

# Laparoscopy decreases complications for obese patients undergoing elective rectal surgery

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## Abstract

**Introduction** While there are many reported advantages to laparoscopic surgery compared to open surgery, the impact of a laparoscopic approach on postoperative morbidity in obese patients undergoing rectal surgery has not been studied. Our goal was to determine whether obese patients undergoing laparoscopic rectal surgery experienced the same benefits as non-obese patients.

**Methods** We identified patients undergoing rectal resections using the National Surgical Quality Improvement Project Participant Use Data File. We performed multivariable analyses to determine the independent association between laparoscopy and postoperative complications.

**Results** A total of 26,437 patients underwent rectal resection. The mean age was 58.5 years, 32.6 % were obese, and 47.2 % had cancer. Laparoscopic procedures were slightly less common in obese patients compared to non-obese patients (36.0 vs. 38.2 %,  $p = 0.0006$ ). In unadjusted analyses, complications were lower with the laparoscopic approach in both obese (18.9 vs. 32.4 %,  $p < 0.0001$ ) and non-obese (15.6 vs. 25.3 %,  $p < 0.0001$ ) patients. In a multivariable analysis controlling for potential confounders, the risk of postoperative complications

increased as the degree of obesity worsened. The likelihood of experiencing a postoperative complication increased by 25, 45, and 75 % for obese class I, obese class II, and obese class III patients, respectively. A laparoscopic approach was associated with a 40 % decreased odds of a postoperative complication for all patients (OR 0.60, 95 % CI 0.56–0.64).

**Conclusion** Laparoscopic rectal surgery is associated with fewer complications when compared to open rectal surgery in both obese and non-obese patients. Obesity was an independent risk factor for postoperative complications. In appropriately selected patients, rectal surgery outcomes may be improved with a minimally invasive approach.

**Keywords** Obesity · Pelvic surgery · Surgical outcomes · Laparoscopic versus open surgery · Rectal surgery

Greater than two-thirds of Americans are obese [body mass index (BMI)  $\geq 30$  kg/m<sup>2</sup>] or overweight (BMI 25.0–29.9 kg/m<sup>2</sup>) [1, 2]. For patients undergoing surgery, obesity is known to be associated with increased postoperative complications and increased technical difficulty [3]. The increased adipose tissue hinders both adequate exposure and direct visualization and often adds to the surgical complexity, resulting in increased operative times and technical complications [4]. Obesity has been shown to independently increase the risk of atelectasis, thromboembolic events, colorectal anastomotic leakage, and surgical site infections (SSI) in patients undergoing colorectal resection [4, 5].

Compared to open surgery, laparoscopic surgery has been associated with fewer postoperative complications, earlier mobilization, and lower infection rates [6]. Compared to the open approach, laparoscopy facilitates

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visualization in a narrow pelvis, reduces hospital length of stay, and results in fewer postoperative complications [7–10]. As a result, laparoscopy has the potential to minimize surgical morbidity and mortality for obese patients. However, in obese patients, laparoscopy is also more challenging due to larger amounts of intraabdominal/visceral fat and potential difficulty obtaining peritoneal access and maintaining pneumoperitoneum. As such, it is unknown whether obese patients undergoing laparoscopic rectal surgery derive the same benefits from a minimally invasive approach as non-obese patients.

The focus of this study was to characterize the outcomes of open and laparoscopic rectal surgery in obese patients and non-obese patients using data from the American College of Surgeons National Quality Improvement Program (ACS-NSQIP). We hypothesized that outcomes would be worse with increasing BMI and that laparoscopic rectal surgery compared to open surgery would improve outcomes for both obese and non-obese patients, with particular effect in the obese population.

## Methods

This study was submitted for review to the Institutional Review Board at the University of Texas Medical Branch and was deemed to be exempt.

### Data source

Data from the ACS-NSQIP Participant Use Data Files (PUF) were used. The ACS-NSQIP is a risk-adjusted, outcome-based, quality improvement program designed to prospectively collect 30-day morbidity and mortality for all major surgical procedures [11]. As a participating institution, the University of Texas Medical Branch was granted access to the data for research purposes.

