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Robotic-assisted colorectal surgery in obese patients: a case-matched series

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Abstract

Background Reports demonstrate laparoscopic colorectal surgery in obese patients is associated with higher conversion to laparotomy and complication rates. While several advantages of robotic-assisted surgery have been reported, outcomes in obese patients have not been adequately studied. Therefore, this study compares outcomes of robotic-assisted surgery in non-obese and obese patients.

Methods A retrospective review of 331 consecutive robotic procedures performed at a single institution between 2009 and 2015 was performed. Patients were divided into non-obese (BMI <30 kg/m^2) and obese (BMI $\geq$30 kg/m^2) groups, and were clinically matched by gender, age, and procedure performed. Intraoperative and postoperative complications, operative time, estimated blood loss, and length of stay were examined.

Results Following matching, each group included 108 patients comprised of 50 men and 58 women. Mean BMI was 24.6 $\pm$ 3.15 and 36.2 $\pm$ 5.67 kg/m^2 ($p < 0.0001$), and the mean age was 59.2 $\pm$ 11.28 years for non-obese patients and 57.1 $\pm$ 12.44 for obese patients ($p = 0.18$). Surgeries included low anterior resection, right colectomy, left colectomy, sigmoid colectomy, excision of rectal endometriosis, total proctocolectomy, APR, subtotal colectomy, ileocecectomy, proctectomy, rectopexy, transanal excision of rectal mass, and colostomy site hernia repair. The mean operative time was 272.69 $\pm$ 115.43 and 282.42 $\pm$ 120.51 min ($p = 0.55$), estimated blood loss 195.23 $\pm$ 230.37 and 289.19 $\pm$ 509.27 mL ($p = 0.08$), conversion to laparotomy 6.48 and 9.26 % ($p = 0.45$), and length of stay 5.38 $\pm$ 4.94 and 4.56 $\pm$ 4.04 days ($p = 0.18$) for the non-obese and obese groups, respectively. Twenty of the non-obese patients had postoperative complications as compared to 27 of the obese patients ($p = 0.30$). However, the prevalence of wound complications was higher in obese patients (1.9 vs 9.3 %; $p = 0.03$).

Conclusion There is no difference in conversion to laparotomy and overall complication rates in non-obese and obese patients undergoing robotic-assisted colorectal surgery. However, obesity is associated with a higher prevalence of wound complications. Robotic-assisted surgery may minimize conversion to laparotomy and complications typically seen in obese patients due to improved visualization, instrumentation, and ergonomics.

Keywords Robotic colorectal surgery · Laparotomy conversion rate · Obesity · Body mass index

Minimally invasive surgery is emerging as the standard of care in the surgical management of colorectal diseases, including cancer. The advantages of laparoscopic colorectal surgery include decreased pain, length of stay, wound complications, cardiac complications, and incidence of pneumonia [1–4]. Furthermore, evidence continues to show oncologic outcomes do not differ between patients undergoing open or laparoscopic surgery [5–8]. A high-risk group of patients thought to benefit from laparoscopic colorectal surgery are the morbidly obese

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since these patients have a higher risk of surgical site infection, dehiscence, pulmonary embolism, and renal failure compared with normal weight patients [9]. Additionally, obesity is associated with several other comorbidities that may contribute to poor outcomes such as diabetes, hypertension, obstructive sleep apnea, and cardiovascular disease. Based on these comorbidities, a less invasive approach to colorectal disease would be optimal [10].

Despite the benefits of a laparoscopic approach, the conversion rate to open laparotomy in colorectal surgery remains high. In several large, randomized controlled trials, the conversion rates ranged from 15 to 29 % [7, 8, 11, 12]. Unfortunately, conversion to open laparotomy was associated with greater morbidity including longer operative times, greater blood loss, increased intraoperative and postoperative complications, and longer length of stays [7, 13]. Increased body mass index (BMI) was one of the principal risk factors associated with the risk of conversion in these studies. In many cases, the thickened and excessive omentum, as well as the mesentery, make it difficult to gain access to deeper areas in the pelvis, as well as the splenic and hepatic flexures. Excessive fat and thickened mesentery can also result in problematic bleeding. Along with increased conversion rates in obese patients, several studies document a higher risk of ileus, wound infections, longer operative time and hospital stays, higher morbidity rate, and higher anastomotic leak rates compared to non-obese patients [14–17].

