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Assessing outcomes in laparoscopic vs open surgical management of adhesive small bowel obstruction

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Abstract

Background Small bowel obstruction is typically managed nonoperatively; however, refractory small bowel obstructions or closed loop obstructions necessitate operative intervention. Traditionally, laparotomy has long been the standard operative intervention for lysis of adhesions of small bowel obstructions. But as surgeons become more comfortable with minimally invasive techniques, laparoscopy has become a widely accepted intervention for small bowel obstructions. The objective of this study was to compare the outcomes of laparoscopy to open surgery in the operative management of small bowel obstruction.

Methods This is a retrospective analysis of operative small bowel obstruction cases at a single academic medical center from June 2016 to December 2019. Data were obtained from billing data and electronic medical record for patients with primary diagnosis of small bowel obstruction. Postoperative outcomes between the laparoscopic and open intervention groups were compared. The primary outcome was time to return of bowel function. Secondary outcomes included length of stay, 30-day mortality, 30-day readmission, VTE, and reoperation rate.

Results The cohort consisted of a total of 279 patients with 170 (61%) and 109 (39%) patients in the open and laparoscopic groups, respectively. Patients undergoing laparoscopic intervention had overall shorter median return of bowel function (4 vs 6 days, $p=0.001$) and median length of stay (8 vs 13 days, $p=0.001$). When stratifying for bowel resection, patients in the laparoscopic group had shorter return of bowel function (5.5 vs 7 days, $p=0.06$) and shorter overall length of stay (10 vs 16 days, $p<0.002$). Patients in the laparoscopic group who did not undergo bowel resection had an overall shorter median return of bowel function (3 vs 5 days, $p<0.0009$) and length of stay (7 vs 10 days, $p<0.006$). When comparing surgeons who performed greater than 40% cases laparoscopically to those with fewer than 40%, there was no difference in patient characteristics. There was no significant difference in return of bowel function, length of stay, post-operative mortality, or re-admission laparoscopic preferred or open preferred surgeons.

Conclusion Laparoscopic intervention for the operative management of small bowel obstruction may provide superior clinical outcomes, shorter return of bowel function and length of stay compared to open operation, but patient selection for laparoscopic intervention is based on surgeon preference rather than patient characteristics.

Keywords Small bowel obstruction · Laparoscopy · Outcomes · Surgical outcomes

Small bowel obstruction (SBO) was the second most common cause of emergency general surgery admissions in 2016 and accounted for up to $3 billion in health care expenditures in the USA [1, 2]. Adhesive disease from prior surgery is by far the most common cause of SBO in the USA, accounting for up to 74% of cases [3]. Less common causes include malignancy, inflammatory bowel disease, and hernias [4]. The standard of care for SBO in patients without peritonitis remains nasogastric tube decompression, aggressive fluid resuscitation, electrolyte repletion, and supportive care. Most cases of SBO will resolve with non-surgical intervention within 48–72 h [5, 6]. However, up to 24% will require surgery for failure of non-surgical management or if they develop signs of compromised bowel [7].

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Exploratory laparotomy remains the standard of care for patients requiring surgical intervention for adhesive SBO [8]. Nonetheless, the use of minimally invasive surgical modalities, such as laparoscopy, have gained popularity over the last few decades, since the first laparoscopic adhesiolysis was described by Bastug et al. [9]. This has led some surgeons to establish laparoscopic exploration as a viable alternative to exploratory laparotomy in select patients with SBO [8, 10]. This technique has been viewed as advantageous given its decreased postoperative pain, faster return of bowel function, and fewer wound complications [11, 12]. This approach has been met with some reservations, as some would argue that laparoscopy is associated with missed bowel injury, incomplete visualization of the small bowel, and higher costs [1–3].

