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Original article

Colectomy for patients with super obesity: current practice and surgical morbidity in the United States

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Abstract

Background: While minimally invasive surgery contributed to improved outcomes in bariatric surgery, less is known about current utilization trends and outcomes related to surgical technique for colorectal resections in super-obese patients (body mass index $\geq$50 kg/m^2).

Objective: The aim of this study was to compare surgical modalities and short-term outcomes of patients with super obesity who underwent elective colectomy in the United States.

Setting: A retrospective review was performed of patients with super obesity who underwent elective colectomy between 2012 to 2018 using the American College of Surgeons National Quality Improvement Program data pool.

Methods: Patients were categorized into an open, laparoscopic, or robotic group. Baseline characteristics and perioperative outcomes including 30-day complications and length of stay were compared between the 3 groups. Furthermore, utilization trends of surgical modalities were assessed.

Results: Of 1199 patients, 338 (28.2%) had open, 735 (61.3%) laparoscopic, and 126 (10.5%) robotic colectomy during the study period, primarily for colon cancer (50.8%). Patients in the open group tended to have more baseline co-morbidities. Laparoscopic approach showed better risk-adjusted outcomes compared with open for postoperative ileus (adjusted odds ratio [aOR]: .6, 95% confidence interval [CI; .383–.965]), overall medical complications (aOR: .4, 95%CI [.3–.8]), and length of stay (OR .6, 95% CI [.394–.968]). Trend utilization showed increasing utilization of the robotic platform over the study period, which was associated with less unplanned conversion to open (aOR .417, 95%CI [.199–.872]).

Conclusion: Laparoscopic colectomy provides advantageous outcomes over open surgery for colectomy in super-obese patients. The robotic platform has been increasingly used over time, and potential benefits need to be further studied. (Surg Obes Relat Dis 2020;16:1764–1769.)

Key words: Minimally invasive; Colectomy; Colorectal surgery; Laparoscopic; Obesity

Obesity represents a technical challenge for minimally invasive surgery (MIS) due to a lack of working space, exposure, weight, and fragility of highly vascularized fat tissue [1,2]. However, short-term outcomes appear to be better after MIS than after open surgery in obese patients (body mass index [BMI] $\geq$30 kg/m^2) [3]. Furthermore, it has been

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proposed that the robotic platform may help overcome some of the limitations of laparoscopy through improved navigation, dexterity, and visualization [3–5].

Super-obese patients (BMI ≥50 kg/m^2) represent a particularly complex subgroup of patients from a medical, metabolic, and surgical perspective [1,2,6–8]. The rising preponderance of super obesity in the United States represents a challenge for nondeferrable nonbariatric-related procedures [1,9,10]. Furthermore, MIS in these patients requires a high degree of expertise and technical skills. While MIS contributed to improved outcomes in bariatric surgery [11,12], less is known about current utilization trends and outcomes related to surgical technique for colorectal resections in super-obese patients.

This study aimed to evaluate surgical modality utilization trends and short-term outcomes in patients with super obesity undergoing elective colectomy.

Methods

The American College of Surgeons National Quality Improvement Program database (ACS-NSQIP) was interrogated to assess patients who underwent an elective colectomy between 2012 and 2018. ACS-NSQIP is a repeatedly validated, national data pool developed for quality improvement purposes representing a risk-adjusted and outcome-based program. In brief, data abstraction from all participant sites is conducted by trained abstractors and a random sample of 20% of patients from each contributing institution is included in the final data set [13]. This study was considered exempt from institutional review board approval.

Participant User Files of ACS-NSQIP were merged with their corresponding "Targeted Colectomy" files. Patients with super obesity (BMI ≥50 kg/m^2) who underwent elective colectomy for any indication using the associated specific Current Procedure Terminology codes (44140, 44141, 44143, 44144, 44145, 44146, 44147, 44150, 44160, 44204, 44205, 44206, 44207, 44208, 44210) were identified. Patients with no operative approach available at the "COL-APPROACH" variable accessed through the targeted colectomy files and patients undergoing an urgent or emergent operation were excluded. Subsequently, patients were categorized according to the operative modality into open, laparoscopic, and robotic groups.