Despite these limitations in laparoscopic surgery, robotic-assisted surgery may be beneficial in the surgical management of obese patients. The use of robotic-assisted surgery has escalated over the last decade, and now is increasingly employed in colorectal surgery. The appeal of robotic-assisted surgery is improved vision, accuracy and precision, favorable surgeon ergonomics, as well as dexterity with wristed instruments as compared to the laparoscopic approach. These advantages may help overcome the limitations of laparoscopic colorectal surgery in obese patients. Therefore, the purpose of this study is to evaluate the effect of obesity on outcomes in robotic colorectal surgery since the evidence in this patient population is limited.

Materials and methods

After obtaining institutional review board approval, a retrospective review of patients undergoing robotic colorectal surgeries from a prospectively maintained database in a single academic institution was performed. Consecutive patients, 18 years of age or older, undergoing planned robotic surgeries using the da Vinci® robotic platform (Intuitive Surgical Inc., Sunnyvale, CA) by our 3-member, fellowship trained, colorectal surgery group between October 2009 and July 2015 were included. All surgeons in the group have been performing robotic-assisted surgery for >2 years, and the senior author has over 7 years of experience. Our technique with port placement and extraction sites has been previously described, and all patients followed a standardized enhanced recovery program which included minimizing nasogastric tubes and drains, early transitioning to oral narcotics, and restarting and advancing diets early in the hospital course [18].

Patients were divided based on preoperative BMI into non-obese (BMI <30 kg/m^2) and obese (BMI ≥ 30 kg/m^2) groups. The standard World Health Organization definition of obesity (BMI ≥ 30 kg/m^2) was used since it is the most commonly used definition in the literature comparing non-obese and obese groups. Patients in each group were then matched 1:1 by gender, age within 10 years, and procedure performed. Primary endpoints evaluated included conversion to laparotomy, as well as intraoperative and postoperative complications. Secondary endpoints examined included operative time, estimated blood loss (EBL), and length of stay. Wound complications (including surgical site infection, seroma, hematoma, and dehiscence), intra-abdominal infections (including anastomotic leaks and intra-abdominal abscesses), hemorrhage requiring transfusion, incisional hernias, prolonged ileus (>10 days), early bowel obstruction, myocardial infarction/stroke, readmission for dehydration, and death were included as complications. Following matching, comparisons between non-obese and obese groups were analyzed using a two-tailed student's t test to compare means between groups, and a two-tailed Fisher's exact test was used to evaluate the number of specific complications and conversions to laparotomy between groups. Results are expressed as mean ± SD for parametric data. A p value ≤ 0.05 was considered statistically significant. A power analysis was performed based on a 10 % difference in postoperative complication/conversion rates between groups, considering a 5 % alpha error, 80 % power, and a two-sided hypothesis. An adequate sample size was determined to be 97 patients per group.

