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Robotic retromuscular hernia repair optimizes short-term outcomes in higher risk patients

Keith Makhecha[1] · Sathvik Madduri[1] · Aaron R. Anderson[1] · Steven D. Mong[1] · Akrem Ahmed[1] · Dimitrios Stefanidis[1] · E. Matthew Ritter[1]

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Abstract

Background Smoking, obesity, diabetes mellitus, and COPD are known risk factors for surgical site occurrences (SSO) following open ventral hernia repair. However, little evidence exists on whether these factors also significantly impact SSO after robotic hernia repair. This is a particularly important distinction because robotic approaches have been associated with fewer wound complications. Our aim was to examine the impact of smoking, obesity, diabetes mellitus, and COPD on postoperative SSO after robotic retromuscular hernia repair.

Methods A retrospective review was conducted of a prospectively maintained database of ventral hernia repairs at three hospitals within our system from October 2019 to July 2022. These included extended totally extraperitoneal (eTEP) and transabdominal approaches along with transversus abdominis release (TAR). Patient demographics, preoperative evaluation, operative details, 30-day follow-up, and patient-reported outcomes were recorded in the Abdominal Core Health Quality Collaborative (ACHQC) database. Patients were grouped according to exposure; smokers vs. non-smokers, obesity (BMI > 40 vs. < 40), and the presence or absence of diabetes mellitus or COPD. The main outcome measure was SSO at one month follow-up. Logistic regression models were used to determine the association between smoking, obesity, diabetes mellitus, and COPD with postoperative SSO.

Results A total of 81 adult patients were included; mean age was 55 ± 13 years and 41% were women. ASA scores were as follows: 1 (0%), 2 (30%), 3 (64%), and 4 (4%). The prevalence of risk factors were smoking 17%, obesity 16%, diabetes mellitus 28%, and COPD 6%. The overall SSO rate at 30-day follow-up was 12.2%. SSO rates for obese vs. non-obese patients were 15.4% vs. 11.5%, respectively (p = 0.7). For smokers, the rate of SSO compared to non-smokers was 11.1% vs. 13.3% (p = 0.5). Logistic regression models showed that obesity (OR 0.75, 95% CI 0.13, 4.31; p = 0.7), diabetes (OR 2.04, 95% CI 0.36, 11.7; p = 0.4), smoking (OR 2.55, 95% CI 0.27, 23.9; p = 0.4), and COPD (OR 0.32, 95% CI 0.03, 3.93; p = 0.4) were not predictive of postoperative SSO.

Conclusion In our study, smoking, obesity, diabetes mellitus, and COPD did not predict 30-day follow-up wound complications after robotic retromuscular hernia repair. Given these findings, patients who are unable to optimize these risk factors may still be offered robotic retromuscular repair without increasing risk of postoperative SSO.

Keywords Robotic hernia repair · Minimally invasive · Surgical site occurrence · Surgical site infection · Complication · Smoking · Obesity · Diabetes · COPD · Retromuscular · Mesh · Follow-up

Smoking, obesity, diabetes mellitus, and COPD are known risk factors for SSO in open ventral and incisional hernia repair (1). Furthermore, optimization of these comorbidities prior to open repair has been shown to significantly decrease wound and other complications (Jensen 2022). Most of the current literature focuses on outcomes following open procedures; there has been little evidence to show if these factors also significantly impact SSO following procedures done minimally invasively.

Robot-assisted laparoscopic surgery has revolutionized the management of ventral and incisional hernias. Robotic surgery allows for more consistent minimally invasive access

✉ E. Matthew Ritter
emritter@iu.edu

[1] Department of Surgery, Comprehensive Hernia Program, Indiana University School of Medicine, 545 Barnhill Dr., EH 121, Indianapolis, IN 46202, USA

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to the retrorectus and retromuscular spaces through both transabdominal and extended totally extraperitoneal (eTEP) approaches. The improved dexterity facilitates achieving primary fascial closure and complex abdominal wall reconstruction using posterior component separation techniques such as the transversus abdominis release (TAR). These approaches are associated with decreased morbidity when compared to open and traditional laparoscopic techniques (2–4). Robotic retromuscular repairs have been shown to have smaller incisions, reduced postoperative surgical site occurrences (SSO), and faster recovery (5, 6). However, there are few studies comparing the incidence of SSO in patient populations with risk factors such as smoking, obesity, diabetes, and COPD.