Baseline demographic, anthropometric, and perioperative data were compared between the 3 groups. Surgical indications were categorized as cancer, inflammatory bowel disease, diverticular disorders and others (such as benign neoplasms). Further assessed were conversion to open rate, various postoperative medical and surgical 30-day complications according to standard ACS-NSQIP definitions and length of index hospital stay (with prolonged length of stay defined upper quartile of the entire cohort (>6 d). Utilization trends by calendar year of the inclusion period were also assessed.

Statistical analysis

Data were reported in frequencies and percentages for categoric variables, or median (interquartile range) for continuous variables. Multigroup comparisons were performed using the X^2 test for categoric variables and the independent Samples Kruskal-Wallis Test for continuous variables. Outcomes with an alpha level of <.1 and event rate ≥10 for all 3 approaches in the univariate analysis were further examined using multivariate binary logistic regression. A *P* value of <.05 was considered significant. Utilization trends of the different surgical approaches over time were assessed using linear regression. The analysis was conducted using the Statistical Package for Social Sciences (SPSS, Version 25; SPSS, Inc., Armonk, NY, USA).

Results

Of 1199 patients identified, 338 (28.2%) had an open colectomy, 735 (61.3%) had a laparoscopic colectomy, and 126 (10.5%) had a robotic colectomy. The most common indication for surgery was colon cancer (50.8%), followed by other diseases (23.4%), diverticular disease (22.4%), and inflammatory bowel disease (3.3%).

Patients undergoing open surgery tended to be older and presented with more confounding co-morbidities, such as type 2 diabetes and cardiovascular co-morbidities (Table 1).

While surgical duration was significantly higher in the robotic group, conversion rate was lower in the robotic compared with the laparoscopic group (13.5% versus 17.6%, adjusted odds ratio [aOR]: .4; 95% confidence interval [CI; .2–.9]).

Patients treated by open surgery were more likely to experience overall complications, surgical complications, and medical complications. More specifically, they were more likely to suffer surgical site infection, postoperative ileus, systemic sepsis, pneumonia, unplanned intubation, failure to wean mechanical ventilation within 48 hours, progressive renal insufficiency, acute renal failure, urinary tract infection, myocardial infarction, prolonged length of stay >6 days, and death within 30 days (Table 2).

After adjusting for baseline characteristics and risk factors, laparoscopy was associated with decreased postoperative ileus, fewer overall medical complications, and fewer patients with a length of stay >6 days compared with the open approach. Robotic surgery was associated with a decreased rate of prolonged length of stay >6 days compared with the open approach (Table 3).

Utilization analysis over time revealed a trend toward increasing utilization of the robotic modality at the expense of open surgery. The laparoscopic approach was the most used and remained stable over time (Fig. 1).

Table 1
Demographic characteristics, anthropometric, and baseline characteristics

