

Robotic-Assisted and Laparoscopic Sigmoid Resection

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ABSTRACT

Background and Objectives: Published comparisons of minimally invasive approaches to colon surgery are limited. The objective of the current study is to compare the effectiveness of robotic-assisted and laparoscopic sigmoid resection.

Methods: A multicenter retrospective comparative analysis of perioperative outcomes from consecutive robotic-assisted and laparoscopic sigmoid resections performed between 2010 and 2015 by six general and colorectal surgeons, who are experienced in both robotic-assisted and laparoscopic surgical techniques and who had >50 annual case volumes for each approach. Baseline characteristics and surgical risk factors between the two groups were balanced using a propensity score methodology with inverse probability of treatment weighting. Mean standardized differences were reported, and in all instances, a p -value < 0.05 was considered statistically significant.

Results: Three hundred thirty-six cases (robotic-assisted, $n = 211$; laparoscopic, $n = 125$) met eligibility criteria and were included in the study. Following weighting, patient demographics and baseline characteristics were comparable between the robotic-assisted ($n = 344$) and laparoscopic ($n = 349$) groups. The laparoscopic group was associated with shorter operating room and surgical times. The robotic-assisted group had lower estimated blood loss and shorter time to first flatus compared to the laparoscopic group. Rates of complications post discharge to 30 d tended to be lower for the RA group: 5.1% vs 8.6% [$p = 0.0657$]. The RA group also had lower rates of readmissions and reoperations: 4% vs 8% [$p = 0.029$] and 0.5% vs 5.1% [$p = 0.0003$], respectively.

Conclusions: Robotic-assisted sigmoid colon resection is clinically effective and provides a minimally invasive alternative to the laparoscopic approach with improved intraoperative and postoperative outcomes for colorectal patients.

Key Words: Sigmoid, Sigmoid resection, Laparoscopy, Robotic-assisted, Minimally invasive surgery.

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INTRODUCTION

Comparisons of laparoscopic and open colon resection techniques and outcomes have been reported in the literature, and in some, the laparoscopic approach was comparable in terms of surgical and postoperative outcomes and was associated with shorter and less complicated recoveries.¹⁻² Despite these demonstrated clinical advantages, the minimally invasive approach to colon surgery has not been widely adopted, most likely due to the technical and ergonomic challenges of laparoscopic sigmoid colon resection, especially in a narrow pelvis.³ There are limited studies published on the comparative effectiveness of robotic-assisted versus laparoscopic sigmoid resection for both benign and malignant disease.⁴ Therefore, this multicenter retrospective study was undertaken to compare perioperative outcomes (through 30 d postoperative) between robotic-assisted (da Vinci® Surgical System, Intuitive Surgical, Inc., Sunnyvale, CA USA)

and laparoscopic sigmoid resection and to explore perioperative outcomes of robotic-assisted and laparoscopic sigmoid resection in subgroups of patients with benign disease, obesity and benign disease and malignant disease.

METHODS

Study Population

A total of 336 patients underwent robotic-assisted (n = 211) or laparoscopic (n = 125) sigmoidectomy by 6 surgeons at 5 medical centers and were included in this retrospective chart review study. Each participating center provided an informed consent waiver specific to the study and provided institutional review board (IRB) approval for retrospective data collection prior to review of the charts. IRB sites (principal investigators' initials) and numbers follow: Aria Health (L.G.) AH15-284; HonorHealth Research Institute (A.A.K.) 825573-1; Morris Hospital and Silver Cross Hospital IRB (R.G.) 813348-1; WIRB (H.L. and G.P.) 1158794; BayCare Health System (C.A.S.) 2015.079-BSJ.

Patient demographics, baseline characteristics, and perioperative outcomes from sigmoid resection cases were retrospectively collected on study-specific data collection forms. International Classification of Diseases, 9th revision (ICD-9) diagnosis codes (153.3, 154.0, 211.3, 211.4, 560.2, 562.10, 562.11, 562.12, 562.13, 555.9, 556, 569.81) were used to identify cases indicated for sigmoid resection surgery. Data were collected for elective cases performed between January 2010 and December 2015 through 30 d prior to each IRB approval. Patients were considered for inclusion if they were male or female patients 18 years old or older and underwent nonemergent robotic-assisted or laparoscopic sigmoid resection for benign or malignant disease.