While improving comorbid medical conditions is always an admirable goal, control of these comorbidities requires time and money (7, 8). During this prehabilitation period, hernias consistently enlarge and approximately 10% of those with hernias can be expected to present for emergency treatment over their lifetime (9). This is associated with higher rates of fistula formation, intraoperative perforation, and in-hospital mortality (10). Restrictions on preoperative control of comorbidities may disqualify large subsections of patients that would benefit from minimally invasive hernia repair. Recent studies suggest that some of these comorbidities may not be strong predictors of outcomes with minimally invasive repair (11). Thus, the aim of this study was to examine whether smoking, obesity, diabetes mellitus, and COPD were associated with increased postoperative SSO after robotic retromuscular hernia repair.

Methods

With institutional review board approval, we conducted a retrospective review of a prospectively maintained database for robotic-assisted retromuscular ventral and incisional hernia repairs within the Abdominal Core Health Quality Collaborative (ACHQC). Procedures were performed at one of three hospitals within our system from October 2019 to July 2022 and only data from our institution were analyzed. Midline and lateral hernias were included, but parastomal hernias were excluded. Transabdominal and extended totally extraperitoneal (eTEP) approaches were used to perform both retrorectus and retromuscular repairs with and without posterior component separation, including transversus abdominis release (TAR). Patient demographics, preoperative evaluation, operative details, 30-day follow-up, and patient-reported outcomes were collected.

The selection criteria for when to perform a robotic retromuscular repair were not standardized across the surgeons, but in general, robotic retromuscular repair was our default approach for defects ranging from 5 cm to 12 cm in maximum defect width. In general, patients with a rectus abdominis diameter of 7 cm or more, with no evidence of prior extensive retromuscular surgery were approached eTEP. Those with narrower rectus muscles or previous retromuscular procedures were approached transabdominally. For patients requiring a transabdominal approach, initial abdominal access was obtained via either an open or optically guided closed approach near the tip of the 10th rib in either the right or left upper quadrant as appropriate. For cases that were accessed eTEP, bilateral semilunar lines were marked with ultrasound by the operative team and the rectus sheath was accessed directly using an optically guided laparoscopic trocar. All additional ports were placed under direct visualization in the same plane as initial access. Either lateral dock or top dock positioning was utilized based on hernia location. Primary fascial closure of the hernia defect was achieved on all reported cases using slowly absorbable barbed suture. 2–0 suture was used for the posterior sheath and 0 for the anterior sheath. The hernia sack was incorporated into the closure of the anterior sheath whenever possible. Use of drains was not standardized, but in general, patients who underwent TAR had a closed suction drain placed on each side that was released. Retromuscular repairs without component separation were not routinely drained. Using glues or other fixation methods was at the discretion of the surgeon, but transfascial suture or tack fixation of mesh was not routinely used.

Patients were grouped according to documented comorbidities; smokers vs. non-smokers, class 3 or severe obesity (BMI > 40 vs. < 40), and the presence or absence of diabetes mellitus or COPD. The main outcome measure was SSO, defined as a surgical site infection with seroma, hematoma, wound drainage, or overlying cellulitis at one month follow-up as determined by physical exam or radiographic study when available. Logistic regression models were used to determine the association between smoking, obesity, diabetes mellitus, and COPD with postoperative SSO.

Continuous variables were reported by their mean (standard deviation), while categorical variables were reported as proportions (percentage) within the tables provided. Variables were compared across groups utilizing Student's t-test or Chi square test depending on variable type. A binary logistic regression model was used to explore potential predictors of interest (BMI, smoking, diabetes, and COPD) associated with the dichotomous outcome (SSO). Data analysis was performed utilizing IBM SPSS Statistics (Version 28) Statistical Software.

