Small-Bowel Obstruction Secondary to Adhesions After Open or Laparoscopic Colorectal Surgery

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ABSTRACT

Background and Objectives: Small-bowel obstruction (SBO) is a common surgical emergency that occurs in 9% of patients after abdominal surgery. Up to 73% are caused by peritoneal adhesions. The primary purpose of this study was to compare the rate of SBOs between patients who underwent laparoscopic (LPS) and those who had open (OPS) colorectal surgery. The secondary reasons were to evaluate the rate of adhesive SBO in a cohort of patients who underwent a range of colorectal resections and to assess risk factors for the development of SBO.

Method: This was a retrospective observational cohort study. Data were analyzed from a prospectively collected database and cross checked with operating theater records and hospital patient management systems.

Results: During the study period, 707 patients underwent colorectal resection, 350 of whom (49.5%) were male. Median follow-up was 48.3 months. Of the patients included, 178 (25.2%) underwent LPS, whereas 529 (74.8%) had OPS. SBO occurred in 72 patients (10.2%): 20 (11.2%) in the LPS group and 52 (9.8%) in the OPS group [$P = .16$; hazards ratio (HR) 1.4 95% CI 0.82–2.48] within the study period. Conversion to an open procedure was associated with increased risk of SBO ($P = .039$; HR 2.82; 95% CI 0.78–8.51). Stoma formation was an independent risk factor for development of SBO ($P = .049$; HR, 0.63; 95% CI 0.39–1.03). The presence of an incisional hernia in the OPS group was associated with SBO ($P = .0003$; HR, 2.85; 95% CI 1.44–5.283). There was no difference in SBO between different types of procedures: right colon, left colon, and rectal surgery. Patients who developed early

small-bowel obstruction (ESBO) were more often treated surgically compared to late SBO ($P = .0001$).

Conclusion: The use of laparoscopy does not influence the rate of SBO, but conversion from laparoscopic to open surgery is associated with an increased risk of SBO. Stoma formation is associated with a 2-fold increase in SBO. Development of ESBO is highly associated with a need for further surgical intervention.

INTRODUCTION

Acute small-bowel obstruction (SBO) is one of the most common surgical emergencies. The incidence of SBO after abdominal surgery is estimated at 9%.[1] Peritoneal adhesions are reported to be the cause of 56% to 75% of all SBOs,[1,2] making them the most common cause of SBO.[3,4] Approximately one-third of people who develop an adhesional obstruction do so within 1 year of surgery,[5] and 7.7% to 18% of patients with adhesional SBO require reoperation with adhesiolysis for definitive treatment.[2,6] The incidence of adhesive SBO depends on patient factors as well as the nature of previous surgery.[2] Pediatric patients tend to have the highest incidence of adhesive SBO, which may be explained, at least in part, by a longer postoperative life span than that of the adult population. Colorectal surgery (CRS), especially pelvic and ileoanal pouch surgery, have very high rates of adhesive SBO.[2,5,7,8] The laparoscopic approach appears to decrease the risk of adhesion formation by 45% (down to 1.4–1.9%[1,2,6,7]) and therefore reduces the need for adhesion-related reoperation.[2] These data, however, are derived from small case series and retrospective studies. Adhesions involving the small intestine and resulting in obstruction tend to occur between the small bowel and the scar, the small bowel and the site of surgery, and between the loops of the small bowel.[5] The mechanism by which the laparoscopic approach reduces the rate of SBO is most likely related to the reduction of tissue trauma and wound size.

The primary purpose of this study was to compare rates of SBO in patients undergoing laparoscopic (LPS) and open (OPS) surgery. The secondary goals were to evaluate the rate

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of adhesive SBO between different colorectal resections, to assess risk factors for development of SBO, and to evaluate the rate of ESBO and its necessity for operative management.