The participating study investigators were general and colorectal surgeons, experienced in both robotic-assisted and laparoscopic surgical techniques and had 50 annual case volumes for each robotic-assisted and laparoscopic colon resection. The study investigators were experienced with surgical management of patients with colonic lesions and with a patient population fitting the study requirements. Each surgeon had more than 5 y of experience with the robotic platform. The study was designed to exclude learning-curve cases as they could influence study outcomes in either group. Consequently, a maximum of 50 of the most recent, consecutive cases of sigmoidectomy from each arm performed by each surgeon through 30 d prior to IRB approval were considered for study inclusion. Per protocol,

emergent cases were excluded. This exclusion criterion accounts for the lower number of patients ultimately included in the study (336 actual vs 500 planned).

All procedures that were performed and described in this study involving human participants were in accordance with the ethical standards of each institutional research committee and in accordance with 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Due to the retrospective nature of this study, informed consent was not required.

Surgical Technique

Robotic-assisted and laparoscopic sigmoidectomies were performed according to the surgical technique of each surgeon. No standardization of the technique was attempted. After induction of anesthesia, time out was performed in line with each institutional protocol. The trocars were placed and pneumoperitoneum obtained. Medial-to-lateral dissection or lateral-to-medial dissection was performed all the way distal at the recto-sigmoid junction. Surgeon preference guided the extent of the dissection and the length of the resected specimen. The specimen extraction occurred through either a left lower-quadrant transverse incision, a Pfannenstiel incision, or a lower-midline incision. The anastomosis was performed with the end-to-end anastomosis stapler of the surgeon's choice. Reported estimated blood loss was based on the quantitative assessment of the volume suctioned into a canister during each case.

Statistical Analysis

The retrospective data were analyzed by comparing outcomes of robotic-assisted and laparoscopic sigmoidectomy patients. All analyses were based on available data. Categorical variables were presented as numbers and percentages and were compared using the χ^2 or Fisher's exact test. The continuous variables are reported as mean and standard deviation and analyzed using t-tests or Wilcoxon rank sum test. To account for treatment selection bias, we attempted to balance the baseline characteristics and surgical risk factors between the robotic and laparoscopic groups using a propensity score methodology with inverse probability of treatment weighting (IPTW).⁵ The IPTWs were estimated using multinomial logistic regression analysis including the following variables: age, gender, body mass index (BMI) category, surgery indication (malignant vs benign), and indicators for comorbidity conditions, previous treatment, previous abdominal surgery, and concomitant surgery. Using this technique, the weights used for patients undergoing laparoscopic surgery were the inverse of 1 minus the propensity score, and weights used for patients receiving robotic-as-

sisted surgery were the inverse of the propensity score alone. Patient characteristics were then reassessed for balance between surgery groups after adjusting for the IPTWs and standardized differences were reported. In all instances, a p -value < 0.05 was considered statistically significant. Data analyses were performed with SAS System version 9.4 (SAS Institute, Inc., Cary, NC).

RESULTS

Across the five medical centers 336 cases (robotic-assisted sigmoidectomy, $n = 211$; laparoscopic sigmoidectomy, $n = 125$) met eligibility criteria and were included in the study (**Figure 1**). All six of the participating surgeons contributed 30–50 robotic-assisted cases and four surgeons contributed 23–58 laparoscopic cases.

For the comparison of groups based on unmatched patient demographics, baseline characteristics and perioper-

ative outcomes (**Table 1**), patients who underwent robotic-assisted sigmoidectomy were significantly younger, had a higher mean BMI, had a lower preoperative malignant diagnosis, and had a higher rate of prior treatment (chemotherapy, conservative therapy “watch and wait”, and surgery) compared to laparoscopic sigmoidectomy patients. Few patients—regardless of whether they were considered within the entire subject population or only in the malignant subgroup—received chemotherapy or surgery prior to the index surgery. Most were treated conservatively. Within the malignant subgroup, one patient in each of the robotic-assisted and laparoscopic subgroups had received chemotherapy; one patient in the laparoscopic subgroup had been treated conservatively; and two and one patients in the robotic-assisted and laparoscopic subgroups, respectively, had received prior surgical treatment. Surgical and operating room times were shorter for the patients in the laparoscopic group. The robotic-as-