Results

We identified a cohort of 81 adult patients who underwent extended totally extraperitoneal (n = 36) and transabdominal (n = 45) ventral hernia repairs across three hospitals within

a single health system and patient characteristics are summarized in Table 1. TAR was required in 4 patients (11%) that were approached eTEP and 42 patients (93.3%) that were approached transabdominally.

The differences in smoking among the studied population are summarized in Table 2. Of the 16 active smokers, 6 patients (37.5%) underwent retrorectus repair alone, while 10 (62.5%) required additional TAR. Surgical site occurrence (SSO) was present in 1 patient (6.3%) in the smoking group and 8 patients (12.3%) in the non-smoking group (p = 0.52). The data regarding obesity are summarized in Table 3. There were 9 obese patients that underwent eTEP (56.3%) and 7 underwent transabdominal repair (43.8%). After 30-day follow-up, SSO occurred in 11.5% of the non-obese patients compared to 15.4% in the obese population (p = 0.350). The comparison between diabetes mellitus and postoperative complications is shown in Table 4. There were 11 patients with diabetes mellitus that underwent eTEP (47.8%) and 12 underwent transabdominal repair (52.2%). After 30-day follow-up, SSO occurred in 2 of the diabetic patients compared to 7 in the non-diabetic population (p = 0.54). The patients with and without COPD are summarized in Table 5. There were 5 patients with COPD that underwent eTEP (83.3%) and 1 that underwent transabdominal repair (16.7%). After 30-day follow-up, SSO occurred in 1 of the COPD patients compared to 8 in the non-COPD population (p = 0.49). None of the nine patients with SSO required intervention. Each of the comorbidities and its observed effect on SSO are compiled in Table 6.

Table 1 Population demographics

Patient characteristics	
Age, mean (SD)	55.07 (12.9)
Gender	
Male	48 (59.3%)
Female	33 (40.7%)
ASA score	
II	25 (30.9%)
III	52 (64.2%)
IV	3 (3.7%)
BMI < 40	65 (80.2%)
BMI > 40	16 (19.8%)
Tobacco usage	
Non-smoker	65 (80.2%)
Active smoker	16 (19.8%)
Diabetes	23 (28.4%)
COPD	6 (7.4%)
Type of hernia	
Ventral	9 (11.1%)
Incisional	71 (87.7%)
Surgical procedure	
eTEP	36 (44.4%)
Transabdominal	45 (55.5%)
Mesh type	
Heavy Weight Microporous Polypropylene (HWMP)	3 (3.7%)
Medium Weight Macroporous Polypropylene (MWMP)	73 (87.7%)
Medium Weight Macroporous PTFE (MWM PTFE)	3 (3.7%)
Mesh Length cm, mean (SD)	26.2 (6.6)
Mesh Width cm, mean (SD)	24.5 (6.5)
Hernia Length cm, mean (SD)	11.1 (6.39)
Hernia Width cm, mean (SD)	7.8 (4.01)
Postoperative complications	
30-day SSO	9 (11.1%)
Readmission	2 (2.5%)

SD Standard Deviation, *ASA* American Society of Anesthesiologists, *BMI* Body Mass Index, *COPD* Chronic Obstructive Pulmonary Disease, *eTEP* Extended Totally Extraperitoneal, *TAR* Transversus Abdominis Release, *SSO* Surgical Site Occurrence

Discussion

This study shows that there was not a significant association between 30-day wound complications and preoperative smoking, obesity, diabetes mellitus, and COPD. This suggests that these comorbidities did not increase the risk of SSO after robotic retromuscular hernia repair. As a result, strict requirements relating to common comorbidities may not be necessary if the robotic approach can be utilized. While ideal preoperative comorbidity management includes weight loss and smoking cessation, a significant subset of patients can be disqualified from surgery after failing to achieve prehabilitation goals. These patients receiving non-operative management incur a 5-year cumulative incidence of acute incarceration of at least 2.59% (12). Therefore, an understanding of the differences in SSO rates across robotic and open repair allows for best stratification of this risk.