	Open n = 338	Laparoscopic n = 735	Robotic n = 126	Total n = 1199	*P* value*
Male	106 (31.4%)	260 (35.4%)	52 (41.3%)	418 (34.9%)	.1
Age	59 (50–67)	56 (48–64)	54 (47–64)	57 (49–65)	**.001**
BMI	53.6 (51–58)	54 (52–58)	54 (51–57)	54 (52–58)	.5
Race					.8
White	245 (72.5%)	513 (69.8%)	96 (76.2%)	854 (71.2%)	
Black	58 (17.2%)	136 (18.5%)	23 (18.3%)	217 (18.1%)	
Asian	2 (.6%)	7 (1.0%)	0	9 (.8%)	
Others	3 (.9%)	10 (13%)	0	13 (11%)	
Unknown	30 (8.9%)	69 (9.4%)	7 (5.6%)	106 (8.8%)	
Hispanic	21 (6.2%)	48 (6.5%)	8 (6.3%)	77 (6.4%)	.8
Underlying disease					**<.0001**
Colon cancer	180 (53.3%)	360 (49%)	69 (54.8%)	609 (50.8%)	
IBD	11 (3.3%)	27 (3.7%)	2 (1.6%)	40 (3.3%)	
Diverticular disorder	54 (16%)	172 (23.4%)	43 (34.1%)	269 (22.4%)	
Others	93 (27.5%)	176 (23.9%)	12 (9.5%)	281 (23.4%)	
T2D	126 (37.3%)	218 (29.7%)	38 (30.2%)	382 (31.9%)	**.04**
Cardiopulmonary					
Dyspnea	84 (24.9%)	126 (17.1%)	13 (10.3%)	223 (18.6%)	**<.0001**
COPD	24 (7.1%)	49 (6.7%)	6 (4.8%)	79 (6.6%)	.7
CHF	8 (2.4%)	9 (1.2%)	0	17 (1.4%)	.1
HTN	237 (70.1%)	486 (66.1%)	88 (69.8%)	811 (67.6%)	.4
Functional status					**.04**
Independent	318 (94.1%)	714 (97.1%)	122 (96.8%)	1154 (96.2%)	
Unknown	2 (.6%)	0	0	2 (.2%)	
On hemodialysis	1 (.3%)	2 (.3%)	0	3 (.3%)	.8
Hematologic					
Bleeding disorder	14 (4.1%)	16 (2.2%)	7 (5.6%)	37 (3.1%)	**.053**
Hematocrit (%)	37.5 (34–41)	39 (35–42)	39 (35–42)	39 (35–42)	**<.0001**
Platelets (1000/μL)	251 (193–315)	272 (221–320)	293 (233–332)	265 (218–318)	**.004**
Transfusion ≥1 pRBC within 72 hr of surgery	6 (1.8%)	3 (.4%)	0	9 (.8%)	**.03**
Nutritional status					
>10% loss of body weight in last 6 mo	4 (1.2%)	7 (1%)	0	11 (.9%)	.5
Albumin	3.7 (3.3–4)	3.8 (3.4–4.1)	3.8 (3.4–4.1)	3.8 (3.4–4.1)	**.03**
Disseminated cancer	25 (4.7%)	24 (3.3%)	3 (2.4%)	52 (4.3%)	**.004**
Chronic steroid use	19 (5.6%)	37 (5%)	6 (4.8%)	62 (5.2%)	.9
Operation time, min	185 (133–277)	190 (141–270)	263 (209–316)	197 (143–281)	**<.0001**

BMI = body mass index; IBD = inflammatory bowel disease; T2D = type 2 diabetes; COPD = chronic obstructive pulmonary disease; CHF = congestive heart failure; HTN = hypertension requiring medication; ASA = American Society of Anesthesiologists; LOS = length of stay; pRBC = packed red blood cells.

Bold indicates significant *P* values.

* Derived from Independent Samples Kruskal-Wallis Test for continuous variables, and X^2 test for categoric variables.

Discussion

This representative large-scale study demonstrated beneficial outcomes associated with laparoscopy over open surgery for colonic resections in the critical patient population with super obesity. The robotic approach achieved outcomes similar to laparoscopy, with the statistical insignificance being likely related to the comparatively small sample size and associated event rates because of the novelty of the platform. While robotic cases were significantly longer, conversion rate was lower than for laparoscopic procedures. While the robotic modality was increasingly used at the expense of open surgery, laparoscopy remained the preponderant platform over the study period.

The increasing incidence of obesity among patients with colorectal diseases is a reflection of the obesity epidemic in the United States [14–16]. Obesity itself is a predisposing factor for colon cancer [17–19] and represents a well-known risk factor for postoperative adverse events [20–22]. Super obesity was repeatedly identified as the strongest predictor of perioperative morbidity for different intraabdominal operations [23,24]. Reasons for worse outcomes are multifactorial and include co-morbidities, compromised intraabdominal working space associated with bulky omentum, mesentery and abdominal wall, and suboptimal visualization of highly vascularized fat wrapped anatomic structures [6–8,25–29]. This imposes significant