With the evolution and increasing adoption of minimally invasive surgery we are beginning to see promising results in favor of laparoscopy in the treatment of adhesive SBO. In a recent study by Sebastian-Valverde et al. [14], laparoscopic intervention was shown to have reduced overall complication rate and mortality rate compared to open intervention. Several similar studies have corroborated these findings [10, 14, 15]. Nonetheless, there are no randomized control trials that confirm the superiority of laparoscopy to an open approach for surgical management of SBO. Furthermore, these studies tend to favor younger patients with fewer co-morbidities and very specific clinical criteria that may not be widely applicable for many practicing surgeons [16]. This lack of high-quality data may impede a more robust adoption of laparoscopy in the management of SBO. At our institution, there is no protocol regarding approach for surgical management of SBO and the choice of laparoscopic versus open approach is at the discretion of the operating surgeon. With this objective in mind, we sought to compare the outcomes of laparoscopic interventions to that of open surgery for the surgical treatment of SBO.

Methods

Study design

This is a descriptive, retrospective study of patients admitted with SBO who underwent laparoscopic or open surgery at a single academic medical center from June 2016 to December 2019. Cases were identified based on billing codes and data were obtained from electronic health record and operative logs for patients with primary diagnosis of small bowel obstruction. The institutional review board approved the study. Inclusion criteria was patients who underwent either exploratory laparotomy or diagnostic laparoscopy for a primary diagnosis of small bowel obstruction. Exclusion criteria included strangulated or incarcerated hernias, SBO related to bariatric surgery, internal hernias, malignant obstructions, radiation enteritis, obstruction related to active inflammatory bowel disease flares, and operations that did not reveal obstruction.

Data collection

Data were collected and divided in four sections: patient baseline characteristics, preoperative data, intraoperative data, and patient outcomes. Patient demographics and comorbidities were analyzed and included age, sex, body mass index (BMI) diabetes mellitus (DM), hypertension, chronic obstructive pulmonary disease (COPD), chronic kidney disease (CKD), coronary artery disease (CAD), peripheral vascular disease (PVD), myocardial infarction, congestive heart failure, liver disease, malignancy, anticoagulation status, neurologic disease, hemiplegia, dementia, smoking, obesity, American Society of Anesthesiologists (ASA) score, and Charslon score [17].

Preoperative data consisted of the presence of peritonitis on physical examination or CT findings requiring immediate surgery. Operative cases were analyzed based on the initial approach of the case, open or laparoscopic. Thus, laparoscopic cases converted to open are included in the laparoscopic group. The intraoperative and postoperative outcomes for cases converted to an open procedure were also analyzed separately. Intraoperative and postoperative data consisted of type of the approach, need for bowel resection, length of stay, 30-mortality, 30-day readmission, and re-operation. We categorized each operation by surgeon and whether a laparoscopic or open approach was selected. Each surgeon was coded and their total number of open and laparoscopic cases were calculated. Surgeons who performed ≥ 10 total cases were classified as "Group A," all other surgeons were classified as "Group B." Within Group A, surgeons were further sub-classified as open preferred or laparoscopic preferred based on the percent utilization of the laparoscopic approach. The postoperative outcomes were then assessed within this group. Our primary outcome was return of bowel function. Secondary outcomes were length of stay, estimated blood loss (EBL), mortality, readmission, and surgical site infection (SSI).

Statistical analysis

A descriptive analysis was performed. Categorical variables are expressed as counts and percentiles. Continuous variables whose distribution approximated normality were reported as mean and standard deviation; median and range was used for continuous variables with skewed distributions. Bivariate analysis was conducted to identify factors associated with type of approach. Chi-square and Fisher's Exact tests were used for categorical variables. T-tests and