### Study sample

Using PUF data from 2005 through 2011, we identified patients with *Current Procedural Terminology* (CPT) codes for open and laparoscopic rectal resections with or without primary anastomosis (CPT codes: 45110, 45111, 45112, 45113, 45119, 45120, 44145, 44146, 44155, 44207, 44208, 44211, 44212, 44157, 44158, 45395, 45397). Only patients undergoing elective operations were included. Patients with a previous operation within 30 days, American Society of Anesthesiologists (ASA) class of 4 or 5, and patients with disseminated cancer were excluded. Patients with missing ASA class, height, or weight measurements, and patients with a BMI < 18 were also excluded (Fig. 1).

## Outcome measures

The outcomes studied included superficial site infections (SSI) deep or organ space infections or dehiscence, pulmonary complications (unplanned intubation, pneumonia, or failure to wean from the ventilator in 48 h), acute renal failure, thromboembolic events (pulmonary embolism, DVT requiring therapy, or DVT/thrombophlebitis), sepsis, need for blood transfusions, return to the operating room, operative time, hospital length of stay, and 30-day mortality. Overall 30-day morbidity was defined as any of the complications listed above.

## Covariates

Patient characteristics included age, BMI, sex, race, ASA class, tobacco use, alcohol use, presence of malignancy, and comorbid conditions. Operative factors included type of procedure (laparoscopic vs. open), wound classification, and creation of a primary bowel anastomosis without a diverting ostomy. BMI categories were defined as: normal: BMI 18 to < 25 kg/m<sup>2</sup>, overweight: BMI 25 to <30 kg/m<sup>2</sup>, obese class I: BMI 30 to <35 kg/m<sup>2</sup>, obese class II: BMI 35 to <40 kg/m<sup>2</sup>, and obese class III: BMI ≥ 40 kg/m<sup>2</sup>. Malignancy was identified using postoperative diagnosis ICD-9 codes. Primary bowel anastomosis without a diverting stoma was defined using the following CPT codes: 45111, 45112, 45113, 45120, 44145, and 44207.

## Statistical analysis

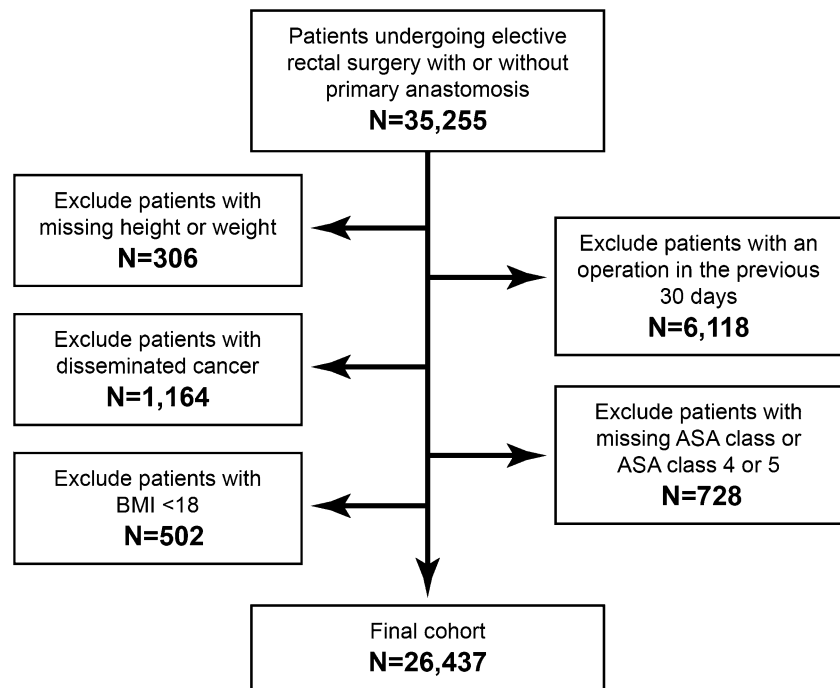
Baseline characteristics of the study cohort were described using descriptive statistics. Bivariate analysis was performed to evaluate the patient factors associated with the operative approach for both obese and non-obese patients; Chi-square tests were used for categorical variables and *t* test for continuous variables. A multivariable logistic regression model was constructed for the entire cohort controlling for patient level factors and including the interaction between operative approach and obesity status to determine the association between operative approach and complications. The interaction was not significant in the multivariable model; therefore, it was not included in the final model. In the final multivariable logistic regression model, BMI was entered as a categorical variable.