Table 2
Postoperative complications

	Open n = 338	Laparoscopic n = 735	Robotic n = 126	Total n = 1199	*P* value*
Any complication[†]	144 (42.7%)	252 (34.4%)	39 (31.2%)	435 (36.4%)	**.014**
Any surgical complication[‡]	131 (38.9%)	235 (32.1%)	37 (29.6%)	403 (33.8%)	.055
SSI	69 (20.4%)	82 (11.2%)	15 (11.9%)	166 (13.8%)	**<.0001**
Superficial SSI	37 (10.9%)	45 (6.1%)	9 (7.1%)	91 (7.6%)	**.02**
Deep SSI	17 (5%)	13 (1.8%)	2 (1.6%)	32 (2.7%)	**.006**
Organ space SSI	21 (6.2%)	27 (3.7%)	7 (5.6%)	55 (4.6%)	.2
Wound disruption	9 (2.7%)	13 (1.8%)	1 (.8%)	23 (1.9%)	.4
Unplanned reoperation	34 (10.1%)	41 (5.6%)	8 (6.3%)	83 (6.9%)	**.03**
Leak	15 (4.4%)	21 (2.9%)	3 (2.4%)	39 (3.3%)	.3
Ileus	70 (20.7%)	77 (10.5%)	17 (13.5%)	164 (13.7%)	**<.0001**
Unplanned conversion to open	NA	129 (17.6%)	17 (13.5%)	146 (12.2%)	**<.0001**
Systemic sepsis	35 (10.4%)	33 (4.5%)	5 (4%)	73 (6.1%)	**.001**
Sepsis	18 (5.3 %)	26 (3.5%)	4 (3.2%)	48 (4%)	.3
Septic shock	19 (5.6%)	9 (1.2%)	1 (.8%)	29 (2.4%)	**<.0001**
Any medical complication[§]	60 (17.8%)	47 (6.4%)	10 (7.9%)	117 (9.8%)	**<.0001**
Any respiratory complication	29 (8.6%)	19 (2.6%)	3 (2.4%)	51 (4.3%)	**<.0001**
Pneumonia	9 (2.7%)	7 (1%)	0	16 (1.3%)	**.03**
Unplanned intubation	17 (5%)	11 (1.5%)	2 (1.6%)	30 (2.5%)	**.002**
On ventilator >48 hr	21 (6.2%)	10 (1.4%)	1 (.8%)	32 (2.7%)	**<.0001**
VTE	14 (4.1%)	11 (1.5%)	2 (1.6%)	27 (2.3%)	**.022**
PE	8 (2.4%)	8 (1.1%)	1 (.8%)	17 (1.4%)	.2
DVT	7 (2.1%)	5 (.7%)	1 (.8%)	13 (1.1%)	.117
Any renal complication	15 (4.4%)	8 (1.1%)	5 (4%)	28 (2.3%)	**.001**
Progressive renal insufficiency	7 (2.1%)	5 (.7%)	5 (4%)	17 (1.4%)	**.008**
Acute renal failure	8 (2.4%)	4 (.5%)	0	12 (1%)	**.01**
UTI	20 (5.9%)	18 (2.4%)	4 (3.2%)	42 (3.5%)	**.02**
Any cardiac complication	9 (2.7%)	3 (.4%)	1 (.8%)	13 (1.1%)	**.004**
Cardiac arrest requiring CPR	5 (1.5%)	3 (.4%)	0	8 (.7%)	.08
MI	6 (1.8%)	0	1 (.8%)	7 (.6%)	**.002**
LOS, d	6 (5–9)	4 (3–6)	4 (3–6)	5 (3–7)	**<.0001**
LOS >6 d	96 (34.7%)	98 (16.9%)	16 (18.8%)	210 (22.3%)	**<.0001**
Unplanned readmission	50 (14.8%)	82 (11.2%)	12 (9.5%)	144 (12%)	.124
Death within 30 d	9 (2.7%)	5 (.7%)	2 (1.6%)	16 (1.3%)	**.03**

SSI = surgical site infection; VTE = venous thromboembolism; PE = pulmonary embolism; DVT = deep venous thrombosis; UTI = urinary tract infection; CPR = cardiopulmonary resuscitation; MI = myocardial infarction; LOS = length of stay.

Bold indicates significant *P* values.