Table 1 Patient characteristics

	Open *n* (%)	Laparoscopic *n* (%)	*p*
Total group	170	109	
Patient characteristics			
Male sex	65 (38.2)	51 (46.8)	0.15
Mean age, year (± SD)	64 (± 16)	65 (± 16)	0.55
BMI, kg/m^2 (± SD)	27 (± 8)	28 (± 8)	0.58
Mean Charlson Score, (± SD)	3.9 (± 2.5)	3.7 (± 2.6)	0.68
Diabetes Mellitus	45 (26.5)	36 (33)	0.23
COPD	11 (6.5)	10 (9)	0.4
CKD	10 (6)	12 (11)	0.2
Hyperlipidemia	34 (20)	35 (32)	0.02
CAD	15 (9)	14 (13)	0.29
PVD	4 (2.3)	1(1)	0.37
Hypertension	103 (61)	61 (56)	0.44
Myocardial infarction	9 (5.3)	5 (4.6)	0.8
Congestive Heart Failure	14 (8.2)	5 (4.6)	0.23
Anticoagulation	4 (2.3)	6 (5.5)	0.19
Liver disease	9 (5.3)	2 (1.8)	0.14
Neurologic disease (CVA or TIA)	13 (7.6)	7 (6.4)	0.69
Hemiplegia	4 (2.3)	4 (3.7)	0.71
Dementia	8 (4.7)	3 (2.7)	0.53
Smoking	12 (7)	8 (7.3)	0.9
Obesity	44 (26)	32 (29)	0.52
ASA			
II	37 (21.7)	34 (31.2)	0.3
III	106 (62.3)	61 (56)	
IV	26 (15.3)	13 (12)	
Peritonitis	15 (8.8)	8 (7.3)	0.6
CT finding requiring immediate surgery	36 (21.3)	20 (18.3)	0.54

BMI Body Mass Index, *COPD* Chronic Obstructive Pulmonary Disorder, *CKD* Chronic Kidney Disease, *CAD* Coronary Artery Disease, *PVD* Peripheral Vascular Disease, *CVA* Cerebrovascular Accident, *TIA* Transient Ischemic Attack, *ASA* American Society of Anesthesiologists score

Wilcoxon rank-sum tests were used for continuous variables. Data were analyzed using SAS v9.4 (SAS Institute, Cary, North Carolina, USA).

Results

During the study period, 49 surgeons performed 279 operations on patients with SBO. The outcomes of the patients' primary surgery were analyzed. There were 170 (61%) patients in the open group and 109 (39%) in the laparoscopy group.

While there was some rate of variability among patient characteristics and comorbidities between the open and laparoscopic groups, we noted no major differences between the two groups. The mean age in the open group was 64 (SD ± 16) years and 65 (SD ± 16) in the laparoscopic group ($p = 0.55$), the average BMI was 27 kg/m^2 (SD ± 8) in the open group vs 28 kg/m^2 (SD ± 8, $p = 0.58$). There were a greater number of American Society Anesthesiology class III (106 vs 61) and IV (26 vs 13) the open group, but no overall difference in ASA score ($p = 0.3$) (Table 1).

Table 2 Intraoperative and postoperative outcomes

	Open *n* (%)	Laparoscopic *n* (%)	*p*
Small bowel resection	77 (45.3)	35 (32.1)	0.02
EBL, median (range)	35(0–2000)	10 (0–750)	0.0012
ROBF, median (range)	6 (0–70)	4 (0–20)	0.001
LOS, median (range)	13 (0–246)	8 (0–72)	0.001
No small bowel resection			
EBL, median (range)	15 (0–410)	10 (0–250)	0.03
ROBF, median (range)	5 (0–70)	3 (0–20)	0.0009
LOS, median (range)	10 (0–104)	7 (0–65)	0.006
30-day mortality	5 (5.4)	2 (2.7)	0.46
30-day Readmission	16 (17.2)	7 (9.5)	0.14
Reoperation	8 (8.6)	5 (6.8)	0.7
SSI	7 (7.5)	0 (0)	0.01
Small bowel resection			
EBL, median (range)	50 (0–2000)	50 (5–750)	0.26
ROBF, median (range)	7 (0–21)	5.5 (1–15)	0.06
LOS, median (range)	16 (0–246)	10 (0–72)	0.002
30-day mortality	7 (9)	2 (5.7)	0.7
30-day Readmission	11 (14.3)	3 (8.6)	0.54
Reoperation	22 (28.5)	3 (8.6)	0.02
SSI	8 (10.4)	5 (14.3)	0.54