Results

Of the 331 consecutive patients in the prospective database, 164 (49.55 %) were women, the mean age was 59.18 ± 12.95 years, and the mean BMI was 28.73 ± 7.21 kg/m^2. Of these patients, 216 were non-obese (mean BMI 24.61 ± 3.22 kg/m^2), and 115 were obese (mean BMI 36.47 ± 6.17 kg/m^2). Following case matching, each group included 108 patients comprised of 50 men and 58 women (Table 1). The mean BMI at surgery for the two groups was 24.60 ± 3.15 and 36.24 ± 5.67 kg/m^2 ($p < 0.0001$), and the mean age was 59.2 ± 11.28 years for non-obese patients and 57.1 ± 12.44 years for obese patients ($p = 0.18$). Indications for surgery were classified as either a benign etiology or malignancy, and 42 (38.89 %) patients in each group had benign indications, while 66 (61.11 %) patients in each group had a malignancy. Procedures performed included low anterior resection ($N = 60$), right colectomy ($N = 60$), sigmoid colectomy ($N = 38$), left colectomy ($N = 30$), excision of rectal endometriosis ($N = 6$), total proctocolectomy ($N = 4$), abdominal perineal resection (APR) ($N = 4$), subtotal colectomy ($N = 4$), ileocecectomy ($N = 2$), proctectomy ($N = 2$), rectopexy ($N = 2$), transanal excision of rectal mass ($N = 2$), and colostomy site hernia repair ($N = 2$). The overall mean operative time was 272.69 ± 115.43 and 282.42 ± 120.51 min ($p = 0.55$), mean EBL 195.23 ± 230.37 and 289.19 ± 509.27 mL ($p = 0.08$), and mean length of stay 5.38 ± 4.94 and 4.56 ± 4.04 days ($p = 0.18$) for the non-obese and obese groups, respectively (Table 1). Seven of the non-obese patients and ten of the obese patients had conversions to laparotomy ($p = 0.45$) with an overall conversion rate of 7.87 %. In addition, 20 of the non-obese patients had a postoperative complication as compared to 27 of the obese patients ($p = 0.30$). In the non-obese group, two out of seven conversions to laparotomy resulted in a postoperative complications, and in the obese group, five out of ten conversions resulted in a complication, which were not statistically significant between groups ($p = 0.62$).

Specific complications were then compared between groups (Table 2). Of all complications, only wound complications were significantly higher in the obese group ($p = 0.03$). Intra-abdominal infections, including anastomotic leaks, were similar between non-obese and obese patients (4.6 and 3.7 %; $p = 0.75$). Next, specific procedures between groups were evaluated. Only procedures with more than one matched pair could be analyzed (Table 3). Procedures analyzed included low anterior resection, right colectomy, sigmoid colectomy, left colectomy, excision of rectal endometriosis, total proctocolectomy, APR, and subtotal colectomy. Operative time, EBL, length of stay, conversion to laparotomy, and complications did not differ between groups except for the procedure of APR with increased EBL in the obese group ($p = 0.01$).

Since higher complication and conversion rates have been reported in colorectal pelvic surgeries, patients were also stratified based on abdominal surgery or pelvic surgery. Abdominal surgeries included 136 patients who underwent right colectomy, left colectomy, sigmoid colectomy, subtotal colectomy, ileocecectomy, and colostomy site hernia repair. Pelvic surgeries included 80 patients who underwent low anterior resection, excision of rectal endometriosis, total proctocolectomy, APR, proctectomy, rectopexy, and transanal excision of rectal mass. With regard to abdominal operations, obese patients had a higher complication rate compared to non-obese patients (30.9 vs 14.7 %; $p = 0.04$), but there was no difference in conversion to laparotomy rates (Table 4). Of the complications, 15 (71.4 %) involved a wound complication or incisional hernia. There were no differences between groups regarding complications and conversions in patients undergoing pelvic surgery. Operative times, EBL, and length of stay also did not differ between non-obese and obese patients for abdominal or pelvic surgeries (Table 4).

Discussion

Although it is known from the laparoscopic literature that conversion to laparotomy and complications are significantly higher in obese patients undergoing colorectal

Table 1 Patient demographics, indication for surgery, estimated blood loss, operative time, length of stay, conversion to laparotomy and complications in non-obese (BMI <30 kg/m^2) and obese (BMI ≥30 kg/m^2) patients following robotic-assisted colorectal surgery

	BMI <30 ($N = 108$)	BMI ≥30 ($N = 108$)	p value
Male	50	50	1.00
Female	58	58	1.00
Age (years)	59.2 ± 11.28	57.1 ± 12.44	0.18
BMI (kg/m^2)	24.6 ± 3.15	36.2 ± 5.67	<0.0001
Indication for Surgery			
Benign	42	42	1.00
Malignancy	66	66	1.00
Estimated blood loss (mL)	195.23 ± 230.37	289.19 ± 509.27	0.08
Operative time (min)	272.69 ± 115.43	282.42 ± 120.51	0.55
Length of stay (days)	5.38 ± 4.94	4.56 ± 4.04	0.18
Conversion to laparotomy	7	10	0.45
Complications	20	27	0.30

A p value <0.05 is considered statistically significant

Table 2 Specific complications in non-obese (BMI <30 kg/m^2) and obese (BMI ≥30 kg/m^2) patients following robotic-assisted colorectal surgery