Analyses were performed with SAS version 9.3 (SAS Inc., Cary, NC, USA). Statistical significance was accepted at the *p* < 0.05 level. All *p* values were from two-sided tests.

## Results

We identified 26,437 patients undergoing elective rectal resections with or without primary bowel anastomosis. Their characteristics are summarized in Table 1. The mean

**Fig. 1** ACS-NSQIP cohort selection 2005–2011. We identified patients with CPT codes for elective rectal resections with or without primary anastomosis. Patients who had had a previous operation within 30 days, those with an ASA class of 4 or 5, or were missing ASA class, height, or weight measurements, patients with disseminated cancer, and patients with a BMI < 18 were excluded



age of the cohort was  $58.5 \pm 14.9$  years, and the mean BMI was  $28.3 \pm 6.2$  kg/m<sup>2</sup>. Thirty-two percent of patients ( $N = 8613$ ) were classified as obese (5247 patients obese class I, 2134 patients obese class II, and 1232 patients obese class III). Cancer was present in 47.2 % of the cohort, and diabetes was documented in 12.2 %. Open procedures were more commonly performed, with 62.6 % of the cohort having an open operation. A primary bowel anastomosis without a protective diverting stoma was performed in 16,878 patients (63.8 %). Postoperative complications occurred in 6221 patients (23.5 %), and 30-day operative mortality was 0.7 % for the overall cohort.

#### Unadjusted analysis—non-obese versus obese patients

Obese patients had a mean BMI of  $35.2 \pm 5.2$  kg/m<sup>2</sup>. They were more likely to be younger, female, black, diabetic, and have a higher ASA class than non-obese patients and less likely to use alcohol and tobacco (Table 1).

Unadjusted operative factors and operative outcomes are given in Table 2. Laparoscopic procedures were performed more commonly in non-obese patients (38.2 vs. 36.0 %,  $p = 0.0006$ ). There was no difference in laparoscopic surgery rates versus open surgery rates between obese men and women. Laparoscopic surgery was performed in 17.7 % of men and 18.2 % of women ( $P = \text{NS}$ ). While wound classification was similar, obese patients were more likely to undergo primary bowel anastomosis without a

diverting stoma. The absence of a protective stoma in this population did not lead to a higher rate of overall complications, deep space infections, or sepsis in these patients. Obese patients with a primary bowel anastomosis without a diverting stoma had a postoperative complication rate of 24.2 % compared to a rate of 34.4 % for patients with a diverting stoma ( $p < 0.0001$ ). The deep or organ space infection rate for this group was 6.5 versus 4.1 % for patients with and without a stoma, respectively ( $p < 0.0001$ ). Similarly, the rate of sepsis was higher in patients with a stoma (8.8 vs. 5.5 %,  $p < 0.0001$ ). Operative times were longer in the obese group. Obese patients had a higher 30-day morbidity rate (27.5 vs. 21.6 %,  $p < 0.0001$ ) and a higher rate of wound, pulmonary, renal, thromboembolic, and septic complications compared to non-obese patients. Obese patients also had more reoperations within the 30-day postoperative period and more blood transfusions (Table 2). Despite the increased complication rates, mean lengths of stay were similar between the two groups (7.7 vs. 7.8 days).

Complication rates were higher for obese patients, regardless of surgical approach. Laparoscopy benefited both groups with lower rates of complications in comparison with open procedures (Fig. 2). When compared to non-obese patients undergoing laparoscopic rectal resection, obese patients undergoing laparoscopic rectal resection had higher overall complication rates and a higher incidence of SSI, deep or organ space infections, wound dehiscence, and blood transfusions (Fig. 2). Length of stay was lower with laparoscopy in both obese (mean = 5.8 vs. 8.8 days,