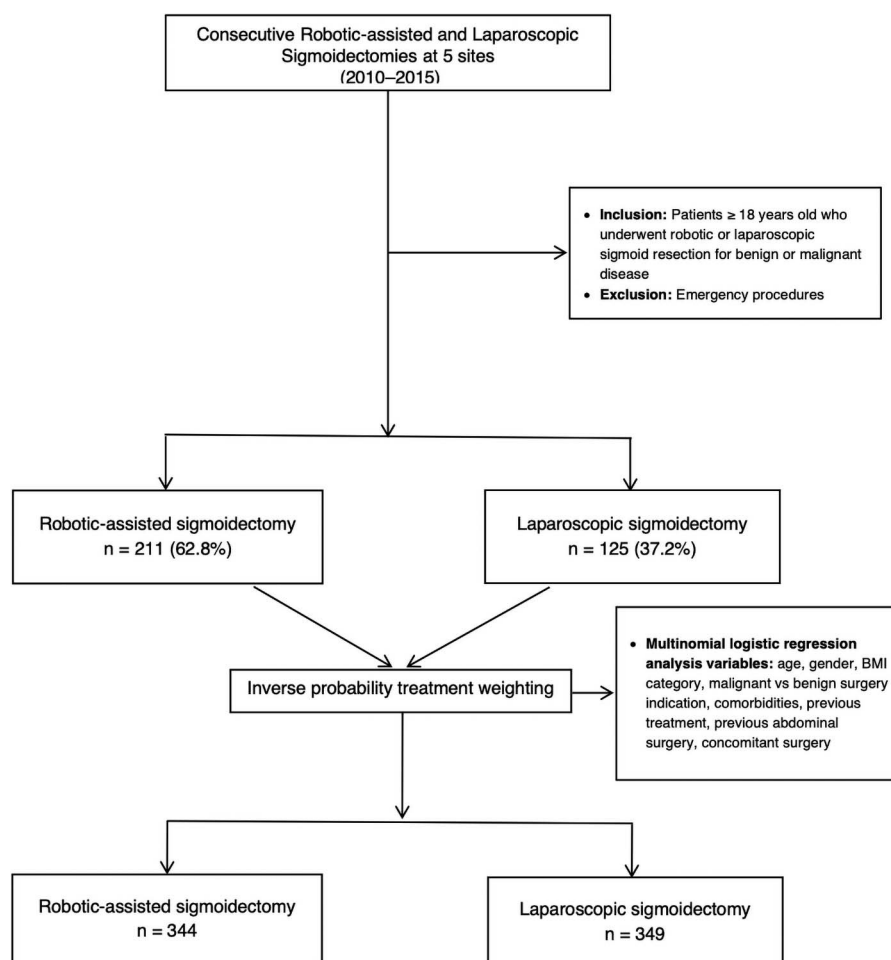


Figure 1. Patient flowchart.

Table 1.
Unmatched Baseline and Perioperative Outcomes from Robotic-Assisted and Laparoscopic Sigmoid Resection

Variable	Robotic-assisted (n = 211)	Laparoscopic (n = 125)	p-value	Standardized Difference
Demographics				
Age (y), mean ± SD	60.2 ± 13.0	65.1 ± 14.3	0.0013	-0.3609
Gender, n (%)			0.1212	0.1386
Female	107 (50.7)	72 (57.6)		
Male	104 (49.3)	53 (42.4)		
BMI (kg/m ²), mean ± SD	29.0 ± 6.2	26.9 ± 4.9	0.0009	0.3681
Categorical BMI, n (%)			0.0038	0.1448
≤24.9 kg/m ²	57 (27)	47 (37.6)		
≥25.0 to ≤29.9 kg/m ²	79 (37.4)	42 (33.6)		
≥30.0 to ≤34.9 kg/m ²	42 (19.9)	31 (24.8)		
≥35.0 kg/m ²	33 (15.6)	5 (4)		
Medical/Surgical History				
Patients with ≥1 comorbidity, n (%)	120 (56.9)	82 (65.6)	0.1143	0.1799
Surgical indication, n (%)			0.0004	0.3957
Malignant disease	34 (16.1)	41 (32.8)		
Benign disease	177 (83.9)	84 (67.2)		
Previous treatment for current condition, n (%)	167 (79.1)	76 (60.8)	0.0003	0.4085
Previous abdominal surgery, n (%)	115 (54.5)	75 (60)	0.3258	-0.1113
Surgery and Hospitalization Characteristics				
Primary procedure, n (%)			0.3767	0.1015
Left hemicolectomy	27 (12.8)	12 (9.6)		
Sigmoidectomy	184 (87.2)	113 (90.4)		
Cases with ≥1 concomitant procedure, n (%)	43 (20.4)	29 (23.2)	0.5425	-0.0684
Surgical time ^a (m), mean ± SD	164.25 ± 63.1	142.2 ± 53.3	0.0007	0.4348
Operating room time ^b (m), mean ± SD	225.2 ± 66.6	198.1 ± 57.5	0.0002	0.3779
Estimated blood loss (ml), mean ± SD	48.1 ± 51.5	59.6 ± 51.2	0.0481	-0.2242
Conversion to open, n (%)	0 (0)	1 (0.8)	0.372	-0.127
Length of stay (d), mean ± SD	3.7 ± 4.6	4.2 ± 4.2	0.3609	-0.0145
Time to flatus (d), mean ± SD	2.0 ± 0.8	2.5 ± 1.9	0.0067	-0.3484
Time to bowel movement (d), mean ± SD	2.6 ± 1.0	3.1 ± 2.05	0.0112	-0.3359
Time to regular diet (d), mean ± SD	3.4 ± 4.2	3.2 ± 2.2	0.4649	0.0814
Complications and Adverse Events				
Complications, n (%)				
Intraoperative	0 (0)	0 (0)	not valid	
Postoperative prior to discharge	5 (2.4)	5 (4)	0.5091	-0.0929
Post discharge to 30 d	20 (4.7)	7 (5.6)	0.7986	-0.0389