	BMI <30 (*N* = 108)	BMI ≥30 (*N* = 108)	*p* value
Wound complication	2 (1.9 %)	10 (9.3 %)	0.03
Intra-abdominal infection	5 (4.6 %)	4 (3.7 %)	0.75
Hemorrhage requiring transfusion	2 (1.9 %)	3 (2.8 %)	0.99
Prolonged ileus	3 (2.8 %)	0 (0.0 %)	0.25
Bowel obstruction	2 (1.9 %)	0 (0.0 %)	0.50
Myocardial infarction/stroke	1 (0.9 %)	1 (0.9 %)	1.00
Readmission for dehydration	1 (0.9 %)	2 (1.9 %)	0.62
Incisional hernia	4 (3.7 %)	8 (7.4 %)	0.37
Death	0 (0.0 %)	0 (0.0 %)	1.00

A *p* value <0.05 is considered statistically significant

surgery, this has not been adequately studied in robotic-assisted colorectal surgery patients. These data demonstrate that there is no difference in overall complication and conversion to laparotomy rates in obese patients compared to non-obese patients in robotic-assisted colorectal surgery. Furthermore, there was no difference in operative time, EBL, and length of stay. Although there was no significant difference in overall complications between groups in this study, there was a significantly higher prevalence of wound complications in obese patients (1.9 vs 9.3 %) when comparing specific complications ($p = 0.03$). These complications included superficial surgical site infections, wound dehiscence, hematomas, and seromas. Additionally, when patients were stratified based on abdominal or pelvic surgery, a higher prevalence of wound complications and incisional hernias were found in obese patients undergoing abdominal surgery.

In addition, a higher prevalence of bleeding has been reported in obese patients, but it was not statistically significant in this study; however, it did approach significance ($p = 0.08$). In evaluating individual procedures, there was a significant increase in EBL in obese patients undergoing APR ($p = 0.01$). Deep pelvic dissection is associated with higher complications, including bleeding, due to the narrow workspace and the proximity of the presacral venous system. However, this specific group has a small sample size, and a larger number of obese patients undergoing APR included in this study may provide different outcomes with better evidence.

Subsequently, there are several limitations to this study, including its retrospective nature conducted at a single academic institution. Although a single institution study minimizes variations in technique and skill set, the sample size is often limited. In this study, all consecutive patients with benign, malignant, and inflammatory processes were included to adequately power the study and were clinically matched only by age, gender, and surgery performed. Therefore, patient heterogeneity may be a possible confounder in this study. Nevertheless, this robotic colorectal series is the largest reported to date including a significant number of higher risk patients such as obese patients and those requiring pelvic surgery.

Furthermore, the current literature has struggled to define obesity, and controversy remains regarding the effect of obesity on outcomes in colorectal surgery [19]. Although sparse, a handful of studies have shown minimal or no difference in outcomes between non-obese and obese patients [20–23]. However, these studies also have significant limitations including small sample sizes and not including pelvic surgeries. A recent case-matched series by Keller et al. [24] evaluating short-term outcomes in obese and non-obese patients undergoing robotic-assisted colorectal surgery also found no difference in operative time, blood loss, complications, length of stay, or conversion rates between the two groups. But similar to previous studies, the small sample size of 45 patients in each group suggests that the study is underpowered to detect any significant difference, and no power analysis was performed. In addition, the series had a low conversion to laparotomy rate (0.0–2.2 %) implying a possible selection bias, since larger regional and national databases demonstrate higher conversion rates of 7.8–10.0 % [25, 26]. The overall conversion rate for this series was 7.87 %, which is similar to previous studies.

Regarding the definition of obesity, some have suggested that visceral obesity is a more reliable measurement than BMI, which neglects several factors including muscle mass and whether the adipose tissue is visceral as opposed to subcutaneous [27, 28]. Computed tomography can be used to calculate a visceral fat volume and is a better predictor of short-term outcomes compared to BMI in certain populations [27, 28]. However, preoperative computed tomography scans were not completed on all patients in this study and could not be evaluated. Despite these limitations, there remains stronger evidence, including evidence from randomized, prospective studies, that obesity (BMI ≥30) has a negative effect on laparoscopic colorectal surgery complications.

