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Multicenter review of robotic versus laparoscopic ventral hernia repair: is there a role for robotics?

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Abstract

Background The utilization of robotic platforms for general surgery procedures such as hernia repair is growing rapidly in the United States. A limited amount of data are available evaluating operative outcomes in comparison to standard laparoscopic surgery. We completed a retrospective review comparing robotic and laparoscopic ventral hernia repair to provide safety and outcomes data to help design a future prospective trial design.

Methods A retrospective review of 215 patients undergoing ventral hernia repair (142 robotic and 73 laparoscopic) was completed at two large academic centers. Primary outcome measure evaluated was recurrence. Secondary outcomes included incidence of primary fascial closure, and surgical site occurrences.

Results Propensity for treatment match comparison demonstrated that robotic repair was associated with a decreased incidence of recurrence (2.1 versus 4.2%, $p < 0.001$) and surgical site occurrence (4.2 versus 18.8%, $p < 0.001$). This may be because robotic repair was associated with increased incidence of primary fascial closure (77.1 versus 66.7%, $p < 0.01$). Analysis of baseline patient populations showed that robotic repairs were completed on patients with lower body mass index (28.1 ± 3.6 versus 34.2 ± 6.4, $p < 0.001$) and fewer comorbidities.

Conclusions Our retrospective data show that robotic repair was associated with decreased recurrence and surgical site occurrence. However, the differences noted in the patient populations limit the interpretability of these results. As adoption of robotic ventral hernia repair increases, prospective trials need to be designed in order to investigate the efficacy, safety, and cost effectiveness of this evolving technique.

Keywords Robotic hernia · Laparoscopic hernia · Retrospective

The laparoscopic approach to ventral hernia repair is increasingly utilized by surgeons and now accounts for approximately 1/2 of all repairs performed [1]. With nearly 400,000 ventral hernias repaired at a cost of over 3 billion dollars each year, small changes or improvements in laparoscopic ventral hernia repair (LVHR) can translate into a substantial impact on health care expenditures and patient outcomes [1].

Early case studies of laparoscopic hernia repairs described the reduction of hernia contents followed by fixation of an intraperitoneal mesh to the anterior abdominal wall for a "bridging repair" [2]. Since the initial reports, there have been a variety of modifications to the technique in an attempt to decrease recurrence and pain, hasten recovery and improve quality of life, and incorporate advances in surgical technology.

The utilization of robotic assistance during LVHR could afford several advantages derived from the additional degrees of freedom associated with robotic instruments. Surgeons, independent of advanced laparoscopic training and/or experience, may be able to more easily adopt and integrate complex technical maneuvers such as laparoscopic

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dissection of the hernia sac and/or intracorporeal suturing. This hypothesis is supported by a recent study completed by Stefanidis et al. comparing the da Vinci® robotic platform versus standard laparoscopic instruments in an FLS (Fundamentals of Laparoscopic Surgery) box trainer model. Findings did show higher suture scores with standard laparoscopic equipment (believed to be secondary to greater previous exposure); however, surgeons showed a clear preference towards robotic suturing [3]. The ability to efficiently complete laparoscopic suturing could potentially allow both increased rates of primary fascial closure as well as fixation of the mesh to the anterior abdominal wall without the need for transfascial sutures or tacks thereby improving postoperative pain, recovery, and function.

There are little published data comparing the outcomes between robotic and LVHR focusing on intraperitoneal mesh placement. Early literature focused upon retrospective reviews [4] and descriptive case series [5]. A retrospective review comparing 39 robotic repairs with 33 laparoscopic repairs observed longer operative times (156 versus 65 min) with larger hernia defects (3.07 versus 2.02 cm) with robotic repair. No differences in perioperative complications were observed with very short-term follow-up (47 days) [6]. A more recent retrospective review of the American Hearnia Society Quality Collaborative database (454 robotic repair and 177 LVHR) showed robotic repair to be associated with fewer surgical site occurrences (5 versus 14%, $p=0.001$); however, the need for occurrence requiring procedural intervention was similar (0 versus 1%, $p=1$) [7]. Currently, there are no long-term data published to compare the outcomes of robotic and LVHR.

We hypothesize that the utilization of a robotic platform will decrease recurrence as well as surgical site occurrences following LVHR.

Methods

In order to investigate robotic and LVHR outcomes, we completed a retrospective review of 215 patients (142 robotic repairs and 73 laparoscopic repairs) at two large academic centers (searching CPT codes 49652, 49653, 49654, 49655, 49656, and 49657). A total of ten surgeons enrolled patients in the study completing both robotic and laparoscopic repairs. As this was a retrospective review, technique, mesh type, and method of mesh fixation were secondary to surgeon preference. Primary outcome measure evaluated was recurrence. Secondary outcomes included incidence of primary fascial closure, and surgical site occurrences, length of stay, and operative time.

After protocol review and approval by the Institutional Review Boards at the University of Texas Health Science Center at Houston and The University of Nevada, Las Vegas School of Medicine, a retrospective chart review was completed on all patients undergoing robotic or laparoscopic ventral and incisional hernia repair from January 2009 through December 2015. All operative CPT codes for laparoscopic ventral and incisional hernia were reviewed in the case logs for inclusion in the study. Exclusion criteria included age < 18, emergent cases, and ventral hernia repair with concomitant cases.

