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Influence of body mass index on outcomes in patients undergoing surgery for diverticular disease

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A B S T R A C T

Background: We hypothesized that increasing body mass index is a risk factor for surgical complications in surgery for diverticulitis. We assessed the relationship of body mass index and surgical complications following surgery for diverticular disease.
Methods: We used National Surgical Quality Improvement Program database from 2005 to 2015. Patients undergoing surgery for diverticular disease during that period were included and stratified into 9 groups based on their body mass index (<18.5, 18.6–24.9, 25.0–29.9, 30.0–34.9, 35.0–39.9, 40.0–44.9, 45.0–49.9, 50.0–54.9, >55). Outcomes of interest were complications of superficial surgical site infection, deep incisional surgical site infection, organ space surgical site infection, wound disruption complications, pneumonia, ventilator dependence >48 hours, acute renal failure, myocardial infarction, return to operating room, and 30-day mortality.
Results: Morbidly obese patients had higher rates of diabetes, hypertension, and steroid use. They had higher American Society of Anesthesiologists classification and were more likely to have emergency and open cases. Interestingly, increased body mass index was inversely associated with age. Increasing body mass index was associated with worse outcomes including superficial surgical site infection, deep incisional surgical site infection, organ space surgical site infection, wound disruption complications, ventilator dependence >48 hours, acute renal failure, and return to operating room. Risk of developing pneumonia didn't have similar correlation with body mass index. Overweight status had protective effect on mortality. No statistically significant differences in increased rates of myocardial infarction were noted. Underweight patients also developed worse outcomes.
Conclusion: Obesity is associated with a number of complications following surgery for diverticulitis. Elevated body mass index adds significant risk to procedures for diverticulitis and should be accounted for in risk stratification models. Patients should be counseled on weight reduction before undergoing elective surgery for diverticular disease.

INTRODUCTION

The incidence of obesity is increasing worldwide [1]. In 2016, the World Health Organization reported that 1.9 billion adults (39%) aged 18 years of age and older were overweight (body mass index 25.0–29.9 kg/m^2) and 650 million (13%) were obese (BMI >30 kg/m^2). In the United States, ~100 million adults (37%) and 12.7 million children (17%) are obese. Every US state has a greater than 20% prevalence rate of obesity with 22 states exceeding 30%.

Obesity predisposes affected individuals to increased risk of comorbid conditions including diabetes, hypertension, and coronary artery disease [2]. In addition, increased body mass index (BMI) is associated with several other common malignancies including cancer of the colon, breast, endometrium, and pancreas [3,4]. Obesity also increases risk of sleep apnea, cholelithiasis, musculoskeletal disorders, severe pancreatitis, infertility, and diverticulitis [1].

As the prevalence of obesity increases, it will become an increasingly important consideration in surgical decision making. Obesity is widely considered a poor risk factor for surgical intervention. Obese patients undergoing cardiac, transplant, urologic, and gynecologic procedures have worse outcomes [5–8]. Recent data suggest that obesity is a risk factor for wound complications but not mortality [9]. In the laparoscopic era, there is a dearth of objective evidence describing the difficulties and morbidity associated with surgical therapy in the morbidly obese undergoing common colorectal surgery procedures.

Diverticular disease of the colon is a common condition especially in the Western World, prevalence of which is increasing with age [10]. It is estimated that approximately 5% of the US population will develop diverticular disease by age 40, increasing to 65% of

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adults over the age of 65 [10]. Most of these patients will be asymptomatic throughout their lifetime, but 10% to 25% of patients with diverticulosis can be expected to develop complications requiring hospitalization or surgical intervention [11]. In the past, recommendations for surgery after an attack of diverticulitis were straightforward. In general, an elective resection was recommended after two episodes of uncomplicated disease or one episode of complicated disease [12,13]. Recent data however, questions the wisdom of these recommendations. Some authors now recommend surgery after the third and fourth attack while others prefer expectant management until a complication occurs [14–17]. Because of uncertainty over current treatment recommendations, patient co-morbidities, including obesity, will play an expanding role in defining the indications for surgical intervention in diverticulitis.

In this study, we sought to evaluate effects of obesity on 30-day morbidity and mortality for patients undergoing resection for diverticular disease. We hypothesized that there was an association between obesity as indicated by Body Mass Index (BMI) above what's considered normal and surgical morbidity and mortality.