Table 1.
Continued

Variable	Robotic-assisted (n = 211)	Laparoscopic (n = 125)	p-value	Standardized Difference
Readmissions ^c , n (%)	8 (3.8)	6 (4.9)	0.6327	-0.0498
Reoperations ^c , n (%)	1 (0.5)	2 (1.6)	0.5572	-0.1113

SD, standard deviation of the mean; BMI, body mass index.

^aSurgical time: skin to skin.

^bOperating room time: wheels in to wheels out.

^cPost discharge to 30 d.

sisted sigmoidectomy group demonstrated lower estimated blood loss (by approximately 12 ml), shorter time to first flatus (approximately 12 h earlier) and shorter time to first bowel movement (approximately 12 h earlier) compared to the laparoscopic group. Groups did not differ on length of hospital stay, perioperative complications, or rates of readmissions and reoperations.

Propensity Weighting

Following IPTW for all multinomial logistic regression analysis variables, patient demographics and baseline characteristics were comparable between the robotic-assisted (n = 344) and laparoscopic (n = 349) groups (Table 2). The laparoscopic group was associated with shorter operating room and surgical times. The robotic-assisted group maintained lower estimated blood loss and shorter time to first flatus when compared to the laparoscopic group. Rates of complications post-discharge to 30 d tended to be lower for the robotic-assisted group: 5.1% vs 8.6% [*p* = 0.0657]. The robotic-assisted group also had lower rates of readmissions and reoperations: 4% vs 8% [*p* = 0.029] and 0.5% vs 5.1% [*p* = 0.0003], respectively.

Subgroup Analyses

Subgroup analyses were performed comparing robotic-assisted and laparoscopic sigmoidectomy approaches for: all patients with a preoperative diagnosis of benign disease (Table 3), obese patients with a preoperative diagnosis of benign disease (Table 4) and all patients with a preoperative diagnosis of malignant disease (Table 5).

DISCUSSION

The literature has demonstrated the advantages of the laparoscopic approach for sigmoid colon surgery when compared with the open technique—especially in terms of length of stay, time to first flatus, time to first bowel

movement, and intraoperative complications.⁶⁻⁷ In their meta-analysis of 22 studies involving a total of 10,898 patients, Siddiqui et al. concluded that, compared with the open approach, laparoscopic sigmoid resection for diverticular disease was associated with lower overall morbidity, earlier return of bowel function, and shorter hospital stay despite the longer operative time of the minimally invasive approach.⁸ Despite the growing adoption of the robotic-assisted technique in colorectal surgery, there are limited published data comparing the outcomes between the robotic-assisted and the laparoscopic approaches for sigmoid colon resection.⁴

The current study provides a multicenter, retrospective analysis of robotic-assisted versus laparoscopic sigmoid colon resection for benign and malignant disease. After propensity weighting, the surgical and operating room times were longer for the robotic-assisted group; whereas, estimated blood loss was lower. Rates of readmissions and reoperations were higher in laparoscopic group compared with robotic-assisted group. A literature search evidenced similar reoperation rates for laparoscopic colorectal resection. Siddiqui et al published a prospective data collection analysis of 718 patients who underwent laparoscopic colorectal resection for both benign and malignant disease.⁹ Group A (n = 476, 66.3%), Group B (n = 190, n = 26.5%), and Group C (n = 52, 7.2%) had, respectively: no previous abdominal surgery, previous abdominal surgery not including colonic surgery, and previous bowel surgery. Of the three groups, reoperation rates within 30 d of surgery were: 5% for Group A, 3% for Group B, and 4% for Group C.