**Table 1** Overall cohort and bivariate analysis comparing patient demographic factors in non-obese and obese patients

Factor	Overall cohort <i>N</i> = 26,437	Normal <i>N</i> = 8622	Overweight <i>N</i> = 9202	Class I obesity <i>N</i> = 5247	Class II obesity <i>N</i> = 2134	Class III obesity <i>N</i> = 1232	<i>p</i> value
Age (mean; years)	58.5 ± 14.9	58.5 ± 17.1	59.3 ± 14.4	58.5 ± 13.1	56.7 ± 12.8	55.1 ± 12.3	<0.0001
BMI (mean; kg/m <sup>2</sup> )	28.3 ± 6.2	22.3 ± 1.8	27.4 ± 1.4	32.2 ± 1.4	37.1 ± 1.4	45.1 ± 5.6	NA
Obesity (yes)	8613 (32.6 %)	NA	NA	NA	NA	NA	NA
BMI category (kg/m <sup>2</sup> )							NA
Normal: <25	8622 (32.6 %)	8622 (100 %)	NA	NA	NA	NA	
Overweight: 25 to <30	9202 (34.8 %)	NA	9202 (100 %)	NA	NA	NA	
Class I obesity: 30 to <35	5247 (19.8 %)	NA	NA	5247 (100 %)	NA	NA	
Class II obesity: 35 to <40	2134 (8.1 %)	NA	NA	NA	2134 (100 %)	NA	
Class III obesity: ≥40	1232 (4.7 %)	NA	NA	NA	NA	1232 (100 %)	
Gender							
Female	12,846 (48.7 %)	4739 (36.9 %)	3758 (29.2 %)	2410 (18.8 %)	1165 (9.1 %)	774 (6.0 %)	<0.0001
Race							<0.0001
White	21,524 (89.6 %)	6922 (32.2 %)	7518 (34.9 %)	4336 (20.1 %)	1755 (8.2 %)	993 (4.6 %)	
Black	1628 (6.8 %)	463 (28.4 %)	532 (32.7 %)	343 (21.1 %)	171 (10.5 %)	119 (7.3 %)	
Hispanic	190 (0.8 %)	65 (34.2 %)	67 (35.3 %)	37 (19.5 %)	16 (8.4 %)	5 (2.6 %)	
Other	666 (2.8 %)	371 (55.7 %)	196 (29.4 %)	68 (10.2 %)	21 (3.2 %)	10 (1.5 %)	
ASA class							<0.0001
1	916 (3.5 %)	399 (43.5 %)	372 (40.6 %)	107 (11.7 %)	31 (3.4 %)	7 (0.8 %)	
2	14,868 (56.2 %)	4974 (33.4 %)	5433 (36.5 %)	2966 (20.0 %)	1039 (7.0 %)	456 (3.1 %)	
3	10,653 (40.3 %)	3249 (30.5 %)	3397 (31.9 %)	2174 (20.4 %)	1064 (10.0 %)	769 (7.2 %)	
Cancer (yes)	12,488 (47.2 %)	4107 (32.9 %)	4412 (35.3 %)	2427 (19.4 %)	938 (7.5 %)	604 (4.9 %)	0.0042
Tobacco use (yes)	4782 (18.1 %)	1852 (38.7 %)	1573 (32.9 %)	850 (17.8 %)	325 (6.8 %)	182 (3.8 %)	<0.0001
Alcohol use (yes)	938 (3.6 %)	315 (33.6 %)	358 (38.2 %)	193 (20.6 %)	49 (5.2 %)	23 (2.4 %)	<0.0001
Diabetes (yes)	3220 (12.2 %)	523 (16.2 %)	995 (30.9 %)	865 (26.9 %)	481 (14.9 %)	356 (11.1 %)	<0.0001

$p < 0.0001$ ) and non-obese (mean = 6.0 vs. 8.7 days,  $p < 0.0001$ ) patients. While all complication rates were higher, open rectal surgery demonstrated similar patterns of morbidity in obese patients compared to non-obese patients (Fig. 2). Obese patients had higher rates of SSI, deep or organ space infections, wound dehiscence, thromboembolic events, sepsis, blood transfusions, and reoperations.