Intraoperative outcomes include EBL (estimated blood loss), small bowel resection. Postoperative outcomes include ROBF (return of bowel function), LOS (length of stay), 30-day mortality rate, 30-day readmission rate, reoperation rate, and SSI (surgical site infection)

Patients undergoing laparoscopic intervention had overall shorter median days to return of bowel function 4 days (range 0–20) vs 6 days (range 0–70) days, ($p = 0.001$) and shorter median length of stay 8 days (range 0–72) vs 13 days (range 0–246) days, $p = 0.001$). Subgroups were made based on whether the patients required small bowel resection or not during the surgery. For those who required small bowel resection ($n = 112$), the laparoscopic group had shorter return of bowel function median 5.5 days (range 1–15) vs 7 (range 0–21) days, ($p = 0.06$) and shorter overall median length of stay as well 10 days (range 0–72) vs 16 days (range 0–246), $p < 0.002$). In those who did not undergo bowel resection, there was an overall shorter median return of bowel function, median 3 days (range 0–20) vs 5 days (range 0–70), $p < 0.0009$) and shorter length of stay, median 7 days (range 0–65) vs 10 days (range 0–104), $p < 0.006$) (Table 2).

A separate analysis of intraoperative and postoperative outcomes was performed of all cases converted from laparoscopic to open. There was a total of 51 laparoscopic cases that converted to open. The median return of bowel function among these cases was 5 days (range 4–8), with a median length of stay of 13 days (range 7–18). A bowel resection was performed in 51% of all cases converted to open. Among the cases of conversion to open, there was an 11.8% 30-day readmission rate and a 7.8% 30-day mortality rate (Table 3).

Our results were further analyzed based on surgeon utilization of each approach. Surgeons who were classified in Group A were analyzed separately as "open preferred" or "laparoscopic preferred." The overall rate of the laparoscopic approach in this study was 39%. We then classified surgeons in Group A as laparoscopic preferred if they performed at least 40% of their surgeries laparoscopically. Otherwise, they were considered open preferred. Patient baseline and preoperative characteristics were compared between these groups including age, BMI, mean Charlson score, bowel resection, malignancy, peritonitis, and CT findings indicating emergency surgery (Table 4). There were no clinically meaningful differences in the preoperative characteristics of patients with the open preferred and laparoscopic preferred groups.

Table 3 Perioperative outcomes of laparoscopic converted to open cases

$n=51$	n (%)
Bowel resection	26 (51)
Intraop complication	5 (9.8)
Reoperation	3 (5.9)
ROBF (median)	5 (4–8)
LOS (median)	13 (7–18)
30-day readmission	6 (11.8)
30-day mortality	4 (7.8)

This table illustrates both intraoperative and postoperative outcomes in the subset of laparoscopic cases that were converted to open laparotomies

The postoperative outcomes of both open and laparoscopic cases for the open preferred and laparoscopic preferred groups within Group A were also compared (Table 5). The laparoscopic preferred group had increased rate of small bowel resections in their laparoscopic cases (14% vs 5%, $p=1.0$). The outcomes of open cases for high volume surgeons in the laparoscopic preferred and open preferred groups were compared when controlling for small bowel resection. (Table 6). The laparoscopic preferred group had a lower 30-day readmission rate (2% vs 5%, $p=0.42$) and reoperation rate (3% vs 10%, $p=0.06$). A similar analysis was performed for laparoscopic cases among the open and laparoscopic preferred high volume surgeons (Table 7).