Surgical times for robotic-assisted colorectal surgeries have been reported as comparable to¹⁰⁻¹² or longer than those for the laparoscopic approach.¹³⁻¹⁵ Our study was designed to include surgeons experienced in both robotic-assisted and laparoscopic colorectal surgeries, thereby excluding learning curve cases, as surgical time decreases with increased robotic-assisted colorectal surgery experi-

Table 2.
Inverse Probability Treatment Weighted Outcomes from Robotic-Assisted and Laparoscopic Sigmoid Resection

Variable	Robotic-assisted (n = 334)	Laparoscopic (n = 349)	p-value	Standardized Difference
Demographics				
Age (y), mean ± SD	61.8 ± 16.2	60.25 ± 25.5	0.3467	0.0718
Gender, n (%)			0.7392	-0.0255
Female	177 (52.9)	180 (51.6)		
Male	157 (47.1)	169 (48.4)		
BMI (kg/m ²), mean ± SD	28.3 ± 7.3	28.3 ± 9.4	0.9185	0.0078
Categorical BMI, n (%)			0.6582	-0.0477
≤24.9 kg/m ²	105 (31.4)	105 (30)		
≥25.0 to ≤29.9 kg/m ²	121 (36.1)	123 (35.2)		
≥30.0 to ≤34.9 kg/m ²	70 (21)	70 (20)		
≥35.0 kg/m ²	38 (11.5)	51 (14.7)		
Medical/Surgical History				
Patients with ≥ 1 comorbidity, n (%)	201 (60.2)	208 (59.5)	0.8556	0.0139
Surgical indication, n (%)			0.7366	-0.0257
Malignant disease	73 (21.8)	72 (20.7)		
Benign disease	261 (78.2)	277 (79.3)		
Previous treatment for current condition, n (%)	242 (72.6)	259 (74.2)	0.6301	-0.0369
Previous abdominal surgery, n (%)	187 (56.1)	179 (51.4)	0.2168	0.0946
Surgery and Hospitalization Characteristics				
Primary procedure, n (%)			0.0007	0.2603
Left hemicolectomy	48 (14.3)	23 (6.5)		
Sigmoidectomy	286 (85.7)	327 (93.5)		
Cases with ≥1 concomitant procedure, n (%)	71 (21.3)	67 (19.1)	0.479	0.0542
Surgical time ^a (min), mean ± SD	224.8 ± 81.8	206.1 ± 94.95	0.0052	0.2112
Operating room time ^b (min), mean ± SD	163.2 ± 76.7	149.9 ± 89.8	0.0388	0.1586
Estimated blood loss (mL), mean ± SD	45.1 ± 60.85	59.1 ± 80.8	0.0109	-0.1959
Conversion to open, n (%)	0 (0)	2 (0.5)	0.1872	-0.1022
Length of stay (d), mean ± SD	3.7 ± 6.1	3.7 ± 5.7	0.9907	-0.0009
Time to flatus (d), mean ± SD	2.0 ± 1	2.4 ± 2.7	0.032	-0.1692
Time to bowel movement (d), mean ± SD	2.6 ± 1.3	2.9 ± 3.0	0.1018	-0.1349
Time to regular diet (d), mean ± SD	3.4 ± 5.1	3.0 ± 3.2	0.2234	0.1004
Complications and Adverse Events				
Complications, n (%)				
Intraoperative	0 (0)	0 (0)	not valid	not valid
Postoperative prior to discharge	7 (2.1)	10 (2.9)	0.5084	-0.0507
Post discharge to 30 d	17 (5.1)	30 (8.6)	0.0657	-0.1416

Table 2.
Continued

Variable	Robotic-assisted (n = 334)	Laparoscopic (n = 349)	p-value	Standardized Difference
Readmissions ^c , n (%)	13 (4)	28 (8)	0.029	-0.1656
Reoperations ^c , n (%)	2 (0.5)	17 (5.1)	0.0003	-0.2824

SD, standard deviation of the mean; BMI, body mass index.
^aSurgical time: skin to skin.
^bOperating room time: wheels in to wheels out.
^cPost discharge to 30 d.

ence.¹³ Upon obtaining proficiency in both robotic-assisted and laparoscopic techniques, surgeons should be able to expect decreased surgical and operating room times—even when performing challenging cases (e.g., cases involving obesity or malignancy). We thought that proficiency and comfort with the technological advantages of the robotic platform (improved surgical field visualization and exposure, greater instrument maneuverability, a higher degree of instrument articulation,¹⁶ improved cognitive and physical ergonomics and decreased surgeon fatigue¹³) might lead to shorter surgical times; however, our results evidenced an 18 m difference.