### Adjusted analyses

Table 3 reports the results for the final multivariable model. We evaluated the interaction between obesity and operative approach (open vs. laparoscopic). The interaction was not statistically significant ( $p$  value of 0.16), indicating that both obese and non-obese patients had similar benefit from the laparoscopic approach. Therefore, the interaction was not included in the final model. After controlling for gender, race, ASA class, primary bowel anastomosis, and

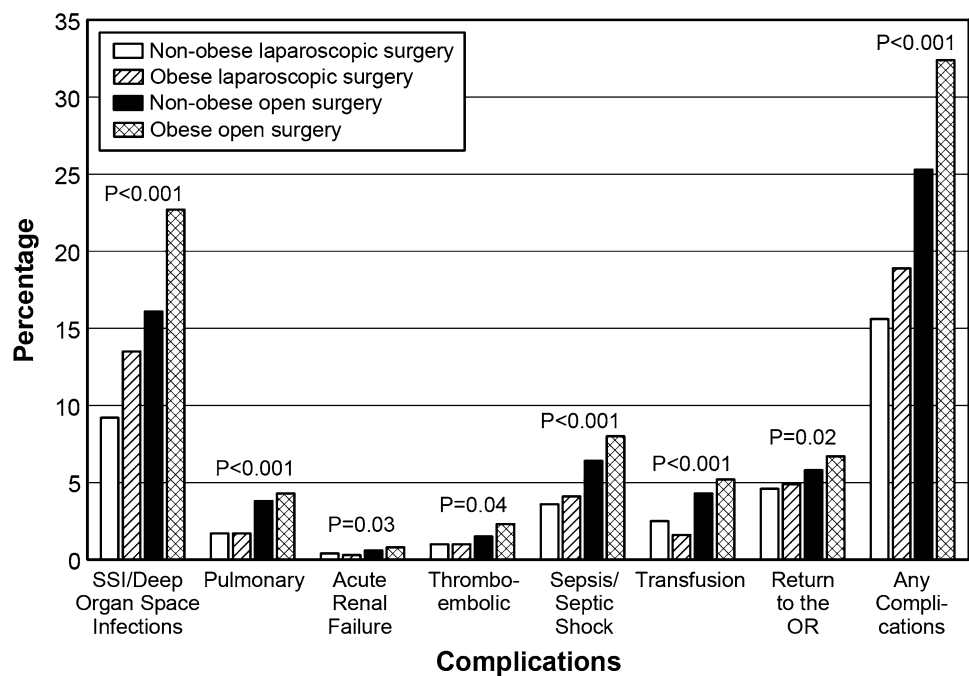
patient comorbidity, a laparoscopic approach was associated with 40 % lower odds of postoperative complications (OR 0.60, 95 % CI 0.56–0.64). The likelihood of postoperative morbidity increased as the degree of obesity worsened. Compared to normal BMI patients, obese class I patients (BMI 30 to <35 kg/m<sup>2</sup>) had 25 % higher odds of developing a postoperative complication, obese class II patients (BMI 35 to <40 kg/m<sup>2</sup>) had 45 % higher odds of developing a postoperative complication, and obese class III patients (BMI ≥ 40 kg/m<sup>2</sup>) had a 75 % higher odds of developing a postoperative complication (Fig. 3).

### Discussion

Our study demonstrates that laparoscopic rectal surgery is associated with lower complication rates when compared to open rectal surgery in both obese and non-obese patients.