METHOD

All patients undergoing CRS from January 2003 through March 2011 were included in this retrospective observational cohort study. Data were obtained from a prospectively collected database and cross-checked against operative records and hospital patient management systems. All patients in our database were followed up for a minimum of 48 months in the outpatient department or until an episode of SBO occurred, whichever came first. Patients who did not attend follow-up appointments were contacted by telephone on a yearly basis. The study was approved by the Ethical Committee of the University of Rome, Tor Vergata, and is reported in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) methodology for observational studies.[9]

A total of 1123 consecutive patients were analyzed for adhesion-induced SBO episodes, requiring either admission or reintervention, with correlation to original surgical approach (laparoscopic vs open). The diagnosis of SBO was defined by a combination of different clinical criteria, including pain, nausea, vomiting, cessation of stools, distension, and abnormal bowel sounds, in addition to imaging confirmation (dilated loops of small bowel and air–fluid levels on abdominal x-ray). All patients with suspicion of SBO underwent a computed tomographic (CT) scan of the abdomen to confirm diagnosis. All admissions for SBO were recorded. The data included the time interval from the date of surgery to the occurrence of SBO, surgery type and setting, readmission length, and findings at reintervention. To avoid large heterogeneic samples, patients undergoing CRS for inflammatory bowel disease, appendectomy, or ventral mesh rectopexy; patients with peritoneal carcinomatosis; and patients with SBO secondary to local or peritoneal recurrence during the follow-up were excluded. After applying the exclusion criteria, a total of 707 patients who underwent CRS were included for statistical analysis.

We calculated SBO-free survival time for different types of procedures twice. First, we calculated it for each procedure. Because of the small number of cases in some groups, we combined procedures and calculated SBO-free survival by surgery type: rectal resection (anterior rectal resection and abdominoperineal resection), left-side resection (sigmoid colectomy, left hemicolectomy and Hartmann procedure), and right-side resection (right hemicolectomy).

ESBO was defined as SBO within 30 days of surgery, when all of the following criteria were met: crampy abdominal pain, vomiting, and radiographic findings consistent with intestinal obstruction. All patients with ESBO were initially treated conservatively with nasogastric decompression, bowel rest, and intravenous hydration. The decision to operate was made clinically by experienced clinicians, based on the following criteria: not responding to conservative treatment, clinical deterioration, rising lactate level, and radiological findings confirming bowel perforation or ischemia.

According to the available literature, the occurrence of SBO after CRS varies between 1.5% and 30%.[2,5,7,8] The laparoscopic approach may reduce the rate of SBO by 45%.[1,2,6,7] With accumulation of laparoscopic experience over time, we expected a further reduction in SBO rate in the laparoscopic group. With the assumption that the laparoscopic approach could reduce the SBO rate down to 2%, whereas the SBO rate in the OPS stayed around 9%, a sample size of 166 patients in each group was needed to yield a power of 80% with a significance level of .05.

Statistical analyses were performed with the StatsDirect version 3.0 for Windows (StatsDirect Ltd., Cheshire, UK). The cumulative incidence of obstructions during the follow-up period after surgery was assessed with the use of the Kaplan–Meier method, and the differences between the 2 groups were compared with the log-rank test. Deaths during follow-up and any losses to follow-up without previous obstructions were considered to be censored observations. Multivariate analyses of the incidence of the obstructions were performed with Cox regression. These analyses took into account age, conversion, operative procedure modality, malignancy status, urgency for surgery, presence of stoma. Other comparisons between treatments were performed with the Mann-Whitney test for continuous or ordered categorical data or the χ^2 test, if appropriate. Analyses were conducted by intent-to-treat, and $P = .05$ (2-sided) was considered to indicate significance.