When no bowel was resected laparoscopically, the laparoscopic preferred group showed 4% reoperation rate compared to 0% in the open preferred ($p=0.56$). The 30-day mortality rate in the laparoscopic preferred group was 1% compared to 0% in the open preferred group without bowel resection ($p=1.0$). When bowel was resected laparoscopically, the 30-day mortality within the laparoscopic preferred group of 0% vs 1% case in the open preferred group ($p=0.26$). The laparoscopic preferred group also showed a lower readmission rate when resecting bowel laparoscopically with 1% vs 2% ($p=0.15$) in the open preferred group.

Discussion

The prior standard for the surgical management of small bowel obstruction has been a laparotomy; however, new guidelines suggest that a minimally invasive approach is a safe alternative [8]. This study shows that when utilized, laparoscopic management of adhesive small bowel obstruction has a quicker return of bowel function and an overall shorter length of stay. Both of these surgical approaches also had a similar safety profile as there was no difference in 30-day mortality in cases involving bowel resection or without bowel resection. Despite the lack of statistical difference in mortality, we found a clinically notable difference in mortality overall as there was 5% mortality difference in the

Table 4 Patient characteristics among high volume surgeons (> 10 operative cases)

	Open preferred ($n=136$) n (%)	Laparoscopic preferred($n=143$) n (%)	p
Mean age, years (±SD)	66.2 (±16)	65.4 (±16)	0.93
BMI, kg/m^2 (±SD)	27.6 (±7)	27.0 (±8)	0.28
Mean Charlson Score, (±SD)	3.7 (±2.4)	3.9 (±2.6)	0.67
Bowel resection	33 (42)	42 (39)	0.61
Malignancy	34 (25)	41 (29)	0.48
Peritonitis	6 (8)	9 (9)	1.0
CT finding requiring immediate surgery	11 (14)	19 (18)	0.55

Table 5 Comparing overall outcomes for all high volume surgeons ($n > 10$ cases)

	Open Preferred ($n = 77$) *n* (%)	Laparoscopic Preferred ($n = 106$) *n* (%)	*p*-value
Open *(n = 111)*	59	52	
30-day mortality	1 (2)	4 (8)	0.18
30-day readmission	9 (15)	6 (12)	0.59
Reoperation	11 (19)	6 (12)	0.42
Small bowel resection	28 (47)	28 (54)	0.57
EBL, median (range)	25 (0–500)	50 (0–700)	0.62
ROBF, median (range)	6 (0–35)	5 (1–70)	0.38
LOS, median (range)	13 (0–44)	13.5 (0–246)	0.98
Laparoscopic ($n = 72$)	18	54	
30-day mortality	1 (6)	1 (2)	0.44
30-day readmission	2 (11)	6 (11)	1.0
Reoperation	1 (6)	5 (9)	1.0
Small bowel resection	5 (28)	14 (26)	1.0
EBL, median (range)	12.5 (5–750)	10 (0–500)	0.40
ROBF, median (range)	5 (1–12)	5 (1–20)	0.88
LOS, median (range)	8 (2–72)	10 (0–40)	0.87

This table compares intraoperative and postoperative outcomes in open and laparoscopic cases for high volume surgeons when categorized by open preferred (< 40% of cases laparoscopic) and laparoscopic preferred (> 40% of cases laparoscopic)

laparoscopic group compared to the open group. Regardless, this shows that an initial laparoscopic approach for surgical management of SBO may yield better or equivalent outcomes compared to laparotomy, even if converted to open.

Additionally, there were significantly lower rates of reoperation in laparoscopic cases involving bowel resection. When stratifying for bowel resection, we found a significantly shorter length of stay; while there was no significant difference in return of bowel function in this group there may be a clinical difference in overall length of stay as there was a median 1.5 day difference. While clinical guidelines suggest a greater safety profile with open approach to small obstruction [8], this study shows there is no difference when using laparoscopy. Nonetheless, our data suggest there is an important clinic impact of an initial laparoscopic approach. It is well described in the SBO literature that laparoscopy is associated with decreased pain, shorter length of stay, and shorter return to work, without an increased complication rate [18]. Our data verifies these findings, but also demonstrate the potential to reduce cost by shortening length of stay. In addition to reducing length of stay, laparoscopic intervention can reduce overall hospital cost with a concomitant decrease in medical work up including serial labs and imaging [6].