**Table 2** Bivariate analysis comparing operative factors and morbidity and mortality in obese and non-obese patients

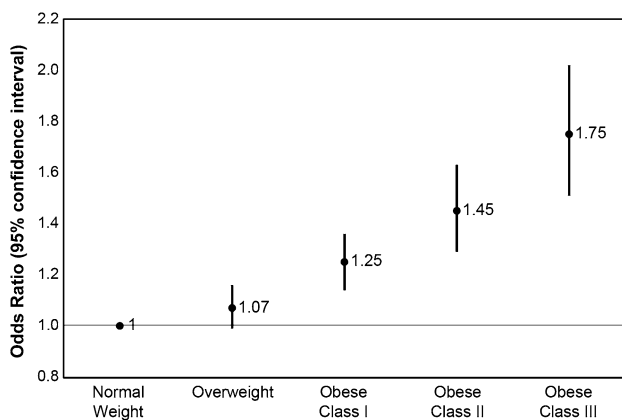
Factor	Normal N = 8622	Overweight N = 9202	Class I obesity N = 5247	Class II obesity N = 2134	Class III obesity N = 1232	p value
Procedure type						<0.0001
Open	5405 (62.7 %)	5620 (61.1 %)	3239 (61.7 %)	1423 (66.7 %)	853 (69.2 %)	
Laparoscopic	3217 (37.3 %)	3582 (38.9 %)	2008 (38.3 %)	711 (33.3 %)	379 (30.8 %)	
Wound classification						NS
Clean	19 (0.2 %)	18 (0.2 %)	16 (0.3 %)	4 (0.2 %)	7 (0.65 %)	
Clean contaminated	7150 (82.9 %)	7605 (82.6 %)	4315 (82.2 %)	1735 (81.3 %)	1006 (81.67 %)	
Contaminated	1026 (11.9 %)	1105 (12.0 %)	650 (12.4 %)	291 (13.6 %)	144 (11.7 %)	
Dirty/infected	427 (5.0 %)	474 (5.2 %)	266 (5.1 %)	104 (4.9 %)	75 (6.1 %)	
Anastomosis w/o stoma (yes)	5118 (59.4 %)	5938 (64.5 %)	3513 (67.0 %)	1473 (69.0 %)	836 (67.9 %)	<0.0001
Operative time (mean; min)	203.3 ± 98.5	211.9 ± 101.7	218.0 ± 103.7	225.3 ± 106	234.3 ± 109.2	<0.0001
Any complication	1848 (21.4 %)	2003 (21.8 %)	1331 (25.4 %)	616 (28.9 %)	423 (34.3 %)	<0.0001
Specific complications						
Superficial wound infections	708 (8.2 %)	986 (10.7 %)	691 (13.2 %)	367 (17.2 %)	279 (22.7 %)	<0.0001
Deep organ space infections	429 (5.0 %)	433 (4.7 %)	248 (4.7 %)	99 (4.6 %)	71 (5.8 %)	NS
Pulmonary	280 (3.3 %)	250 (2.7 %)	167 (3.2 %)	78 (3.7 %)	44 (3.6 %)	NS
Acute renal failure	32 (0.4 %)	59 (0.6 %)	27 (0.5 %)	14 (0.7 %)	13 (1.1 %)	0.01
Thromboembolic	126 (1.5 %)	108 (1.2 %)	97 (1.9 %)	41 (1.9 %)	22 (1.8 %)	0.006
Sepsis/septic shock	461 (5.4 %)	501 (5.4 %)	317 (6.0 %)	150 (7.0 %)	100 (8.1 %)	0.0001
Transfusion	355 (4.1 %)	292 (3.2 %)	196 (3.7 %)	96 (4.5 %)	47 (3.8 %)	0.005
Return to the OR	486 (5.6 %)	472 (5.1 %)	298 (5.7 %)	137 (6.4 %)	85 (6.9 %)	0.03
Length of stay (mean; days)	7.8 ± 7.0	7.6 ± 6.5	7.5 ± 5.8	7.9 ± 7.7	8.6 ± 8.8	<0.0001
30-day mortality	76 (0.9 %)	51 (0.6 %)	32 (0.6 %)	12 (0.6 %)	9 (0.7 %)	NS

**Fig. 2** Overall complication rate and specific complications in patients undergoing rectal surgery stratified by operative approach and presence of obesity

**Table 3** Multivariable logistic regression models modeling the odds of developing a postoperative complication in non-obese and obese patients

Factor (Ref.)	OR (95 % CI)
Laparoscopic procedure type (open)	0.60 (0.56–0.64)
BMI category (normal)	
Overweight	1.07 (0.99–1.16)
Obese class I	1.25 (1.14–1.36)
Obese class II	1.45 (1.29–1.63)
Obese class III	1.75 (1.51–2.02)

Model also controlled for age, sex, race, ASA class, creation of an anastomosis, diabetes, dyspnea, COPD, esophageal varices, congestive heart failure, history of MI, previous coronary stent, angina, hypertension, peripheral vascular disease, dialysis, hemiparesis, cerebrovascular accidents, presence of preoperative wound, chronic steroid use, >10 % weight loss in 6 mos prior to surgery, bleeding disorder, cancer diagnosis, chemotherapy, radiation, and preoperative sepsis

**Fig. 3** Odds ratios of developing a postoperative complication based on BMI category

Controlling for patient factors, the risk of developing a postoperative complication in patients undergoing rectal surgery increased as BMI increased. For patients with a BMI  $\geq 40$ , the risk of postoperative morbidity was 75 % higher even after controlling for operative approach.