Table 3 Operative time, estimated blood loss, length of stay, conversion to laparotomy, and complication for specific robotic-assisted surgeries in non-obese (BMI <30 kg/m^2) and obese (BMI ≥30 kg/m^2) patients

	BMI <30 (*N* = 108)	BMI ≥30 (*N* = 108)	*p* value
Low anterior resection	30 (27.78 %)	30 (27.78 %)	1.00
Operative time (min)	327.47 ± 118.94	334.77 ± 106.46	0.80
Estimated blood loss (mL)	227.67 ± 246.03	234.00 ± 204.56	0.91
Length of stay (days)	6.57 ± 7.89	4.13 ÷ 1.79	0.11
Conversion to laparotomy	2 (1.9 %)	2 (1.9 %)	1.00
Complications	8 (7.4 %)	4 (3.7 %)	0.20
Right colectomy	30 (27.78 %)	30 (27.78 %)	1.00
Operative time (min)	186.47 ± 66.76	195.17 ± 42.43	0.55
Estimated blood loss (mL)	108.67 ± 104.75	197.83 ± 288.25	0.12
Length of stay (days)	4.40 ± 1.78	4.00 ± 1.39	0.33
Conversion to laparotomy	1 (0.9 %)	3 (2.8 %)	0.31
Complications	5 (4.6 %)	11 (10.2 %)	0.11
Sigmoid colectomy	19 (17.59 %)	19 (17.59 %)	1.00
Operative time (min)	268.05 ± 103.59	278.47 ± 79.69	0.73
Estimated blood loss (mL)	181.58 ± 192.63	313.68 ± 456.23	0.26
Length of stay (days)	4.37 ± 2.34	4.79 ± 2.25	0.56
Conversion to laparotomy	2 (1.9 %)	1 (0.9 %)	0.56
Complications	3 (2.8 %)	7 (6.5 %)	0.25
Left colectomy	15 (13.89 %)	15 (13.89 %)	1.00
Operative time (min)	279.60 ± 67.16	271.73 ± 59.16	0.74
Estimated blood loss (mL)	210.00 ± 195.67	231.33 ± 207.91	0.77
Length of stay (days)	6.60 ± 4.87	4.73 ± 1.91	0.18
Conversion to laparotomy	1 (0.9 %)	3 (2.8 %)	0.29
Complications	1 (0.9 %)	2 (1.9 %)	0.56
Excision of rectal endometriosis	3 (2.78 %)	3 (2.78 %)	1.00
Operative time (min)	427.00 ± 136.04	355.00 ± 167.03	0.59
Estimated blood loss (mL)	183.33 ± 152.75	156.67 ± 57.74	0.87
Length of stay (days)	2.33 ± 0.58	1.33 ± 1.53	0.35
Conversion to laparotomy	0 (0.0 %)	0 (0.0 %)	1.00
Complications	2 (1.9 %)	0 (0.0 %)	0.37
Total proctocolectomy	2 (1.85 %)	2 (1.85 %)	1.00
Operative time (min)	365.00 ± 35.36	661.00 ± 439.82	0.44
Estimated blood loss (mL)	275.00 ± 318.19	2150.00 ± 2899.14	0.46
Length of stay (days)	4.50 ± 2.12	22.5 ± 26.16	0.43
Conversion to laparotomy	0 (0.0 %)	0 (0.0 %)	1.00
Complications	0 (0.0 %)	1 (0.9 %)	0.42
Abdominal perineal resection	2 (1.85 %)	2 (1.85 %)	1.00
Operative time (min)	325.5 ± 7.78	457.50 ± 17.68	0.51
Estimated blood loss (mL)	350.00 ± 353.55	925.00 ± 954.59	0.01
Length of stay (days)	7.50 ± 4.95	8.00 ± 2.83	0.91
Conversion to laparotomy	0 (0.0 %)	0 (0.0 %)	1.00
Complications	0 (0.0 %)	0 (0.0 %)	1.00
Subtotal colectomy	2 (1.85 %)	2 (1.85 %)	1.00
Operative time (min)	325.5 ± 35.36	367.50 ± 38.89	0.76
Estimated blood loss (mL)	125.00 ± 318.19	100.00 ± 0.00	0.77
Length of stay (days)	6.00 ± 2.12	4.00 ± 2.83	0.63
Conversion to laparotomy	0 (0.0 %)	0 (0.0 %)	1.00
Complications	1 (0.9 %)	1 (0.9 %)	1.00