RESULTS

A total of 707 patients, 350 (49.5%) male and 357 (50.5%) female, were included in the study and statistical analysis. The median follow up was 48.3 months (range, 0.1–121.9). Of the, 178 (25.2%) patients underwent laparoscopic procedures (LPS), 27 (15.7%) procedures were converted to open (OPS). These patients were included in the statistical analysis on an intent-to-treat basis (**Figure 1** shows the study selection process).
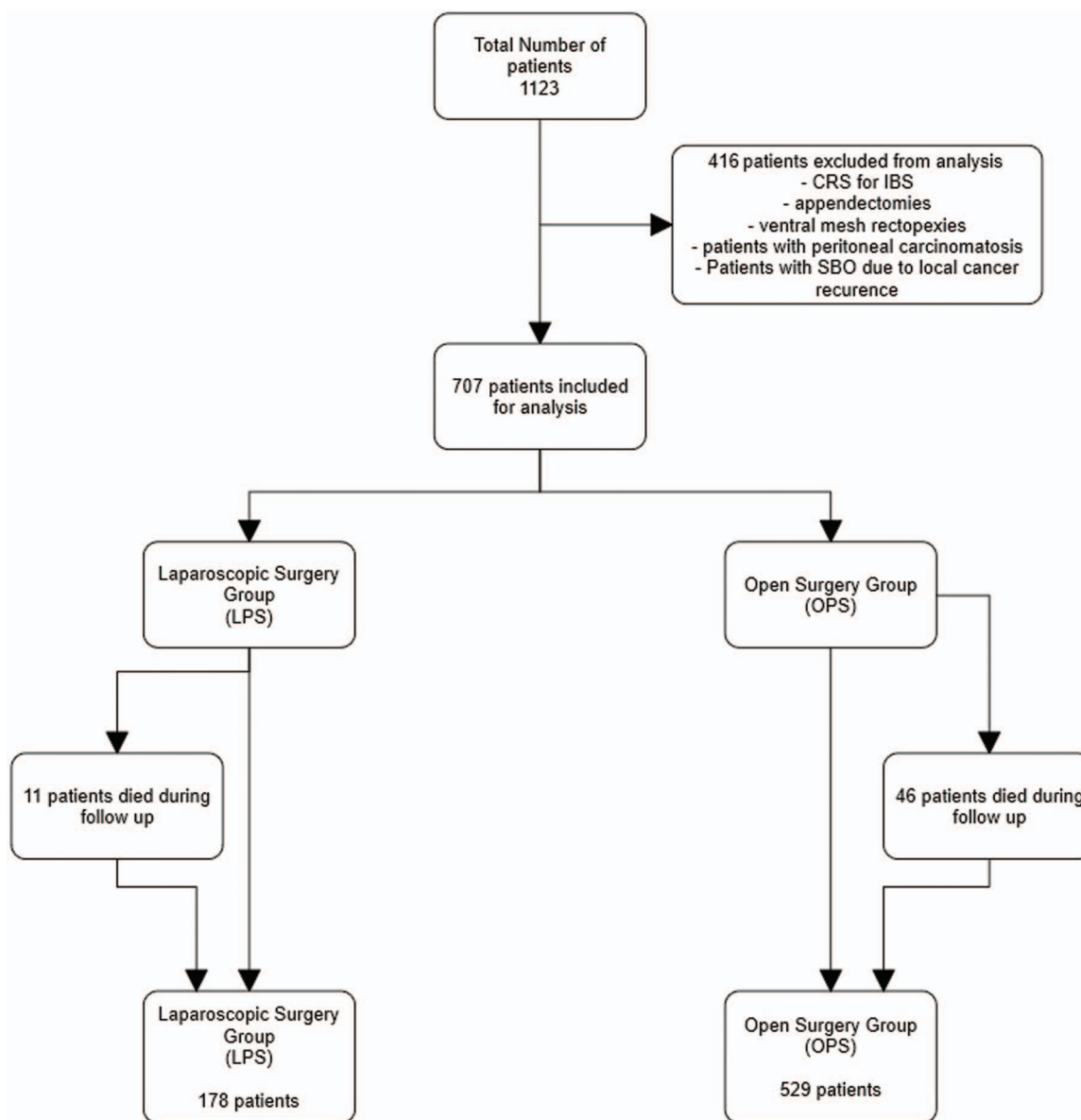
Figure 1. The selection process for inclusion in the 2 study groups.

The OPS and LPS groups displayed similar patient characteristics (**Table 1**) with an overall median patient age of 68.4 years (range, 16.6–93.6). However, the groups were different in operative characteristics, with a higher proportion of elective cases in the LPS group and a higher rate of stoma formation in the OPS group. The groups were also different when analyzed by procedure, with a higher proportion of left hemicolectomy and sigmoidectomy in the LPS group and more Hartmann procedures and subtotal colectomy in the OPS group (**Table 2**). There was no difference among other procedures (right hemicolectomy, APR, LAR, and others).

During the follow-up period, 57 (6.2%) patients died: 11 and 46 in the LPS and OPS groups, respectively. Of those patients, 53 (93%) received a diagnosis of malignancy. Among the patients who died during the follow-up period, 1 in the LPS group and 9 in the OPS group had SBO. All of these patients were included in the statistical analysis.