NB: the numbers do not add up because patients experiencing multiple complications were accounted for as one.

* Derived from independent Samples Kruskal-Wallis test for continuous variables and X^2 test for categoric variables.

[†] Any complication: any surgical and/or any medical complication.

[‡] Any surgical complication includes superficial SSI, deep SSI, organ/space SSI, ileus, leak, unplanned reoperation, death within 30 days, unplanned conversion to open, sepsis, septic shock, and/or wound disruption.

[§] Any medical complication includes: pneumonia, unplanned intubation, on a mechanical ventilator for >48 hours, PE, DVT, progressive renal failure, acute renal failure, UTI, cardiac arrest requiring CPR, or MI.

challenges on surgical conduct and puts these patients at higher risk of surgical site infections, organ space infections, sepsis, and septic shock [10,30]. Furthermore, the preponderance of co-morbidities in super-obese patients increases the risk of potentially devastating cardiopulmonary complications [31–33].

In this analysis, MIS colectomy appeared to be relatively safe with lower rates of overall, specific surgical and medical morbidity alongside a shorter length of stay compared with the open approach. The high rate of postoperative septic complications after open surgery is of concern but in line with a former ACS-NSQIP analysis, which found that obesity (BMI >30 kg/m^2) was an independent risk factor for postoperative sepsis [5,24]. The overall complication rate of 34.4% for laparoscopic and 31.2% for robotic surgery compares well with a previous analysis that found a rate of 41.4% after minimally invasive colectomy [10]. However, the same study reported higher rates of surgical site infection (24.2% versus 11.2%), anastomotic leak (4.8% versus 2.9%), and postoperative ileus (10.5% versus 6.5%) after laparoscopic surgery than our study.

ACS-NSQIP does not provide information about training or specialization of operating surgeons, which may have differed among the 3 modalities. This is important because there is growing evidence associating MIS fellowship training with improved outcomes [34,35]. Furthermore, indications for surgery were not equally distributed between the 3 groups, which has to be considered when comparing

Table 3
Multivariate analysis

	Laparoscopic versus open		Robotic versus open		Robotic versus laparoscopic	
	OR* (95%CI)	*P* value	OR* (95%CI)	*P* value	OR* (95%CI)	*P* value
Any complication†	.9 (.6–1.3)	.5	.6 (.3–1)	.066	.668 (.397–1.24)	.129
Any surgical complication‡	.962 (.671–1.4)	.8	.6 (.4–1.1)	.1	.663 (.391–1.25)	.128
Any SSI	.656 (.409–1.051)	.08	.525 (.242–1.136)	.102	.793 (.368–1.705)	.552
Unplanned reoperation	.7 (.379–1.295)	.257	.864 (.342–2.184)	.757	1.2 (.489–2.997)	.679
Ileus	**.6 (.383–.965)**	**.035**	.704 (.348–1.423)	.328	1.2 (.619–2.415)	.563
Unplanned conversion to open	NA		NA		**.417 (.199–.872)**	**.02**
Any medical complication§	**.4 (.3–.8)**	**.004**	.5 (.2–1.4)	0.2	1 (.4–2.6)	.972
LOS >6 d	**.618 (.394–.968)**	**.035**	**.375 (.171–.822)**	**.014**	.608 (.283–1.308)	.203

OR = odds ratio; CI = confidence interval; SSI = surgical site infection; LOS = length of stay; NA = not applicable.
Bold indicates significant *P* values.
* Adjusted for age, type 2 diabetes, dyspnea, preoperative functional health status, disseminated cancer, open wound/wound infection, bleeding disorder, transfusion ≥1 unit packed red blood cells in 72 hours before surgery, American Society of Anesthesiologists class, wound class, and total operation time.
† Any complication: any surgical and/or any medical complication.
‡ Any surgical complication includes: superficial SSI, deep SSI, organ/space SSI, ileus, leak, unplanned reoperation, death within 30 days, unplanned conversion to open, sepsis, septic shock, and/or wound disruption.
§ Any medical complication includes: pneumonia, unplanned intubation, on a mechanical ventilator for >48 hours, pulmonary embolism, deep venous thrombosis, progressive renal failure, acute renal failure, urinary tract infection , cardiac arrest requiring cardiopulmonary resuscitation, or myocardial infarction.

duration of surgery and postoperative outcomes. Nevertheless, the results of the present study suggest treatment of these complex high-risk patients in specialized settings providing a high degree of MIS experience.