METHODS

Data Sources and Study Population. To perform our investigation, we used the National Surgical Quality Improvement Patient Safety in Surgery database (NSQIP PSS). The NSQIP PSS is a prospective, and risk adjusted database which is an effective tool for examining surgical outcomes of surgical events. The database has the advantage of standardized data collected by trained nurse interviewers. The NSQIP PSS reports 30-day morbidity and mortality outcomes for major inpatient and outpatient surgical procedures. These data are collected prospectively by a highly trained, site designated nurse through a variety of different techniques ranging from chart review to post-discharge telephone interviews. Trauma and pediatric patients are excluded, as are repeat operations within 30 days [18]. We identified patients within the NSQIP dataset from 2005 through 2015. Data was analyzed retrospectively.

Codes for Current Procedural Terminology, 4th edition (CPT-4) and *International Classification of Diseases* (*ICD-9*) were used to identify patients who underwent a laparoscopic or open colectomy as well as colostomy or ileostomy creation, Hartmann's procedures, or other related procedures (as listed in the appendix) for a diagnosis of diverticulosis or diverticulitis. To be included in the study population, patients had to have a procedure code for surgery for diverticulitis (CPT codes 44,140–44,188, 44,204–44,208, 44,320, 44,620, 44,625, 44,626) with a diagnosis code of diverticulosis or diverticulitis (*ICD-9* codes 562.11 and 562.13). Using these criteria, we identified 52,196 patients for our study.

We divided our cohort into eight groups based on their body mass index (BMI). We used the NIH-defined BMI obesity classification as the basis for our BMI groups. Patients with BMI between 18.5 kg/m^2 and 24.9 kg/m^2 were considered patients with normal weight and

served as a control group. Table 1 shows the distribution of all patients we identified into groups based on their BMI.

Outcomes Variables. Key variables recorded included basic demographic information such as age, gender, and race/ethnicity. We also examined several risk factors including ASA class, history of diabetes mellitus, hypertension, congestive heart failure or recent MI, bleeding disorders, functional health status prior to surgery, steroid use, and smoking status. Preoperative albumin values were examined as albumin has been associated with mortality after surgery. Operative outcomes detailed were operative approach (open versus laparoscopic), whether the operation was emergent or elective, and length of surgery. Overall complications were identified as patients with one or more of the specific NSQIP-defined complications. The primary postoperative measures were 30-day outcomes as determined using standard NSQIP definitions. Postoperative outcomes of interest were superficial surgical site infection (SSI), deep incisional SSI, organ space SSI, wound disruption complications, pneumonia, ventilator>48 hours, acute renal failure, MI, presence of septic shock, return to OR, and mortality within 30 days.

Statistical Analysis. Univariate analyses were conducted to obtain summary measures (eg, proportions, means, medians, standard deviations) of all variables. As appropriate, bivariate analysis were conducted to test the association of the characteristics with BMI using a 2-sided χ^2 test of independence, or ANOVA. Furthermore, we obtained odds ratios (OR) and 95% confidence intervals (CI) from separate multivariable logistic regression models to evaluate the association of BMI with each complication adjusting for age, gender, race/ethnicity, diabetes, smoking status, ASA class, procedure type, preoperative serum albumin, emergent operation, and total operation time. To test whether the trend by BMI categories was significant, BMI categories were included as a continuous variable. A 2-sided *P* value <.05 was considered to be significant. Research involving this national database with de-identified data qualifies for exemption from IRB.

RESULTS

Our study cohort included 52,196 patients based on procedure and diagnosis inclusion criteria. Distribution of patients by BMI is shown in Fig 1. Mean BMI of the cohort was 29.4 ± 6.5 kg/m^2.

The baseline characteristics of the patients in our cohort are shown in Table 2 and Table 3.

Results from bivariate analysis indicate that all variables other than bleeding disorders and having prior MI were associated with BMI. It is notable that patients with higher BMIs had increased rates of comorbid conditions such as diabetes mellitus, hypertension, or CHF, were more likely to use steroids, had higher ASA classification, tended to be more functionally dependent and were more likely to have an emergent surgery. In addition, their length of total hospital stay and operative times were longer. Notably, higher BMI patients were younger.