The Ventral Hernia Working Group (VHWG) grading scale provides a validated prediction of SSO rates across different patient populations undergoing open ventral hernia repair. Within this system, Grade 1 patients have a low risk of complications, whereas Grade 2 patients have comorbidities including each of the four risk factors assessed in this paper with an additional comorbidity of immunosuppression. We would therefore predict the SSO rate of our patient population, if open repair was performed, to be between 14 and 29% (13). Our data showed the robotic 30-day SSO rate of 11.1%. This suggests that the minimally invasive approach afforded by the robot may reduce the risk of SSO when compared to open repair, despite being offered to highly comorbid patients.

To provide further context, we compared our results with existing literature assessing SSO across similarly high-risk patient populations. A retrospective, propensity score matched comparison of robotic and open ventral hernia

Table 2 Smoking and the effect on postoperative complications

Patient characteristics	Non-Smoker (n = 65)	Smoker (n = 16)	p value
Age, mean (SD)	55.78 (12.99)	52.19 (13.01)	0.166
Gender			
Male	36 (55.4%)	12 (75.0%)	
Female	29 (44.6%)	4 (25.0%)	0.153
ASA score			
II	19 (29.2%)	6 (37.5%)	
III	42 (64.6%)	10 (62.5%)	0.734
IV	3 (4.6%)	0 (0%)	
Weight			0.556
BMI < 40	53 (81.5%)	12 (75%)	
BMI > 40	12 (18.5%)	4 (25%)	
Diabetes	21 (32.3%)	2 (12.5%)	0.115
COPD	3 (4.6%)	3 (18.8%)	0.088
Type of hernia			
Ventral	7 (10.8%)	3 (12.5%)	
Incisional	57 (87.7%)	14 (87.5%)	0.869
Surgical procedure			0.618
eTEP	30 (46.2%)	6 (37.5%)	
Transabdominal	35 (53.8%)	10 (62.5%)	
Mesh type			0.249
HWMP	2 (3.1%)	1 (6.3%)	
MWMP	59 (86.2%)	14 (87.5%)	
MWM PTFE	3 (4.6%)	0 (0%)	
Mesh Length, mean (SD)	11.56 (6.45)	8.87 (5.88)	0.231
Mesh Width, mean (SD)	7.66 (3.84)	8.26 (4.82)	0.118
Postoperative complications			
30-day SSO	8(13.3%)	1 (7.1%)	0.523
Readmission	1(1.6%)	1 (6.7%)	0.350

SD Standard Deviation, *ASA* American Society of Anesthesiologists, *BMI* Body Mass Index, *eTEP* Extended Totally Extraperitoneal Repair, *TAR* Transversus Abdominis Release, *SSO* Surgical Site Occurrence

repair in patients with BMI greater than 35 and smoking or diabetes status was the first to show equivocal 30-day SSO with improved infection and intervention rates in the robot repair sample (14). This study's robotic 30-day SSO rate of 23% was higher than our 11.1%, however, their inclusion criteria of two concurrent risk factors, different BMI cutoffs defining obesity, and exclusion of COPD status introduced limitations in direct comparison of SSO.

More recently, the ORREO trial was a prospective randomized controlled trial that directly compared open and robotic ventral hernia repair up to two years postoperatively (15). The trial randomized 100 patients with similar hernia characteristics and at least one of the four comorbidities included in our study, though obesity was classified as BMI > 30. In this study, 2-year follow-up was completed and no significant difference was found between the groups across SSI, SSO, readmission, or hernia recurrence. The authors found a robotic 2-year SSO rate of 47.8% and state that their rate is higher than the Gaskins trial due to its selection and reporting biases introduced by voluntary, surgeon-entered data in ACHQC. However, further study is needed, as the SSO rate varies from our study's to a degree that attributing this to confounding biases would require formal analysis. This study was the first of its kind but would benefit from further trials as it was underpowered; the authors reported difficulty in reaching their desired sample size due to the randomization process and patient preference for one approach over the other, as well as follow-up of only 62% of enrolled patients. Given our shorter term, 30-day follow-up, we are unable to compare patient attrition, however, it is possible that patients following up for 2 years are self-selected as having adverse outcomes, whereas those without complications may be less inclined to follow-up beyond 30 days.