During the observation period, SBO occurred in 72 patients (10.2%) with 20 cases (11.2%) in the LPS group and 52 (9.8%) in the OPS group. There was no significant difference between the groups ($P = .16$; HR 1.4; 95% CI

Table 1.
Patient Demographics

Characteristic	LPS	OPS	Total	P
Median age	64.1 (range 17.3–89.9)	69.4 (range 16.6–93.6)	68.4 range (16.6–93.6)	.3
Male	78 (43.8)	272 (51.4)	350 (49.5)	.09
Female	100 (56.2)	257 (48.6)	317 (50.5)	
Elective surgery	149 (83.7)	272 (51.4)	421 (59.5)	.0001
Emergency surgery	29 (16.3)	257 (48.6)	286 (40.5)	
Benign	48 (27)	136 (25.7)	184 (26)	.74
Malignant	130 (73)	393 (74.3)	523 (74)	
Creation of stoma	19 (10.7)	207 (39.1)	226 (32)	
Ileostomy	9 (47.4)	109 (52.7)	128 (56.6)	.0001
Colostomy	10 (52.6)	98 (47.3)	108 (43.4)	
No of patients with SBO	20 (11.2)	52 (9.8)	72 (10.2)	.69
Surgery for SBO	5 (25)	17 (32.7)	22 (30.6)	.72
Early SBO (<30 days)	6 (30)	13 (25)	19 (26.4)	.89
Surgery due to early SBO	3 (50)	10 (76.9)	13 (68.4)	.32
Median time between first operation and reoperation for ESBO (days)	10 (range 10)	11 (range 2–18)	11 (range 3–18)	

N = 707. Data are the number (percentage of the total group), unless otherwise stated.

Table 2.
Type of Procedure in LPS and OPS

Procedure	LPS n = 178 (25.2)	OPS n = 529 (74.8)	P
Right hemicolectomy	53 (29.8)	108 (20.4)	.01
Left hemicolectomy and sigmoidectomy	62 (34.8)	120 (22.7)	.002
Hartmann's procedure	6 (3.4)	62 (11.7)	.002
Abdominoperineal resection of the rectum	2 (1.1)	16 (3)	.16
Subtotal colectomy	3 (1.7)	32 (6)	.04
Anterior and low anterior rectal resection	28 (15.7)	110 (20.8)	.17
Other	24 (13.5)	81 (15.3)	.63

N = 707. Data are the number (percentage of the total group), unless otherwise stated.

0.82–2.48) (**Table 1**). Of note, the incidence of SBO increased significantly in patients who underwent conversion from laparoscopic to open procedure (P = .039; HR, 2.82; 95% CI 0.78–8.51).

There was a tendency toward increased frequency of SBO in the emergency group; however, it did not reach statistical significance (P = .066; HR 0.64; 95% CI 0.38–1.08). In subgroup analysis, SBO was more common in emergency OPS than in elective cases (P = .033; HR 0.55; 95% CI 0.31–1.01). There was no significant difference in emergency LPS when compared to elective (P = .82; HR 0.88; 95% CI 0.28–2.75) (**Table 3**).

Overall, 523 (74%) patients were operated on for colorectal malignancy. There was no significant difference in SBO after surgery for malignant compared to benign disease (P = .15; HR 1.42; 95% CI 0.84–2.43). There was a tendency toward SBO in patients with malignancy who underwent OPS, but it did not reach statistical

Table 3.
SBO in Stoma Group

Surgery/Pathology	SBO	No SBO	*P*
Total (n = 226)			
Elective	15	115	.37
Emergency	15	81	
Benign	12	52	.13
Malignant	18	144	
LPS (n = 19)			
Elective	5	5	.21
Emergency	2	7	
Benign	2	6	.36
Malignant	5	6	
OPS (n = 207)			
Elective	10	110	.14
Emergency	13	74	
Benign	10	46	.06
Malignant	13	138	

Table 4.
Multivariate Analysis of Risk Factors for SBO

	Beta	SE	*t*	HR	*P*
Age	0.026998	0.267638	0.100875	1.027366	.91965
Malignancy	−0.22057	0.271687	−0.81187	0.802058	.416872
LPS vs. OPS	−0.45082	0.298882	−1.50835	0.637107	.131476
Conversion	0.846197	0.517358	1.635612	2.675226	.101931
Urgent surgery	0.282514	0.270735	1.043508	1.326461	.296721
Stoma	0.568307	0.264183	2.151189	1.765275	.031469

lowest rate (HR 1.73), but the difference did not reach statistical significance. In addition, there was no significant difference in SBO-free survival time when right colon, left colon, and rectal surgery (*P* = .99; **Table 2**) were compared, even in a subgroup analysis for LPS (*P* = .13) and OPS (*P* = .62).