Fig 2 shows distribution of operative procedures by type, whereas Fig 3 shows operative procedures by approach (open versus laparoscopic). Important to note that open procedures became more prevalent as BMI increased.

After controlling for patients' age, gender, race/ethnicity, diabetes, smoking status, ASA class, procedure type (open versus laparoscopic), preop serum albumin, total operation time, and emergency nature of the operation, multivariable regression analysis was performed to evaluate the association of BMI with each postoperative complication (Fig 4, *A* and *B* and Table 4).

On multivariable regression analysis, postoperative complications progressively increased with increasing BMI [SSSI (*P* < .0001), DSSI (*P* < .0001), organ space SSI (*P* < .0001), wound disruption (*P* < .0001), ventilator dependence >48 hours (*P* < .0001), acute renal

Table 1
Distribution of patients into groups based on BMI

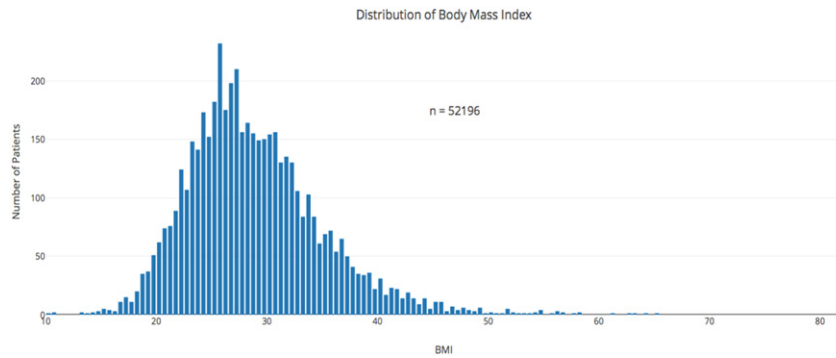| Groups	BMI (kg/m^2)	NIH defined obesity classification
1	<18.5	Underweight
Control	18.5–24.9	Normal weight
2	25.0–29.9	Overweight
3	30.0–34.9	Obesity, Class I
4	35.0–39.9	Obesity, Class II
5	40.0–44.9	Extreme Obesity, Class III
6	45.0–49.9	Extreme Obesity, Class III
7	50.0–54.9	Extreme Obesity, Class III
8	>55	Extreme Obesity, Class III

Fig 1. Distribution of patients by BMI.

failure (*P* = .0022), septic shock (*P* < .0001), and return to OR (*P* < .0001)]. There was no such relationship noted between higher BMI and rates of complications for 30-day mortality (*P* < .0001) and pneumonia (*P* < .0001). Correlation of BMI and postoperative MI did not reach statistical significance (not shown) because of a sample size. Notably, underweight patients with BMI <18.5 also had worse outcomes. For this group of patients, rates of complications were higher in the following categories: organ space SSI, wound disruption, pneumonia, prolonged ventilator dependence, return to OR and 30-day mortality. Underweight patients fared even worse than their obese counterparts particularly with complications such as pneumonia and 30-day mortality.

Table 2
Baseline characteristics of patients undergoing surgery for diverticular disease stratified by BMI (N = 52,196)