Furthermore, the results of this study ultimately show that the surgical approach to SBO in our institution is more likely influenced by surgeon preference and training rather than patient characteristics. The surgical experience of the surgeons included in this analysis varied widely from 1 to 42 years since completing fellowship training; however, we did not differentiate surgeons based on prior fellowship training. Among the surgeons in Group A, the preoperative characteristics were not significantly different between the open and laparoscopic preferred groups (Table 4). This suggests that surgeons who frequently perform explorations for SBO in the laparoscopic preferred group did not select

Table 6 Comparing postoperative outcomes among surgeons who frequently perform operative SBO cases

	Open Preferred ($n = 59$) *n* (%)	Laparoscopic Preferred ($n = 52$) *n* (%)	*p*-value
Open			
No bowel resection (n = *55)*	31	24	
30-day mortality	1 (3)	1 (4)	1.0
30-day readmission	4 (13)	4 (17)	0.71
Reoperation	1 (3)	3 (13)	0.31
Bowel resection (n = *56)*	28	28	
30-day mortality	0 (0)	3 (11)	0.23
30-day readmission	5 (17)	2 (7)	0.42
Reoperation	10 (36)	3 (11)	0.06

High volume surgeon is defined at ≥ 10 SBO cases performed in the time period. This group is further subdivided in open preferred (< 40% of cases laparoscopic) and laparoscopic preferred (≥ 40% of cases laparoscopic)

Table 7 Postoperative outcomes for high volume surgeons, comparing open preferred and laparoscopic preferred surgeons when controlling for bowel resection

	Open Preferred ($n=18$)	Laparoscopic Preferred ($n=54$)	p-value
Laparoscopic			
No bowel resection ($n=43$)	13	40	
30-day mortality	0 (0)	1 (3)	1.0
30-day readmission	0 (0)	5 (13)	0.31
Reoperation	0 (0)	4 (10)	0.56
Bowel resection (n = *19)*	5	14	
30-day mortality	1 (20)	0 (0)	0.26
30-day readmission	2 (40)	1 (7)	0.15
Reoperation	1 (20)	1 (7)	0.46

a laparoscopic approach on patient baseline characteristics alone. While there were no detectable statistically significant differences in postoperative median mortality, reoperation, and readmission between open preferred and laparoscopic preferred due to an underpowered sample, it is important to note the clinical differences in outcomes. In fact, there was a 30-day mortality rate of 0% in laparoscopic preferred when resecting bowel laparoscopically, which suggests improved clinical outcomes with this approach in the hands of experienced surgeons. However, surgeons in the laparoscopic preferred group showed a higher mortality (1% vs 0%), reoperation (4% vs 0%), and re-admission (5% vs 0%) when no bowel resection was performed; however, this discrepancy can be explained by patient selection. Open preferred surgeons may select the classic "healthier" patient for laparoscopy, whereas the laparoscopic preferred surgeons may have a lower threshold to utilize laparoscopy in more difficult cases or patients with more comorbidities leading to more frequent adverse postoperative outcomes. After performing analysis on high volume surgeons, the groups were notably underpowered. Because of this small sample size, the p-values were not able to be indicate statistical significance. However, there are important differences in the absolute values that serve clinical importance such a low mortality rate, reoperation, and readmission rates. The postoperative data from this analysis, including 30-day mortality, readmission, and reoperation between the laparoscopic preferred and open preferred groups and can serve as hypothesis generating data.