Although not exclusive to benign sigmoidectomy, a faster bowel recovery has been reported for robotic-assisted compared to laparoscopic colectomy patients.^{18–19} Performing surgery in the obese patient is technically challenging, especially during the learning period of laparoscopic surgery—largely due to difficulties with exposure and dissection.^{20–21} Although safe, laparoscopic colon resection in obese patients is associated with longer surgical times and higher conversion rates.^{21–23} The trend toward improved times and outcomes in the robotic-assisted group suggests that robotic assistance may facilitate the surgeon’s ability to overcome such technical difficulties. This advantage was noticeable especially in the obese group, where we observed a trend toward less difference in surgical and operating room times.

Among patients with malignant disease, lower estimated blood loss, faster bowel recovery and shorter length of stay have been reported for robotic-assisted versus laparoscopic colectomy.^{18–19,24} Although statistically significant, the difference in blood loss between the robotic-assisted and laparoscopic groups was approximately 36 ml and likely reflected the technological ability of the robot for performing finer and more precise dissection as opposed to a clinically relevant outcome.²⁵ We found that patients who underwent robotic-assisted sigmoidectomy experienced faster bowel recovery. The faster bowel recovery most

likely played a role in the 2.4 d shorter hospital stay for the robotic-assisted sigmoidectomy patients. As hypothesized by Trastulli and colleagues, the robotic platform’s ergonomic enhancement, “fulcrum effect” mitigation, and instrument precision may contribute to less dissection-related trauma to the viscera, tissues and mesentery—all of which may lead to faster bowel recovery and shorter hospital stay.²⁴ Prior studies reported an earlier bowel recovery and shorter hospital stay for laparoscopy than laparotomy in malignant colectomy,² a faster bowel recovery and shorter length of stay for robotic-assisted than laparoscopy in colectomy,^{18–19,24} a shorter hospital stay for robotic-assisted than laparoscopy in malignant colorectal surgery,²⁶ and a faster bowel recovery, fewer days to soft diet and shorter hospital stay for robotic-assisted than laparoscopy in malignant anterior resection surgery.²⁷ Our findings build on the existing literature by demonstrating an earlier recovery of bowel function and shorter hospital stay for patients who undergo robotic-assisted, compared to laparoscopic, malignant sigmoidectomy.

The current study is limited by its retrospective design. A randomized, prospective comparative study of outcomes from robotic-assisted and laparoscopic sigmoidectomy patients is optimal but difficult, as it requires patient willingness to be randomized. The study design mitigated learning curve bias by including surgical patients only after surgeons became proficient in both robotic-assisted and laparoscopic techniques. Additionally, we chose to perform inverse probability of treatment weighting of baseline variables to reduce patient selection bias and allow our analysis of demographically and clinically comparable patient populations.

CONCLUSION

Robotic-assisted sigmoid colon resection is clinically effective. When robotic-assisted surgery is utilized in more complex sigmoid colon resection scenarios, it

Table 3.

Subset of Patients Undergoing Surgery for Treatment of Benign Disease (n = 261): Demographic and Baseline Medical Characteristics, Perioperative Outcomes, and Adverse Events