		BMI									
		<18.6	18.6–24.9	25–29.9	30–34.9	35–39.9	40–44.9	45–49.9	50–54.9	>= 55	
Variable	Categories	N (Col%)	N (Col%)	N (Col%)	N (Col%)	N (Col%)	N (Col%)	N (Col%)	N (Col%)	N (Col%)	P
Age in Categories	1. 18–39	24 (3.1)	560 (4.6)	1145 (6.2)	1037 (8.5)	665 (12.4)	310 (14.8)	139 (18.2)	51 (17.9)	33 (17.7)	<.0001
	2. 40–59	245 (31.6)	4608 (38.0)	8356 (45.2)	6013 (49.6)	2767 (51.5)	1097 (52.5)	390 (51.0)	149 (52.3)	91 (48.9)	
	3. 60–79	373 (48.1)	5725 (47.2)	7865 (42.6)	4669 (38.5)	1812 (33.7)	639 (30.6)	219 (28.6)	77 (27.0)	60 (32.3)	
	4. 80+	133 (17.2)	1238 (10.2)	1101 (6.0)	410 (3.4)	125 (2.3)	43 (2.1)	17 (2.2)	8 (2.8)	2 (1.1)	
Gender	Female	558 (72.2)	7485 (61.8)	8568 (46.5)	6089 (50.3)	3130 (58.3)	1381 (66.2)	540 (70.7)	198 (69.5)	127 (68.6)	<.0001
Race/ Ethnicity	NH White	629 (85.6)	9960 (86.2)	14,838 (84.4)	9492 (82.3)	4008 (78.7)	1526 (76.9)	533 (73.1)	203 (73.8)	117 (66.5)	<.0001
	NH Black	51 (6.9)	538 (4.7)	879 (5.0)	760 (6.6)	490 (9.6)	226 (11.4)	101 (13.9)	39 (14.2)	33 (18.8)	
	Hispanic	24 (3.3)	555 (4.8)	1146 (6.5)	881 (7.6)	412 (8.1)	166 (8.4)	69 (9.5)	17 (6.2)	20 (11.4)	
	Other race/ ethnicity	31 (4.2)	498 (4.3)	716 (4.1)	403 (3.5)	185 (3.6)	67 (3.4)	26 (3.6)	16 (5.8)	6 (3.4)	
Diabetes		26 (3.4)	489 (4.1)	1225 (6.7)	1297 (10.9)	759 (14.6)	343 (16.9)	171 (23.2)	59 (21.8)	36 (20.5)	<.0001
Current smoker		296 (38.2)	2930 (24.2)	3870 (21.0)	2547 (21.0)	1133 (21.1)	421 (20.2)	166 (21.7)	59 (20.7)	46 (24.7)	<.0001
Functional health status	Totally Dependent	12 (1.6)	75 (0.6)	67 (0.4)	55 (0.5)	11 (0.2)	11 (0.5)	6 (0.8)	5 (1.8)	2 (1.1)	<.0001
CHF/MI		10 (2.9)	110 (2.2)	129 (1.7)	86 (1.8)	50 (2.4)	24 (3.0)	11 (3.7)	1 (1.0)	4 (5.4)	.0061
Hyper-tension		318 (41.0)	4729 (39.0)	8248 (44.7)	6141 (50.6)	2954 (55.0)	1151 (55.1)	452 (59.1)	180 (63.2)	108 (58.1)	<.0001
Steroid use		67 (8.6)	771 (6.4)	893 (4.8)	565 (4.7)	265 (4.9)	76 (3.6)	41 (5.4)	17 (6.0)	17 (9.1)	<.0001
Bleeding disorders		44 (5.7)	495 (4.1)	701 (3.8)	457 (3.8)	187 (3.5)	84 (4.0)	41 (5.4)	12 (4.2)	8 (4.3)	.0455
ASA classification	1. No Disturb	18 (2.3)	616 (5.1)	829 (4.5)	339 (2.8)	82 (1.5)	13 (0.6)	3 (0.4)	0 (0.0)	3 (1.6)	<.0001
	2. Mild Disturb	345 (44.5)	6905 (56.9)	11,191 (60.6)	7067 (58.3)	2634 (49.1)	757 (36.3)	199 (26.0)	38 (13.3)	46 (24.7)	
	3. Severe Disturb	322 (41.5)	3925 (32.4)	5634 (30.5)	4208 (34.7)	2381 (44.3)	1182 (56.6)	492 (64.4)	210 (73.7)	109 (58.6)	
	4. Life Threat/ Moribund	90 (11.6)	683 (5.6)	812 (4.4)	513 (4.2)	272 (5.1)	136 (6.5)	70 (9.2)	37 (13.0)	28 (15.1)	
Emergency case		185 (23.9)	1921 (15.8)	2625 (14.2)	1713 (14.1)	768 (14.3)	345 (16.5)	125 (16.3)	69 (24.2)	44 (23.7)	<.0001

Table 3
Baseline characteristics of patients undergoing surgery for diverticular disease stratified by BMI (N = 52,196)