All patients underwent hernia repair with intraperitoneal underlay mesh placement. As this was a retrospective review, multiple operative decisions including mesh size and laparoscopic fixation technique were deferred to surgeon preference. Robotic repairs all utilized the da Vinci® robotic system (Intuitive Surgical, Sunnyvale, CA). The most commonly utilized robotic technique included lysis of adhesions and reduction of hernia contents. The preperitoneal space was then entered and the space developed to mobilize and reduce or excise the hernia sac. After reduction of intraabdominal pressure, primary fascial closure was obtained per surgeon preference most commonly with a running absorbable 0 barbed suture (V-LOC™ absorbable suture, Covidien Inc, Mansfield, MA). The selected mesh was then fixed to the anterior abdominal wall via a circumferential V-LOC suture with full thickness bites through the posterior fascia.

LVHR was most commonly completed by similar lysis of adhesions and potential attempts at hernia sac reduction. If primary fascial closure was pursued, it was completed with a laparoscopic needle passer through stab incisions over the hernia. While mesh fixation technique was left to surgeon preference the most common method was a combination of transfascial sutures and tacks. The most common materials utilized with 0 PDS (polydioxanone) suture and absorbable tacks. While attempts at primary fascial closure and hernia sac resection were attempted in many hernia repairs, these factors were not controlled and also deferred to surgeon preference.

Patient characteristics identified included age, gender, American Society of Anesthesiologists (ASA) score, body mass index (BMI), hernia size, status of hernia recurrence, and the presence of comorbid medical conditions. Operative variables included case length (as defined by operative nursing logs from cut time to time of closure) as well as the incidence of primary fascial closure and hernia sac resection. Outcome measures recorded included recurrence, length of stay, and surgical site occurrence (seroma and surgical site infection). Recurrence and seroma formation were identified by clinical exam during post-operative visits in our chart review. Surgical site occurrence was identified from clinic notes with SSI defined as cellulitis, opening of a wound, or treatment requiring antibiotics. Of note, review of the records did not show the need for any invasive post-operative intervention or percutaneous drainage of seroma.

Two analyses were performed: First, the overall cohort was compared, and second, a propensity for treatment analysis was performed. For the overall cohort, robotic and laparoscopic repairs were compared using unpaired *t* test, kruskal Wallis test, or Chi-square. Then, a stepwise, multivariable logistic regression was performed for SSO. For the propensity for treatment match, patients were matched based upon factors considered to be important in selecting treatment including age, ASA score, BMI, previous hernia repairs, and hernia defect size (measured by hernia diameter). Outcomes for the propensity score matched cohorts were compared using McNemar's test. Of note, an alpha value of 0.5 was utilized, and continuous data are presented as mean ± standard deviation.

Results

Overall cohort

There were 215 total cases: 73 laparoscopic repairs and 142 robotic repairs. The robotic patient population was more likely to be male and have a lower BMI. All other preoperative patient characteristics were found to be similar (Table 1). Although the incidence of hernia sac resection was similar between the groups, primary fascial closure was achieved more often with robotic repair (71.1 versus 54.8%, $p=0.05$). Alternatively, operative times were shorter with laparoscopic repair (98.7 SD 56.6 min versus 116.9 SD 47.9 min, $p=0.03$).

No difference in recurrence was noted between the treatment groups (Table 2). However, robotic repair was associated with decreased overall surgical site occurrences,

Table 1 Baseline demographic and operative variables for laparoscopic and robotic ventral hernia repair

	Laparoscopic ($n=73$)	Robot ($n=142$)	*p* value
Demographic variables			
Age mean (SD)	49.5 (13.3)	53.2 (13.2)	0.06
Gender (number male)	24 (32.8%)	71 (50.0%)	0.02
ASA	2.6 (0.7)	2.5 (0.7)	0.34
BMI mean (SD)	35.7 (7.9)	31.6 (5.1)	<0.01
COPD	5 (6.8%)	12 (8.4%)	0.79
Diabetes	14 (19.2%)	19 (13.3%)	0.26
Smoking	28 (38.4%)	44 (31.0%)	0.29
Immunosuppression	2 (2.8%)	2 (1.4%)	0.61
Previous hernia repairs	25 (34.2%)	50 (35.2%)	0.82
Creatinine mean (SD)	1.1 (0.9)	0.9 (0.6)	0.37
Albumin mean (SD)	3.8 (0.7)	3.9 (0.3)	0.27
Horizontal diameter of hernia mean cm (SD)	4.1 (2.1)	4.3 (3.2)	0.76
Operative variables			
Hernia sac resection	10 (13.7%)	28 (19.7%)	0.35
Primary fascial closure	40 (54.8%)	101 (71.1%)	0.05
Length of case mean min (SD)	98.7 (56.6)	116.9 (47.9)	0.03