A robotic approach showed decreased conversion rate compared with laparoscopic colectomy (13.5% versus 17.6%, $P < .0001$; aOR .417; 95%CI (.199–.872). This is consistent with previous studies suggesting robotics potential to overcome limitations of laparoscopy in bariatric patients because of its 3-dimensional visualization and 360 articulation [12]. Despite a decreased conversion rate, the present study could not demonstrate significantly improved short-term postoperative outcomes. The reasons for this observation may be multifactorial and related to type II error (small sample size of the robotic group) and early experience (prolonged surgical duration).

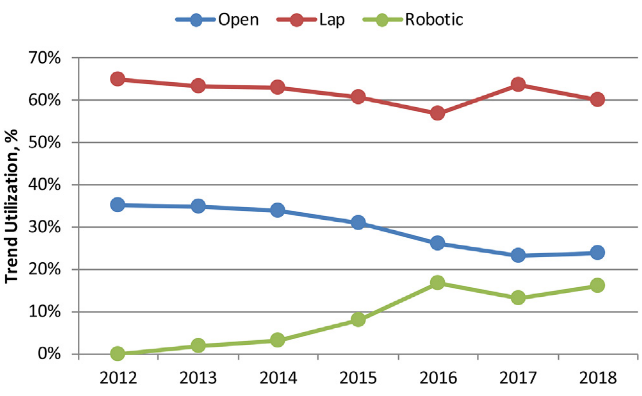

Fig. 1. Trend utilization of the different operative modalities between 2012 and 2018 for patients with super obesity. Open approach: the utilization of the open approach was 35.1% in 2012 and decreased to 23.8% in 2018 (slope −2.4% per year; 95% CI [−3.7% to −1%], *P* value = .001). Laparoscopic approach: the utilization of the laparoscopic approach was 64.9% in 2012 and decreased to 60.2% in 2018 (slope −.6% per year; 95% CI [−2% to .9%], *P* value .435). Robotic approach: the utilization of the robotic approach was 0% in 2012 and increased to 16% in 2018, (slope 2.9% per year; 95% CI [2%–3.8%], *P* value < .0001).

Utilization analysis over time revealed a significant increase in robotic approach at the expense of open surgery and unchanged trends with the laparoscopic approach. These results suggest the robotic platform has allowed further uptake of minimally invasive approaches to colectomy and the associated advantages in this challenging group of patients.

This analysis is limited by its retrospective design and natural variance of data quality in a large nationwide data set. The study is also prone to selection bias, as shown by the comparatively sicker patient cohort of patients undergoing open surgery, in which co-morbidities potentially precluded them from undergoing a minimally invasive approach. This was addressed by adjusting outcomes through multivariable regression analysis. ACS-NSQIP includes only 20% of patients of participating centers. However, these patients represent a random sample. Furthermore, long-term outcomes and surgical specifics including extent of resection and type of dissection (high tie, low, tie, mesocolic), anastomosis configuration and completeness of MIS approach (extra versus intracorporeal vessel dissection, mobilization, transection, anastomosis) are not available in the ACS-NSQIP data pool. Finally, differences in pre-, peri- and postoperative care, setting and case volumes of participating institutions, and surgeons' experience are not captured. It is unknown whether these potential confounders were equally distributed between the 3 groups.

Conclusion

Patients with superobesity represent a high-risk population from a medical and surgical standpoint. MIS approaches for elective colectomy appear to be safe and to provide benefits regarding overall and specific postoperative morbidity, length of stay, and 30-day mortality. The robotic platform may facilitate implementation of MIS modalities for super-obese patients evidenced by the increased utilization associated with a concomitant decrease in open approach. Treatment in specialized settings providing a high degree of MIS expertise likely contributes to better outcomes.

Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article.

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