Variables	<18.6 N (Mean;SD)	18.6–24.9 N (Mean;SD)	25–29.9 N (Mean;SD)	30–34.9 N (Mean;SD)	35–39.9 N (Mean;SD)	40–44.9 N (Mean;SD)	45–49.9 N (Mean;SD)	50–54.9 N (Mean;SD)	>= 55 N (Mean;SD)	P
Age in years	775 (64.6;13.7)	12,131 (62;13.3)	18,467 (59.2;12.7)	12,129 (56.8;12.5)	5369 (54.7;12.6)	2089 (53.3;12.7)	765 (52.3;13)	285 (52.2;13.2)	186 (52.7;13.1)	<.0001
Pack-years of smoking	269 (16.9;25.2)	3993 (11.6;21.2)	5947 (10.4;19.9)	3778 (10.3;20.2)	1634 (10.3;21.4)	627 (8.3;17)	234 (12.2;22.9)	84 (13.4;22.9)	56 (5.9;13)	<.0001
Work relative value unit	775 (27.1;3.8)	12,131 (27.6;3.7)	18,467 (27.8;3.6)	12,129 (27.7;3.6)	5369 (27.7;3.6)	2089 (27.4;3.6)	765 (27.5;3.6)	285 (27.5;3.5)	186 (27.4;3.3)	<.0001
Pre-operative serum albumin	579 (3.4;0.8)	8362 (3.7;0.7)	12,234 (3.8;0.7)	7954 (3.8;0.7)	3563 (3.7;0.7)	1429 (3.7;0.7)	550 (3.5;0.7)	209 (3.4;0.6)	128 (3.4;0.8)	<.0001
Pre-operative creatinine	735 (0.9;0.7)	11,212 (0.9;0.7)	16,979 (1;0.6)	11,153 (1;0.7)	5011 (1;0.7)	1943 (1;0.7)	723 (0.9;0.7)	273 (0.9;0.5)	175 (1.1;1.1)	<.0001
Total operation time	775 (148.3;72.1)	12,129 (159.4;75.7)	18,465 (168.3;77.8)	12,123 (175.9;81.4)	5368 (183.5;86.4)	2089 (190.4;85.7)	765 (198.2;98.4)	285 (197.7;88.9)	186 (198.3;107.2)	<.0001
Length of total hospital stay	772 (10.2;9)	12,127 (7.6;7.8)	18,458 (7;6.6)	12,120 (7.1;7.2)	5361 (7.8;7.5)	2087 (8.6;11.5)	764 (9.3;9.2)	285 (10.9;12.6)	186 (10.3;8.6)	<.0001

DISCUSSION

Obesity is known to increase morbidity, impair quality of life and is one of the important causes of mortality [19,20]. Obesity generally is considered to be an independent risk factor in patients undergoing surgery, but the degree of risk has not been analyzed in a precise fashion. There is little data to say that excessive body weight in itself should be a contraindication to surgery. However, obesity is oftentimes linked to abnormal cardiorespiratory and metabolic function, which, as a result, may predispose to increased complications in postoperative period [21–24].

Both morbid obesity and diverticular disease continue to contribute to rising health care costs, although a direct relationship between the two has not been established. In our study, we sought to find out whether obesity is an independent risk factor for postoperative complications and to clarify the role of BMI on outcomes of surgery for diverticular disease in particular. To the best of our knowledge, this is the first review of its kind where complication rates are stratified by BMI in this particular subgroup of patients. We took into account and controlled for possible risk factors such as concurrent illnesses and ASA classification, which is well known and reliable predictor of mortality [24]. Additionally, we recognized that the type of surgery has the major impact on the surgical risk and therefore controlled for open versus laparoscopic and elective versus emergent surgery. Other possible confounding factors were also accounted for such as age, gender, race and ethnicity. Because we assembled our patients from a large database, we were able to achieve enough power to detect differences in most postoperative complications in our cohort. Our data demonstrates that despite their younger age, patients with higher BMIs who are undergoing surgery for diverticular disease have increased rates of SSSI, DSSI, organ space SSI, wound disruption, ventilator dependence >48 hours, acute renal failure, and return to OR. There was a progressive increase

in the likelihood of these complications with increasing BMI class. Rates of pneumonia did not demonstrate the same progressive increase with higher BMI. We did not find statistically significant differences in increased rates of MI in our study.

It is notable to mention that 30-day mortality showed mixed results in our cohort group. The literature is equivocal on obesity being a predictor of mortality. This somewhat protective effect of obesity on mortality has been previously demonstrated [26]. Mullen, et al. [25] showed that overweight and moderately obese patients undergoing nonbariatric general surgery had paradoxically lower risks of mortality compared with patients with normal weight. Similar results were demonstrated in other patient populations [27–29]. The obesity paradox was first noticed by Mercedes Carnethon and colleagues [28] in relation to people with heart disease and diabetes where being overweight appeared to be protective. There is a growing body of evidence to suggest that mortality is lowest in overweight and obese persons, and that leaner adults had the highest relative total and cardiovascular mortality [28]. Our data is consistent with these findings confirming the existence of an obesity paradox.