Among patients with SBO, conservative treatment failed in 22 (31%), and surgical intervention was necessary, with no difference between LPS (5; 25%) and OPS (17; 32.7%) groups (*P* = .72). In 19 (26.8%) patients, an ESBO developed (≤1 month after surgery): 6 (30%) in the LPS group and 13 (25%) in the OPS group (*P* = .89). Three (50%) patients with ESBO in the LPS group and 10 (76.9%) in the OPS group underwent surgery (*P* = .32). ESBO was significantly associated with failure of conservative management and a necessity for surgical intervention (*P* = .0001).

In a Cox regression model of factors associated with SBO, only stoma formation was found to be associated with increased risk of SBO in a multivariate analysis (*P* = .032; **Table 4**).

significance (*P* = .054; HR 1.74; 95% CI 0.91–3.29) (**Table 4**).

In 226 (32%) cases, a stoma was created (ileostomy or colostomy). An SBO developed a higher percentage of patients with a stoma (13.7%; 31) versus those with no stoma (8.7%; 42). The presence of a stoma increased the risk of an SBO (*P* = .049; HR 0.63; 95% CI 0.39–1.03). There was no significant difference in incidence of SBO in relation to type of stoma: ileostomy versus colostomy (*P* = .12; HR 0.57; 95% CI 0.28–1.16; **Table 3**).

In 68 (9.6%) patients, an incisional hernia (IH) developed after surgery: 11 (6.2%) in the LPS group and 57 (10.7%) in the OPS group. There was a strong trend toward development of an IH after OPS but it did not reach statistical significance (*P* = .07%). SBO developed in 3 patients with IH in the LPS group and in 14 in the OPS group. IH was associated with the development of an SBO in the OPS group (*P* = .0003; HR 2.85; 95% CI 1.44–5.283). None of the patients with either an IH or an SBO in the LPS group required surgical treatment, whereas 2 patients with an IH and SBO in the OPS group required surgery. Patients with an IH and SBO in the OPS group were less likely to require surgical treatment than the other patients with SBO (*P* = .02).

The Hartmann procedure was associated with the highest rate of SBO (HR 1.73) and left hemicolectomy with the

DISCUSSION

In our series, the overall incidence of SBO was 10.2%, which falls within the range of 1.5% to 32.6% reported in the literature.[3,5,8,10–13] There was no difference in incidence of SBO between the LPS and OPS groups. However, in our series, these groups represent heterogenic patient populations, precluding meaningful statistical analysis.

Many published series suggest that the laparoscopic approach, which decreases incisional trauma, can reduce the overall rate of SBO.[6,14–16] Duepree reported rates of SBO after laparoscopic and open colorectal procedures of 1.9% and 6.1% respectively,[6] compared to 11.2% and 9.8% in

our series. However, his results represent a retrospective cohort study mainly based on questionnaires sent out to patients. There was also a significantly shorter follow-up period of 31 months. In contrast, our study had a longer mean follow-up period (53.9 months), which may be responsible for the higher number of SBOs in our LPS group. Previous larger series, which were designed primarily to compare adhesion rates after laparoscopic and open procedures and which subsequently reported lower rates of SBO after laparoscopy, focused on gastric bypass and antireflux surgery.[14–16] In contrast, colorectal procedures are renowned for high rates of adhesive SBO,[2,5,7,8] and this may also explain the higher rates of SBO after laparoscopic procedures in our study. Our findings are consistent with those of the 5-year follow-up of the COLOR trial. In that study, a difference was detected in the risk of an adhesional SBO between the open and laparoscopic groups.[17] Moreover, in a recent meta-analysis Pecorelli et al[18] found that the laparoscopic approach is associated with a significant reduction in the occurrence of SBO but only when the conversion rate to open procedures is less than 15%. In our study, the conversion rate was 15.7%, which explains the lack of a difference in the SBO rate.

