammatory response syndrome, *ARDS* acute respiratory distress syndrome, *SSI* surgical site infection

recovery pathway that included epidural analgesia, and psychosocial/family support (which was not limited or controlled). A similar proportion of patients in each cohort had closed suction drains, so any difference in short-term postoperative pain was unlikely due to indwelling drains. In addition, use of fibrin sealant alone to secure mesh, a practice supported by current literature and used in this study, may impact perception of pain postoperatively [19]. One factor that likely contributed to hospital LOS in both cohorts is the use of an enhanced recovery pathway, which is known to accelerate intestinal recovery, shorten hospital LOS, and minimize readmissions after ventral hernia repair [20]. Future prospective studies with assessment and comparison of postoperative pain scores using a validated scoring system would help clarify this issue. As for selection bias, every effort was made to offer eligible patients either o-TAR or r-TAR. Choice of operation varied based on patient-level factors, need for concomitant procedure (or involvement of other surgical specialists), as well as hernia and soft tissue characteristics.

When performed by experienced surgeons, o-TAR yields lower wound morbidity compared with open external oblique release, though the risk for wound-related events remains an issue [21]. Novitsky and colleagues reported on 426 consecutive o-TAR patients and found an SSE of 18.7%, SSI of 9.1%, hernia recurrence of 3.7%, and mesh debridement of 0.7% at a mean follow-up of 31.5 months. Most patients (66%) had a clean (CDC I) wound and 84% received permanent synthetic mesh [22]. Compared to published results, the present study showed similarly low rates of SSE and SSI after o-TAR. Like the previous report, most patients (96.2%) in the current series received either permanent synthetic mesh or hybrid (synthetic/biologic) mesh in the setting of clean or clean-contaminated wounds. Despite the similarities in short-term outcomes between these two studies, it can be difficult to generalize the current results to other patient populations due to potential variation in hernia characteristics, surgical technique, mesh type, and duration of follow-up.

Another retrospective, multi-institutional propensity-matched cohort study of patients from the Americas Hernia Society Quality Collaborative demonstrated the benefits of robot-assisted retromuscular VIH repair regarding hospital LOS, SSO, SSI, and SSOPI. The study propensity-matched 222 patients who underwent open retromuscular VIH repair to 111 patients who had robot-assisted retromuscular VIH repair. A similar proportion of patients in each cohort underwent TAR (83% o-TAR vs. 85% r-TAR, $P = 0.7$). Ultimately, the authors showed that patients who underwent a robot-assisted retromuscular VIH repair experienced a significantly shorter hospital LOS (1 day) with no difference in 30-day SSI rates (4vs. 2%, $P = 0.5$). Compared to open retromuscular VIH repair, the study demonstrated a significantly higher rate of SSO following the robot-assisted approach (14 vs. 32%, $P < 0.01$). The most common SSO was seroma not requiring procedural intervention. Out to 30 days postoperatively, few patients in the open and robot-assisted retromuscular VIH repair groups suffered SSOPI (5 vs. 4%, $P = 0.8$) [17]. Outcomes of the present study compare favorably to this published report in terms of shorter hospital LOS and low rates of SSO, SSI, and SSOPI using a robot-assisted approach to VIH repair. Longer follow-up will be ideal to determine true SSOPI and hernia recurrence rates after r-TAR.

There are limitations to this study. These data represent a single surgeon and single institution experience, so outcomes may not be generalizable and could vary based on surgeon and institutional characteristics. The reported operations represent advanced cases performed by a high-volume hernia surgeon with experience in o-TAR and robot-assisted minimally invasive hernia repair. Given the complexity of r-TAR, these operations should be reserved for surgeons experienced with both o-TAR and minimally invasive hernia repair techniques. While the data were collected prospectively, selection bias may have influenced results. To minimize selection bias, all patients regardless of CDC wound classification were analyzed with follow-up out to 90 days postoperatively. Including individuals with higher wound classes who are at increased risk for complications captures as many potential SSE as possible. The two cohorts were not propensity matched, but the two groups were statistically similar regarding demographics as well as hernia and mesh-specific details. The sample sizes, though small, were sufficient to detect a clinically significant difference in the primary outcome measure.

The learning curves of o-TAR and r-TAR are yet to be defined. A robot-assisted approach presents unique technical challenges that must be considered and overcome to ensure a safe, effective operation that is at least equivalent to o-TAR. To minimize the technical challenges that would impact short-term clinical outcomes, this study was undertaken after the operating surgeon had overcome the general learning curve of the robotic surgical platform for other various hernia repair techniques. While the goal was to minimize hospital LOS among all patients, it is possible that the r-TAR patients felt ready for hospital discharge earlier compared to o-TAR patients. Besides use of a robotic surgical platform, the shortened hospital LOS in the r-TAR group may be attributable to less pain from smaller incisions, less traction on abdominal wall musculature, and/or minimal use of transfascial sutures for mesh fixation.

Conclusions

The robotic surgical platform facilitates a safe, minimally invasive approach to complex abdominal wall reconstruction, specifically TAR. In the hands of experienced hernia

surgeons familiar with both the technique and technology, r-TAR results in demonstrably shorter hospital LOS with at least similar 90-day outcomes compared to o-TAR, which may translate to patient-centered value in health care delivery. The potential value of r-TAR seems apparent even during the learning curve. Randomized controlled trials are needed to determine and compare long-term clinical outcomes and overall costs of o-TAR and r-TAR.

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