Underweight patients also demonstrated worse outcomes in our cohort. Their lower BMI predisposes them to increased rates of organ space SSI, wound disruption, pneumonia, prolonged ventilator dependence, higher incidence of return to OR and increased 30-day mortality. Several other authors had similar results. A BMI <18.5 kg/m2 was shown to be an independent factor affecting outcome in surgical critical care patients [30]. In patients undergoing transcatheter aortic valve implantation, underweight patients demonstrated a higher incidence of major and life-threatening and of major vascular complications, compared with normal weight patients [31].
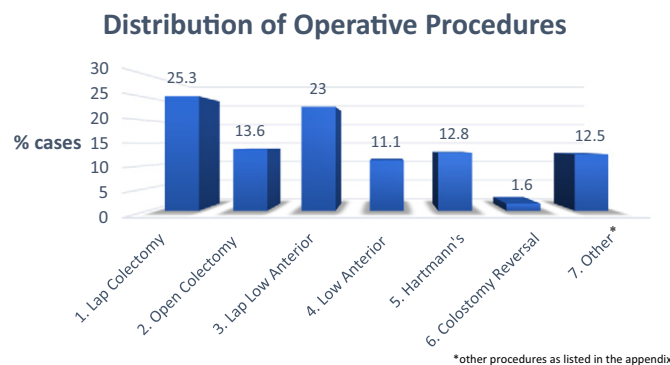

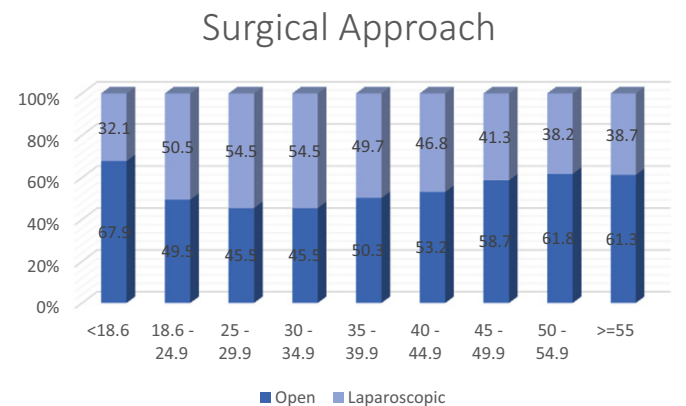**Fig 2.** Distribution of operative procedures by type.

Fig 3. Distribution of operative procedures by approach (open versus laparoscopic), p < 0.0001.