Variable	Robotic-assisted (n = 177)	Laparoscopic (n = 84)	p-value
Age (y), mean ± SD	59.57 ± 13.26	64 ± 14.03	0.014
Gender, n (%)			0.4216
Female	96 (54.2)	50 (59.5)	
Male	81 (45.8)	34 (40.5)	
BMI (kg/m ²), mean ± SD	28.78 ± 5.95	26.97 ± 4.88	0.0105
Categorical BMI, n (%)			0.0408
≤24.9 kg/m ²	48 (27.1)	31 (36.9)	
≥25.0 to ≤29.9 kg/m ²	64 (36.2)	29 (34.5)	
≥30.0 to ≤34.9 kg/m ²	37 (20.9)	20 (23.8)	
≥35.0 kg/m ²	28 (15.8)	4 (4.8)	
Patients with ≥1 comorbidity, n (%)	97 (54.8)	52 (61.9)	0.2788
Previous treatment for current condition, n (%)	165 (93.2)	74 (88.1)	0.1638
Previous abdominal surgery, n (%)	99 (55.9)	52 (61.9)	0.3613
Primary procedure, n (%)			0.3994
Left hemicolectomy	12 (6.8)	3 (3.6)	
Sigmoidectomy	165 (93.2)	81 (96.4)	
Cases with ≥1 concomitant procedure, n (%)	36 (20.3)	17 (20.2)	0.9849
Surgical time ^a (min), mean ± SD	162.67 ± 64.15	145.37 ± 54.73	0.0341
Operating room time ^b (min), mean ± SD	223.24 ± 67.91	203.89 ± 57.77	0.0252
Estimated blood loss (mL), mean ± SD	50.73 ± 51.31	53.87 ± 44.56	0.6309
Length of stay (d), mean ± SD	3.85 ± 4.96	3.54 ± 2.15	0.4718
Time to flatus (d), mean ± SD	1.98 ± 0.79	2.22 ± 1	0.0598
Time to bowel movement (d), mean ± SD	2.58 ± 1.07	2.79 ± 1.27	0.2008
Time to regular diet (d), mean ± SD	3.63 ± 4.47	2.89 ± 1.22	0.0535
Conversion to open, n (%)	0 (0)	0 (0)	
Complications, n (%)			
Postoperative prior to discharge	5 (2.8)	2 (2.4)	1
Post discharge to 30 days	7 (4)	3 (3.6)	1
Readmissions ^c , n (%)	6 (3.4)	2 (2.4)	1
Reoperations ^c , n (%)	1 (0.6)	1 (1.2)	0.5372

SD = standard deviation of the mean; BMI = body mass index.

^aFirst incision to closure (skin to skin).

^bPatient entering operating room to patient leaving operating room (wheels in to wheels out).

^cDischarge to 30 days.

offers technical and procedural advantages over laparoscopic surgery that could translate in less blood loss, shorter time to first flatus and bowel movement, and lower rates of readmissions and reoperations. Robotic-

assisted sigmoid resection provides a minimally invasive alternative to the laparoscopic approach with improved intraoperative and postoperative outcomes for colorectal patients.

Table 4.

Subset of Patients Who Underwent Surgery for Treatment of Benign Disease and Whose Body Mass Index ≥ 30 kg/m² (N = 88): Demographic and Baseline Medical Characteristics, Perioperative Outcomes, and Adverse Events

Variable	Robotic-assisted (n = 65)	Laparoscopic (n = 23)	p-value
Age (y), mean \pm SD	56.31 \pm 12.62	59.61 \pm 15.21	0.3104
Gender, n (%)			
Female	29 (44.6)	13 (56.5)	0.3258
Male	36 (55.4)	10 (43.5)	
BMI (kg/m ²), mean \pm SD	35.12 \pm 4.2	33.14 \pm 3.0	0.0403
Categorical BMI, n (%)			
≥ 30.0 to ≤ 34.9 kg/m ²	37 (56.9)	19 (82.6)	0.0423
≥ 35 kg/m ²	28 (43.1)	4 (17.39)	
≥ 30.0 to ≤ 34.9 kg/m ²	37 (56.9)	19 (82.6)	0.114
≥ 35 to 39.9 kg/m ²	18 (27.7)	3 (13)	
≥ 40 kg/m ²	10 (15.4)	1 (4.3)	
Patients with ≥ 1 comorbidity, n (%)	41 (63.1)	17 (73.9)	0.3461
Previous treatment for current condition, n (%)	62 (95.4)	21 (91.3)	0.4675
Previous abdominal surgery, n (%)	40 (61.5)	13 (56.5)	0.6727
Primary procedure, n (%)			
Left hemicolectomy	4 (6.2)	0 (0)	0.2233
Sigmoidectomy	61 (93.8)	23 (100)	
Cases with ≥ 1 Concomitant procedure, n (%)	6 (9.2)	6 (26.1)	0.0429
Surgical time ^a (min), mean \pm SD	184.5 \pm 73.4	171.13 \pm 63.6	0.4407
Operating room time ^b (min), mean \pm SD	243.7 \pm 72.25	238.87 \pm 60.7	0.7748
Estimated blood loss (mL), mean \pm SD	57.08 \pm 58.7	68.7 \pm 60.3	0.4203
Length of stay (d), mean \pm SD	3.49 \pm 3.51	3.22 \pm 1.4	0.6026
Time to flatus (d), mean \pm SD	1.82 \pm 0.6	2.09 \pm 0.9	0.1877
Time to bowel movement (d), mean \pm SD	2.31 \pm 1.0	2.19 \pm 0.8	0.6231
Time to regular diet (d), mean \pm SD	3.4 \pm 3.2	2.56 \pm 0.9	0.0669
Conversion to open, n (%)	0 (0)	0 (0)	
Complications, n (%)			
Postoperative prior to discharge	3 (4.6)	1 (4.3)	1
Post discharge to 30 days	2 (3.1)	1 (4.3)	1
Readmissions ^c , n (%)	1 (1.5)	1 (4.3)	0.4566
Reoperations ^c , n (%)	0 (0)	1 (4.3)	0.2614