Obesity presents a unique set of challenges in surgery. The increased subcutaneous adipose tissue often mandates larger incisions. The excess visceral adipose tissue can limit the ability to visualize relevant anatomy, makes retraction difficult, and may necessitate more extensive tissue dissection [3]. Limited visualization is particularly challenging for a surgeon operating in the confines of the pelvis [12]. Furthermore, increased adiposity and higher intraabdominal pressures may cause difficulty achieving and maintaining sufficient pneumoperitoneum for a laparoscopic approach [13]. All of these factors place obese

patients at higher risk of perioperative complications. Obesity has been shown to be an independent risk factor for numerous postoperative complications including infections, thromboembolic events, sepsis, anastomotic leaks, and incisional hernias [4, 5, 14]. In the study by Pikarsky and colleagues, conversion to an open procedure occurred with dramatically higher frequency in obese patients (39 vs. 13.4 %,  $p = 0.01$ ) undergoing segmental colorectal resection [14].

While obese patients generally have worse outcomes regardless of operative approach, our study suggests that laparoscopy is equally beneficial in this population relative to non-obese patients. Previous studies have confirmed that laparoscopy has the added potential benefits of improved visualization, smaller incision size, decreased wound complications, and quicker mobilization in comparison with open surgery [6, 10]. Early ambulation after laparoscopic surgery contributes to faster resolution of postoperative ileus, reduces the risk for thromboembolic events and pulmonary complications, and subsequently leads to shorter length of stay [6, 15, 16]. In addition, the smaller incisions used in minimally invasive surgery produce less pain, allowing for a reduction in the use of narcotics, and contribute to earlier return of bowel function [6, 17]. Our study confirms the benefits of laparoscopy specifically for the obese population, in whom we observed fewer infectious, pulmonary, and thromboembolic complications with a laparoscopic approach. As a result, our data suggest that the increased difficulty of laparoscopy in the setting of obesity does not negate the benefits.

There are several limitations associated with a retrospective analysis. A significant limitation of our study is the inability to determine the laparoscopic to open conversion rate, and many obese patients who are categorized as having undergone an open procedure may have initially started with a minimally invasive approach. It is well known that conversions are associated with increased morbidity [18]. Increasing BMI and distal colon/rectal procedures are independent risk factors for laparoscopic conversions [19–21]. Since we are unable to analyze patients on an intent-to-treat basis based on the initial surgical approach, it is possible that the higher complication rate seen with open procedures is partly a reflection of this limitation in both groups. Likewise, the reason for selection of an open versus laparoscopic approach is not known. There are patient factors, such as previous abdominal surgery, and surgeon factors, such as limited MIS experience, which are relative contraindications to a laparoscopic approach. Therefore, there is likely significant selection bias; however, we would anticipate this bias to be similar in both obese and non-obese patients. Lastly, this analysis relies on the coding of procedures and diagnoses, which is dependent on accurate coding by the surgical

team. Discrepancies between the diagnosis and the procedure performed were encountered. For example, we noted that some patients diagnosed with sigmoid cancers or diverticulitis were coded as having undergone low anterior resections rather than a segmental colectomy. Although a colectomy is performed for both procedures, the two operations pose different operative challenges and are likely to have different complication profiles. Despite these limitations, our study offers novel insight into the optimal treatment of rectal pathology in the setting of obesity.

In conclusion, laparoscopic rectal surgery is associated with fewer complications when compared to open rectal surgery for both obese and non-obese patients. Given the increased risk of postoperative morbidity with increasing BMI, minimally invasive rectal surgery may be of greater benefit to the obese patient. As obesity rates increase, establishing safe surgical approaches to rectal pathology in the setting of associated comorbidities and increased adiposity will be of paramount importance. In appropriately selected obese patients, rectal surgery outcomes may be improved with a minimally invasive approach.

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#### Compliance with ethical standards

**Disclosures** Gabriela M. Vargas, Eric P. Sieloff, Abhishek D. Parmar, Nina P. Tamirisa, Hemalkumar B. Mehta, and Taylor S. Riall have no conflict of interest or financial ties to disclose.

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