A

Multivariable Regression Results

B

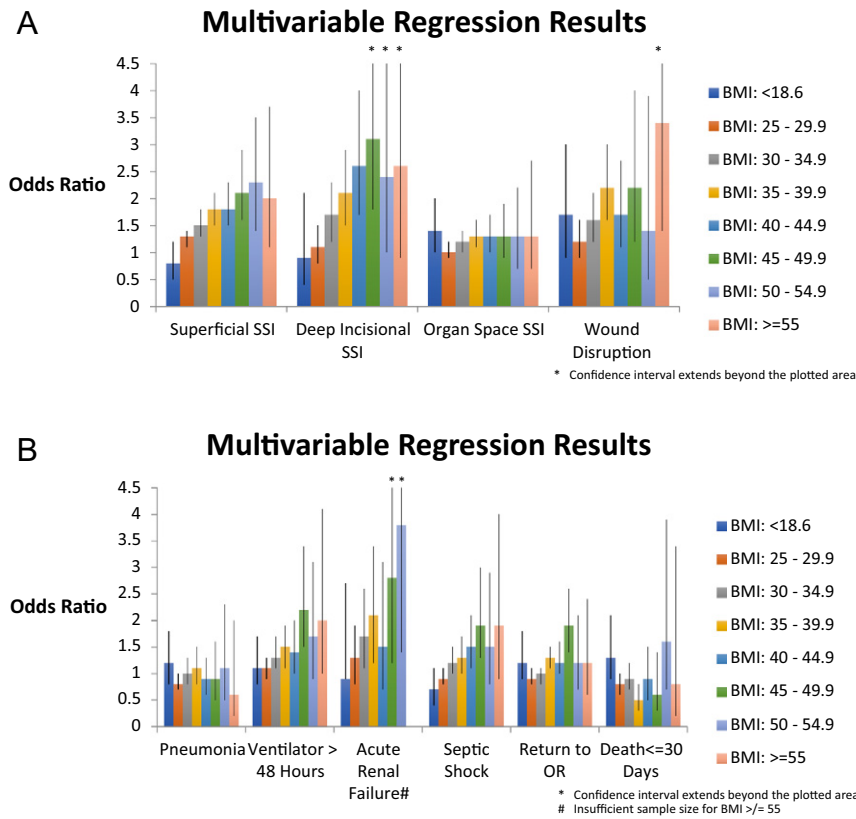### Multivariable Regression Results

Fig 4. A, Multivariable regression results. B, Multivariable regression results.

Our study has several limitations which should be addressed. Although our study is based on multi-institutional data, it represents large and specialty medical centers which are likely to commonly perform complex surgery for diverticular disease. These institutions are not an accurate representation of current general surgical practices. In addition, our study is disease specific and thus cannot be generalizable to other surgical conditions. NSQIP database does not contain information on the indications for surgery. Therefore, we do not have the ability to ascertain whether obese patients are more likely to develop complications of advanced diverticular disease or be denied surgery when these events do occur. NSQIP database does not provide Hinchey classification nor the number of diverticular episodes prior to operative intervention, therefore it is difficult to determine the disease severity. In addition, despite the satisfactory power of our study, the retrospective nature of it carries known limitations such as inherent selection bias typical of large population database series.

In conclusion, the findings of our study may change recommendations for elective resections for diverticular disease in superobese populations. Because the indications for surgical intervention in diverticular disease are changing, a demonstrable increase in morbidity in obese populations may suggest that non-surgical approaches may be favorable for these patients. In addition, elevated BMI adds significant risk to procedures for diverticulitis and should be accounted for when using SSI and ROR as quality indicators.

Abbreviations

BMI	Body Mass Index
NSQIP PSS	National Surgical Quality Improvement Program Patient Safety in Surgery
MI	Myocardial infarction
ASA Classification	American Society of Anesthesiologists Classification
SSI	Surgical Site Infection
SSSI	Superficial Surgical Site Infection
DSSI	Deep Surgical Site Infection