Table 3 Obesity and the effect on postoperative complications

Patient characteristics	BMI < 40 (n = 65) BMI > 40 (n = 16)	p value	
Age, mean (SD)	56.37 (12.57)	49.81 (13.7)	0.070
Gender			
Male	38 (58.5%)	10 (62.5%)	
Female	27(41.5%)	6 (37.5%)	0.772
ASA score			
II	24 (36.9%)	1(6.3%)	
III	38 (58.5%)	14 (87.5%)	0.005
IV	2 (3.1%)	1 (6.3%)	
Tobacco usage			0.281
Non-smoker	53 (81.5%)	12 (75%)	
Active smoker	12 (18.5%)	4 (25%)	
Diabetes	21 (32.3%)	2 (12.5%)	0.065
COPD	5 (7.7%)	1 (6.5%)	0.423
Type of hernia			
Ventral	6 (9.2%)	3 (18.8%)	
Incisional	59 (90.8%)	12 (75%)	0.353
Surgical procedure			0.002
eTEP	27(41.5%)	9 (56.3%)	
Transabdominal	38(58.5%)	7 (43.9%)	
Mesh type			0.010
HWMP	3 (4.6%)	0 (0%)	
MWMP	61 (93.8%)	12 (75.0%)	
MWM PTFE	1 (1.5%)	2 (12.5%)	
Mesh Length, mean (SD)	11.37 (6.44)	9.55 (6.15)	0.179
Mesh Width, mean (SD)	7.42 (3.65)	9.44 (5.25)	0.104
Postoperative complications			
30-day SSO	7(10.8%)	2 (12.5%)	0.350
Readmission	1(1.5%)	1 (6.3%)	0.458

SD Standard Deviation, *ASA* American Society of Anesthesiologists, *BMI* Body Mass Index, *eTEP* Extended Totally Extraperitoneal, *TAR* Transversus Abdominis Release, *SSO* Surgical Site Occurrence

Whereas our study suggests reduction of SSO with robotic repair when compared to previous literature, there are limitations attributable to our study design. One limitation was that the database included retromuscular repairs performed by only two surgeons using two Da Vinci Surgical Systems (Si and Xi). The two surgeons represented by our data operate within a practice focused on abdominal wall surgery, thus these data may not be directly extrapolated to surgeons with a broader practice. Although this study has a larger cohort size and follow-up period than previously reported studies, long-term SSO and a larger sample size would strengthen the results of this study. This would allow for a more meaningful analysis of the impact of comorbidities and the necessity of prehabilitation.

One similar limitation was that SSO was determined retrospectively using clinic notes and radiologic imaging available 1–3 months postoperatively. The limited time frame of this follow-up may result in under-reported rates of SSO. While most SSO occur within the first 30-days, some wound complications can take up to 1-year to present (16). Additionally, patients without radiological imaging may have an increased risk of missing SSO if these were subclinical or not clearly documented during the postoperative visit. Therefore, further investigation, potentially incorporating point of care ultrasound for determination of postop seroma and longer-term follow-up is warranted to ensure this benefit persists.