SD standard deviation

Table 2 Outcome measures following laparoscopic and robotic repair

	Laparoscopic ($n=73$)	Robot ($n=142$)	*p* value
Post-operative variables/outcomes			
Length of stay mean (SD)	0.7 (0.3)	1.4 (0.4)	0.09
SSI	5 (6.8%)	0	<0.01
Seroma	14 (19.2%)	13 (9.1%)	0.02
SSO	24 (32.8%)	24 (16.9%)	0.01
Recurrence	5 (6.8%)	11 (7.7%)	1
Follow-up weeks mean (SD)	23.6 (8.4)	12.3 (2.6)	0.01

SD standard deviation

seroma formation, and surgical site infection. No difference was observed in mean hospital stay. On multivariable analysis, SSO was associated with smoking (OR 3.73, 95% CI 1.28–11.87) while robotic repair was protective (OR 0.23, 95% CI 0.08–0.67).

Propensity for treatment matched cohorts

Overall, 96 patients were able to be matched (48 in each study group). Even after propensity score matching, robotic repair was associated with improved ability to achieve primary fascial closure (67 versus 77%, $p < 0.01$). SSOs (18.8 versus 4.2%, $p < 0.001$) and recurrence (4.2 versus 2.1%, $p < 0.01$) were reduced with robotic repair. Of note, the median observed follow-up was 6.0 weeks (IQR 3.9–9.4) for laparoscopic repair and 4.9 weeks (IQR 2.0–11.5) for robotic repair.

Discussion

Robotic-assisted LVHR, in our study, was associated with increased operative times, increased rates of primary fascial closure, and decreased overall surgical site occurrences. Evaluation of the entire patient cohort shows equivocal recurrence; however, propensity score matching and univariate analysis showed decreased recurrence as well as decreased surgical site occurrences after robotic hernia repair. These findings could be secondary to the increased incidence of primary fascial closure observed with robotic repair. Further evaluation indicates that the patient populations may not have been equal with the robotic arm having lower BMI patients with fewer comorbid conditions somewhat limiting the results.

The importance of primary fascial closure and resection of the hernia sac on surgical site occurrences (recurrence, seroma formation, and hematoma) is a topic of increasing interest. A recent systemic review comparing laparoscopic repair with primary fascial closure to a "bridging" repair suggested lower recurrence (0–5.7 versus 4.8–16.7%) and seroma formation rates (5.6–11.4 versus 4.3–27.8%) with primary fascial closure [8]. However, a more recent multicenter retrospective review of 1594 patients by Weenergren et al. failed to show a difference in either recurrence, seroma formation, or surgical site infection [9]. To further investigate this important question, Tandon et al. completed a meta-analysis of 16 studies consisting of 3638 patients. Significantly fewer adverse events (recurrence, pseudorecurrence, eventration, or tissue bulging) were found following primary fascial closure (RR 0.25, 95% CI 0.18–0.33, $p < 0.001$). In addition, decreased seroma formation (RR 0.37, 95% CI 0.23–0.57, $p < 0.001$) and shorter hospital stays were observed [10]. Overall, the necessity of primary fascial closure and hernia sac resection remains a topic of debate.

An additional topic of interest is the effect of LVHR on post-operative pain and return to function. Recent prospective long-term studies indicate significant post-operative pain and mobility restriction up to 1 month following laparoscopic ventral hernia repair [11]. While research is still ongoing, the mesh fixation technique seems to be the primary factor in the development of post-operative pain. Fixation with either permanent or absorbable tacks, transfascial sutures, or both transfascial sutures and tacks have all been associated with a significant effect on early post-operative pain and function [12, 13]. The published data currently available indicate that the development of novel techniques which could improve post-operative functionality would offer significant benefit to patient outcomes. While this review was unable to properly evaluate pain scoring, additional research into the effect of robotic fixation with a running suture is warranted.

This retrospective study is limited secondary to the potential for selection bias which is evident by the differing baseline patient population characteristics. While it is not uncommon to initially select "healthier" patients when developing a new technique, the interpretability of the results is affected by these differences. An additional limitation is surgeon preference or bias as the cases were not randomized. This could certainly affect the technical outcomes of hernia repair. Therefore, additional randomized, prospective trials are required to truly investigate the effect of robotic repair on hernia recurrence and patient outcomes.

Conclusions

Our retrospective data show that robotic repair was associated with increased operative time, increased rates of fascial closure, and decreased surgical site occurrences. The technique appears to be safe and not associated with increased complication rates. However, the differences in the patient populations limit the interpretability of these results. As robotic ventral hernia repair increases in popularity, additional prospective trials need to be designed in order to investigate the efficacy, safety, and cost effectiveness of this evolving technique.

Compliance with ethical standards

Disclosures Drs. Walker and Shah have sponsored research agreements with Neosurgical and Medigus Inc. to complete randomized controlled trials for medical devices. Dr. Tsuda receives an honoria to proctor for Intuitive Surgical and to speak for Acelity Inc. Dr. Wilson has sponsored research agreements with Neosurgical and Medigus Inc. to complete randomized controlled trials for medical devices. He receives an honoria to speak for Ethicon and Gore Inc. He receives an honoria

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