Acknowledgment

Table 4
Multivariable regression results, odds ratio of studied complications

	Superficial SSI	Deep incisional SSI	Organ space SSI	Wound disruption	Pneumonia	Ventilator > 48 hours	Acute renal failure	Septic shock	Return to OR	Death < = 30 days
BMI	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<18.6 vs 18.6–24.9	0.8 (0.5,1.2)	0.9 (0.4,2.1)	1.4 (1.0,2.0)	1.7 (0.9,3.0)	1.2 (0.8,1.8)	1.1 (0.8,1.7)	0.9 (0.3,2.7)	0.7 (0.4,1.1)	1.2 (0.9,1.8)	1.3 (0.9,2.1)
25–29.9 vs 18.6–24.9	1.3 (1.1,1.4)	1.1 (0.8,1.5)	1.0 (0.9,1.2)	1.2 (0.9,1.6)	0.8 (0.7,1.0)	1.1 (0.9,1.3)	1.3 (0.8,1.9)	0.9 (0.8,1.1)	0.9 (0.8,1.1)	0.8 (0.6,1.0)
30–34.9 vs 18.6–24.9	1.5 (1.3,1.8)	1.7 (1.2,2.3)	1.2 (1.0,1.4)	1.6 (1.2,2.1)	1.0 (0.8,1.3)	1.3 (1.1,1.7)	1.7 (1.1,2.6)	1.2 (1.0,1.5)	1.0 (0.8,1.1)	0.9 (0.7,1.2)
35–39.9 vs 18.6–24.9	1.8 (1.5,2.1)	2.1 (1.5,2.9)	1.3 (1.1,1.6)	2.2 (1.6,3.0)	1.1 (0.8,1.5)	1.5 (1.1,1.9)	2.1 (1.2,3.4)	1.3 (1.0,1.7)	1.3 (1.1,1.5)	0.5 (0.3,0.8)
40–44.9 vs 18.6–24.9	1.8 (1.5,2.3)	2.6 (1.7,4.0)	1.3 (1.0,1.7)	1.7 (1.1,2.7)	0.9 (0.6,1.3)	1.4 (1.0,2.0)	1.5 (0.7,3.1)	1.5 (1.1,2.1)	1.2 (1.0,1.6)	0.9 (0.5,1.5)
45–49.9 vs 18.6–24.9	2.1 (1.6,2.9)	3.1 (1.8,5.3)	1.3 (0.9,1.9)	2.2 (1.2,4.0)	0.9 (0.5,1.6)	2.2 (1.5,3.4)	2.8 (1.2,6.3)	1.9 (1.3,3.0)	1.9 (1.4,2.6)	0.6 (0.3,1.4)
50–54.9 vs 18.6–24.9	2.3 (1.4,3.5)	2.4 (1.0,5.7)	1.3 (0.7,2.2)	1.4 (0.5,3.9)	1.1 (0.5,2.3)	1.7 (0.9,3.1)	3.8 (1.4,10.3)	1.5 (0.8,2.9)	1.2 (0.7,2.1)	1.6 (0.7,3.9)
> = 55 vs 18.6–24.9	2.0 (1.1,3.7)	2.6 (0.9,7.3)	1.3 (0.7,2.7)	3.4 (1.4,8.2)	0.6 (0.2,2.0)	2.0 (1.0,4.1)	0.0 (0.0,I)	1.9 (0.9,4.0)	1.2 (0.6,2.4)	0.8 (0.2,3.4)

Author Contribution

Olga Beresneva, MD and Jason Hall, MD contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Appendix A. Appendix

Current Procedural Terminology (CPT) Codes included in the study.
44,140 Colectomy, partial with anastomosis.
44,141 Colectomy, partial; with skin level cecostomy or colostomy.
44,143 Colectomy, partial; with end colostomy and closure of distal segment (Hartmann type procedure).
44,144 Colectomy, partial; with resection, with colostomy or ileostomy and creation of mucofistula.
Laparoscopic colostomy.
44,145 Colectomy, partial; with coloproctostomy (low pelvic anastomosis).
44,146 Colectomy, partial; with coloproctostomy (low pelvic anastomosis), with colostomy.
44,147 Colectomy, partial; abdominal and transanal approach.
44,150 Colectomy, total, abdominal, without proctectomy; with ileostomy or ileoproctostomy.
44,151 Colectomy, total, abdominal, without proctectomy; with continent ileostomy.
44,155 Colectomy, total, abdominal, with proctectomy; with ileostomy.
44,156 Colectomy, total, abdominal, with proctectomy; with continent ileostomy.
44,157 Colectomy, total, abdominal, with proctectomy; with ileoanal anastomosis, includes loop ileostomy, and rectal mucosectomy, when performed.
44,158 Colectomy, total, abdominal, with proctectomy; with ileoanal anastomosis, creation of ileal reservoir (S or J), includes loop ileostomy, and rectal mucosectomy, when performed.
44,160 Colectomy, partial, with removal of terminal ileum with ileocolostomy.
44,188 Laparoscopy, surgical, colostomy or skin level cecostomy.
44,204 Laparoscopy, surgical; colectomy, partial, with anastomosis.
44,205 Laparoscopy, surgical; colectomy, partial, with removal of terminal ileum with ileocolostomy.
44,206 Laparoscopy, surgical; colectomy, partial, with end colostomy and closure of distal segment (Hartmann type procedure).
44,207 Laparoscopy, surgical; colectomy, partial, with anastomosis, with coloproctostomy (low pelvic
anastomosis).
44,208 Laparoscopy, surgical; colectomy, partial, with anastomosis, with coloproctostomy (low pelvic
anastomosis) with colostomy.
44,320 Colostomy or skin level cecostomy.
44,620 Closure of enterostomy, large or small intestine.
44,625 Closure of enterostomy, large or small intestine; with resection and anastomosis other than colorectal.

44,626 Closure of enterostomy, large or small intestine; with resection and colorectal anastomosis (eg, closure of Hartmann type procedure).

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