A *p* value <0.05 is considered statistically significant

Table 4 Operative time, estimated blood loss, length of stay, conversion to laparotomy, and complication for specific abdominal and pelvic robotic-assisted surgeries in non-obese (BMI <30 kg/m^2) and obese (BMI ≥30 kg/m^2) patients

	BMI <30 ($N = 108$)	BMI ≥30 ($N = 108$)	p value
Abdominal surgeries	68 (63.0 %)	68 (63.0 %)	1.00
Operative time (min)	233.93 ± 91.59	240.99 ± 73.34	0.62
Estimated blood loss (mL)	163.68 ± 190.94	232.13 ± 323.32	0.14
Length of stay (days)	4.96 ± 3.06	4.34 ± 1.83	0.16
Conversion to laparotomy	4 (5.9 %)	7 (10.3 %)	0.35
Complications	10 (14.7 %)	21 (30.9 %)	0.04
Pelvic surgeries	40 (37.0 %)	40 (37.0 %)	1.00
Operative time (min)	338.60 ± 122.74	352.85 ± 150.07	0.64
Estimated blood loss (mL)	248.88 ± 279.81	386.18 ± 718.78	0.26
Length of stay (days)	6.10 ± 7.07	4.93 ± 6.24	0.43
Conversion to laparotomy	3 (7.5 %)	3 (7.5 %)	1.00
Complications	10 (25.0 %)	6 (15.0 %)	0.30

A p value <0.05 is considered statistically significant

Despite the negative effects on health, obesity rates continue to increase in the USA with over a third of the adult population having a BMI ≥30 kg/m^2, and at least 1 in 20 Americans are considered as morbidly obese with a BMI ≥40 kg/m^2 [29, 30]. Therefore, minimally invasive colorectal surgeons will continue to see an increasing amount of obese and morbidly obese patients as obesity continues to be associated with increased complications and conversions to laparotomy. The reasons are likely multifactorial, but include patient comorbidities, a bulky omentum and mesentery, decreased intra-abdominal space and visualization, a thicker abdominal wall increasing torsion on laparoscopic instruments which limits efficient movements and reach, and also a surgeon's skill set. Typically, none of these factors are modifiable at the time of surgery since the surgeon's skill set is dependent on time and experience. However, with robotic-assisted surgery, several of these factors can be modified. The high-definition, three-dimensional camera improves visualization. The wristed, robotic instruments allow for more precise dissections, especially in the deep pelvis, as well as the hepatic and splenic flexures. The robotic platform allows for self-retraction and improved ergonomics. Near-infrared technology enables real-time identification of structures and tissue perfusion. And furthermore, the estimated learning curve is approximately 20 cases, even for surgeons who lack significant laparoscopic experience [31].

In conclusion, there is no difference in conversion to laparotomy and overall complication rates in obese and non-obese patients undergoing robotic-assisted colorectal surgery. However, wound complications continue to have a higher prevalence in obese patients. In addition, there is no difference in EBL, operative time, and length of stay between non-obese and obese patients. Therefore, robotic-assisted surgery may offer several advantages compared to laparoscopic surgery including improved visualization, dexterity, and surgeon ergonomics, which may improve outcomes. Although there are few studies showing the benefits of robotic-assisted colorectal surgery in general, obese patients with higher risks of intra-operative and postoperative complications may see a greater benefit than non-obese patients. However, additional prospective studies are required in order to compare laparoscopic and robotic-assisted colorectal surgery outcomes in obese patients.

Compliance with ethical standards

Disclosures Drs. Harr, Luka, Kankaria, Juo, and Agarwal have nothing to disclose and have no financial relationships with device companies. Dr. Obias is a consultant for Intuitive Surgical and teaches courses on robotic-assisted colorectal surgery.

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