SD = standard deviation of the mean; BMI = body mass index.

^aFirst incision to closure (skin to skin).

^bPatient entering operating room to patient leaving operating room (wheels in to wheels out).

^cDischarge to 30 days.

Table 5.

Subset of Patients with Preoperative Diagnosis of Malignant Disease (n = 75): Demographic and Baseline Medical Characteristics, Perioperative, and Oncologic Outcomes and Adverse Events

Variable	Robotic-assisted (n = 34)	Laparoscopic (n = 41)	p-value
Age (y), mean ± SD	63.5 ± 11.2	67.5 ± 14.6	0.203
Gender, n (%)			
Female	11 (32.4)	22 (53.7)	0.0643
Male	23 (67.6)	19 (46.3)	
BMI (kg/m ²), mean ± SD	30.0 ± 7.4	26.8 ± 4.9	0.0369
Categorical BMI, n (%)			
≤24.9 kg/m ²	9 (26.5)	16 (39)	0.1041
≥25.0 to ≤29.9 kg/m ²	15 (44.1)	13 (31.7)	
≥30.0 to ≤34.9 kg/m ²	5 (14.7)	11 (26.8)	
≥35 kg/m ²	5 (14.7)	1 (2.4)	
Patients with ≥1 comorbidity, n (%)	23 (67.6)	30 (73.2)	0.6009
Previous treatment for current condition, n (%)	2 (5.9)	2 (4.9)	1
Previous abdominal surgery, n (%)	16 (47.1)	23 (56.1)	0.4354
Primary procedure, n (%)			
Left hemicolectomy	15 (44.1)	9 (22)	0.0405
Sigmoidectomy	19 (55.9)	32 (78)	
≥1 Concomitant procedure, n (%)	7 (20.6)	12 (29.3)	0.3896
Oncologic outcomes			
Tumor size (cm), mean ± SD	3.09 ± 1.65 ^a	3.57 ± 2.31 ^b	0.3323
Harvested lymph nodes (n), mean ± SD	15.6 ± 7.5 ^a	16.05 ± 7.1 ^b	0.8094
TNM Stage			0.465
I	12 (37.5)	13 (39.4)	
II	7 (21.9)	6 (18.2)	
III	13 (40.6)	11 (33.3)	
IV	0 (0)	3 (9.1)	
Missing	2	8	
Surgical time ^c (min), mean ± SD	172.5 ± 56.6	135.7 ± 50.4	0.004
Operating room time ^d (min), mean ± SD	235.2 ± 59.3	186.3 ± 55.7	0.0004
Estimated blood loss (mL), mean ± SD	34.6 ± 51.2	71.5 ± 61.7	0.0069
Length of stay (d), mean ± SD	3.1 ± 1.5	5.5 ± 6.5	0.0234
Time to flatus (d), mean ± SD	2.2 ± 0.8	3.1 ± 2.9	0.0602
Time to bowel movement (d), mean ± SD	2.6 ± 0.9	3.8 ± 2.9	0.0256
Time to regular diet (d), mean ± SD	2.4 ± 1.4	3.6 ± 3.2	0.0411
Conversion to open, n (%)	0 (0)	1 (2.4)	1

Table 5.
Continued

Variable	Robotic-assisted (n = 34)	Laparoscopic (n = 41)	p-value
Complications, n (%)			
Intraoperative	0	0	—
Postoperative prior to discharge	0 (0)	3 (7.3)	0.2465
Post discharge to 30 d	3 (8.8)	4 (9.8)	1
Readmissions ^c , n (%)	2 (5.9)	4 (10)	0.6809
Reoperations ^c , n (%)	0 (0)	1 (2.5)	0.3533

BMI, body mass index; SD, standard deviation; TNM, tumor, node, metastasis.

^an = 33.

^bn = 41.

^cskin to skin.

^dwheels in to wheels out

^eDischarge to 30 days.

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