Table 4 Diabetes and the effect on postoperative complications

Patient characteristics	Non-Diabetic (n = 58)	Diabetic (n = 23)	p value
Age, mean (SD)	52.79 (13.48)	60.83 (9.73)	0.002
Gender			
Male	38 (65.5%)	10 (43.5%)	
Female	20 (34.5%)	13 (56.5%)	0.069
ASA score			
II	22 (37.9%)	3 (13%)	
III	34 (58.6%)	18 (78.3%)	0.077
IV	1 (1.7%)	2 (8.7%)	
Weight			0.115
BMI < 40	44 (75.9%)	21 (91.3%)	
BMI > 40	14 (24.1%)	2 (8.7%)	
Tobacco usage			0.115
Non-smoker	44 (75.9%)	21 (91.3%)	
Active smoker	14 (24.1%)	2 (8.7%)	
COPD	20 (87%)	3 (13%)	0.220
Type of hernia			
Ventral	9 (15.5%)	0 (0%)	
Incisional	48 (82.8%)	23 (100%)	0.869
Surgical procedure			0.438
eTEP	25 (43.1%)	11 (47.8%)	
Transabdominal	33 (56.9%)	12 (52.2%)	
Mesh type			0.772
HWMP	3 (5.2%)	0 (0%)	
MWMP	51 (86.2%)	22 (91.3%)	
MWM PTFE	2 (3.4%)	2 (4.3%)	
Mesh Length, mean (SD)	10.5 (5.68)	12.63 (8.07)	0.067
Mesh Width, mean (SD)	7.72 (3.92)	7.93 (4.36)	0.397
Postoperative complications			
30-day SSO	7 (13.7%)	2 (8.7%)	0.540
Readmission	1 (1.8%)	1 (4.3%)	0.505

SD Standard Deviation, *ASA* American Society of Anesthesiologists, *BMI* Body Mass Index, *eTEP* Extended Totally Extraperitoneal Repair, *TAR* Transversus Abdominis Release, *SSO* Surgical Site Occurrence

Table 5 COPD and the effect on postoperative complications

Patient characteristics	Non-COPD (n = 75)	COPD (n = 6)	p value
Age, mean (SD)	54.55 (13.33)	61.67 (4.08)	0.003
Gender			
Male	43 (57.45%)	5 (83.3%)	
Female	32 (42.7%)	1 (16.7%)	0.393
ASA score			
II	25 (33.3%)	0 (0%)	
III	47 (62.7%)	5 (83.3%)	0.145
IV	2 (2.7%)	1 (16.7%)	
Weight			0.844
BMI < 40	60 (80%)	5 (83.3%)	
BMI > 40	15 (20%)	1 (16.7%)	
Tobacco usage	0.088		
Non-smoker	62 (82.7%)	3 (50%)	
Active smoker	13 (17.3%)	3 (50%)	
Diabetes	20 (26.7%)	3 (50%)	0.345
Type of hernia			
Ventral	8 (10.7%)	1 (16.7%)	
Incisional	66 (88%)	5 (83.3%)	0.872
Surgical procedure			0.087
eTEP	31 (41.3%)	5 (83.3%)	
Transabdominal	44 (58.7%)	1 (16.7%)	
Mesh type			0.312
HWMP	3 (4.0%)	0 (0%)	
MWMP	67 (88%)	6 (83.3%)	
MWM PTFE	3 (4.0%)	0 (0%)	
Mesh Length, mean (SD)	11.01 (6.23)	11.75 (10.01)	0.411
Mesh Width, mean (SD)	7.6 (3.81)	11.13 (6.51)	0.043
Postoperative complications			
30-day SSO	8 (11.6%)	1 (20.0%)	0.487
Readmission	2 (2.8%)	0 (0%)	1.000

SD Standard Deviation, *ASA* American Society of Anesthesiologists, *BMI* Body Mass Index, *eTEP* Extended Totally Extraperitoneal Repair, *TAR* Transversus Abdominis Release, *SSO* Surgical Site Occurrence

Table 6 Comorbidities and lack of significant association with SSO

	Odds Ratio	95% CI	*p value*
BMI > 40	0.75	0.23–7.76	0.74
Diabetes	2.04	0.09–2.91	0.42
Active Smoker	2.55	0.04–3.68	0.41
COPD	0.32	0.26–37.6	0.38

Conclusion

In this retrospective review, preoperative comorbidities including smoking, obesity, diabetes mellitus, and COPD were not associated with increased rates of SSO 30-days after robotic retromuscular hernia repair. Given this finding, patients who are unable to optimize these risk factors may still be offered robotic retromuscular repair without increasing risk of postoperative SSO.

Declarations

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