Stoma formation was associated with an increased incidence of SBO, with no difference in the incidence between an ileostomy or colostomy. This result contrasts with data that were reported by Lee et al,[19] who found that the presence of a colostomy was a very strong independent risk factor for an adhesive SBO, increasing the chances of having an adhesive SBO by 2.5 times compared with patients without a stoma.[19] Of note, in the same report, ileostomy formation was not associated with increased risk of SBO, a clear contrast to our results. The mechanism by which the presence of a stoma significantly influences SBO, is unclear. We hypothesize that bringing the surface of the bowel and its mesentery adjacent to the abdominal wall along with changing the long axis of the mesentery triggers the formation of adhesions. Stoma formation may also promote internal herniation of the small bowel behind the stoma.

In our study, the rate of development of an IH after LPS and OPS was 6.2% and 10.7%, respectively. These findings are lower than all reported rates of IH. Taylor et al[21] found that the incidence of an IH in the OPS groups was 9.2% versus 8.6% in the laparoscopic.[20] Bartels et al[21] reported that the rate of IH was as high as 10.1% after LPS and 16.8% after OPS. The higher rates of IHs in both of these studies may be related to the type of the surgery; all of the colonic resections were performed for malignancy. The

presence of an IH was associated with an increased risk of SBO in the OPS group but not in the LPS group. The reason for this remains unclear. It may be because of the mimicking of an SBO by the hernia; however, the use of a CT scan in our study ruled out this possibility. As previously reported by other authors, the incidence of an IH is increased by the presence of wound infections. Theoretically, the presence of wound infections increases the rate of adhesion formation, which in turn influences the SBO rate. Whatever the exact cause of the IH in the OPS group, the risk of development of an SBO increased by ~3-fold.

In our study, we found that conversion of laparoscopic to open surgery was an independent risk factor for SBO. This association was reported in the recent meta-analysis, where low conversion rates played a key role in reducing the rates of SBO.[18] The mechanism underlying this difference is unclear. Conversion to open is often indicative of operative complexity. In addition, the combination of laparoscopic and open approaches may increase primary incisional trauma, which in turn may increase formation of adhesions.

Many researchers have indicate that ESBO is a risk factor for adhesional late SBO.[19,22] ESBO is a common complication after rectal surgery, secondary only to anastomotic leak.[23,24] The overall incidence of ESBO reported in the literature varies between 6.4% and 9.5%[22,23,25,26] in contrast to the 20% reported in the current study. We also found no difference in the incidence of ESBO between LPS and OPS, which again deviates from data published to date.[27] ESBO is very difficult to differentiate clinically from a postoperative ileus, and there are no clear diagnostic guidelines. It is possible that, within this dataset, some episodes of postoperative ileus had been recorded as ESBO, accounting at least in part for the increased incidence of ESBO. However, in our study, 80% of people with a diagnosis of ESBO underwent surgery after the failure of conservative management. If most cases were in fact related to postoperative ileus, we would expect to see a lower overall reoperation rate.

Our data indicate that patients with ESBO more frequently require operation than patients with late SBO. The mechanism for this is unclear. It may be that ESBO represents a more severe adhesional response to surgery that, in turn, reduces the likelihood of successful conservative treatment. This mechanism may also account for the increased risk of late SBO in patients in whom ESBO develops, which has been observed in some studies.[19,27]

The incidence of adhesional SBO also depends on the type of primary surgery performed. The rate of SBO was

highest after the Hartmann procedure, followed by rectal surgery, and was lowest after left colectomy, although the difference did not reach statistical significance. There was also no difference when we classified procedure by operative site: rectal surgery and left and right colon. This finding is different from that reported in the literature,[22,27] which shows the highest rates of SBO in rectal and pelvic surgery.[2,5,7,8]

The strength of our study is that it involved a large number of patients who underwent a wide range of colorectal procedures. However, there are limitations. First, the study was not a randomized control study, and there was selection bias in operative approach, which was left to the discretion of the operating surgeon. It is likely that easier cases were managed with laparoscopy and difficult cases with open surgery. This study was conducted in a single tertiary cancer referral center, which also may have contributed to the selection bias. The groups, LPS and OPS, were unequal in size and procedure performed, which may have influenced the rate of SBO.

CONCLUSION

Adhesional SBO obstruction is a common complication, after CRS. The heterogenous nature of patient groups in this study precludes meaningful analysis regarding the impact of the laparoscopic or open approach on the development of SBO. However, our results suggest that stoma formation and the presence of an IH in the open group increase the risk of the development of SBO. In addition, an ESBO after CRS is less likely to resolve with conservative management and requires reoperation in 50% of cases. This outcome should be kept in mind when treating such patients.

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