Previous studies that have illustrated safety with laparoscopic exploration in management of adhesive small bowel obstruction suggest a bias toward healthier patients. Sebastian-Valverde et al. [14] suggests that patients selected for laparoscopy were younger and had fewer co-morbidities. In a block randomized study by Sallinen et al. [19], the authors showed favorable outcomes when using laparoscopy for adhesiolysis including shorter length of stay and fewer postoperative complications. However, this study utilized high selective inclusion criteria, including only patients with high likelihood of single band SBO. In our study, surgeons who were above average users of laparoscopy for management of small bowel obstruction showed no difference patient selection including age, BMI, Charlson score, and concerning CT findings. Thus, surgeons involved in this study do not exhibit the same selection bias as seen in other studies. The above average laparoscopic users had notably improved clinical outcomes when utilizing laparoscopy over an open approach with zero mortalities and one readmission when stratifying for bowel resection. This group of laparoscopic preferred users demonstrate improved outcomes in a comparable patient population compared the remainder of the cohort. This suggests that surgeons that utilize a greater volume of laparoscopic cases generate superior outcomes compared to open in small obstruction operations when performing bowel resection.

While most prior studies that support laparoscopy for management of adhesive small bowel obstruction focus on complication rate, most also illustrate shorter return of bowel function with this surgical modality [6, 10, 15, 20]. In a large retrospective study utilizing National Surgical Quality Improvement Program (NSQIP) outcomes data by Kelly et al. [10], the authors found a postoperative length of stay of 4.7 days in the laparoscopic group vs 9.9 days in the open group. A similar study performed in a single center by Byrne et al. [6] also illustrated decreased median length of stay in their laparoscopic group at 5 days vs. 7 days. Our study found a median overall length of stay in the laparoscopic group to be 8 days vs. 13 days in the open group, showing a similarly significant difference. In the Byrne et al. (2015) study [6], they also investigated the time to return of bowel function, showing a median return in 3.0 days in those undergoing laparoscopy vs 3.9 days for open surgery. This study also illustrates a 33% decrease in length of stay in laparoscopy vs open (4 days vs 6 days). While Byrne et al. showed a shorter time to return of bowel function with laparoscopy, it was defined as documented return of flatus, whereas this study defined it as initiating a regular diet. Thus, initiation of a regular diet may be slightly longer by 1–2 days after passing flatus based on clinical practice as some clinicians chose to start a liquid diet prior to starting patients on a full diet.

For SBO cases involving bowel resection, this study also shows that laparoscopy has shorter length of stay, mortality, readmission, and reoperation. Bowel resection is more commonly performed during an open procedure compared to laparoscopic [8]. Bowel resection has been described as technically difficult in laparoscopy due to

difficult visualization and difficulty handling bowel [14]; thus, surgeons choose an open operation. However, our data shows fewer mortalities (2% vs 7%), readmissions (3% vs 11%), and reoperations (3% vs 22%) with a laparoscopic approach. Even when laparoscopic cases are converted to open, our data shows there is a shorter return of bowel function and lower mortality, reoperation, and readmission compared to open. In fact, our data suggest that bowel resection may be an important factor to convert laparoscopic cases to a laparotomy as 51% of cases of conversion involved a bowel resection. These more "technically difficult" cases still show a greater outcome and safety profile with an initial laparoscopic as compared to open surgery.

While this study corroborates emerging data that favors the use of laparoscopy in the surgical management of small bowel obstruction [6, 10, 14], it is important to recognize its limitations. This was a single center, retrospective study with a limited number of cases obtained by billing codes. The cohort was underpowered and was unable to detect statistically significance in key data points such as mortality despite having notably fewer cases. Similarly, we attempted to address selection bias toward open surgery by stratifying our data for above average laparoscopy users. However, this group was relatively small and too underpowered to detect a statistically significant difference regarding the primary outcome. Additionally, the retrospective nature of the study is limited by data reporting including underreporting of postoperative complications such as surgical site infection or morbidities that presented to another hospital.

Despite these limitations, this study highlights the safety and efficacy of laparoscopic adhesiolysis and bowel resection in the management of small bowel obstruction. It also illustrates the significantly shorter length of stay associated with a laparoscopic approach. The cost implications of these results should be studied in the future to address the concern of increased operating room cost associated with laparoscopic surgery [12], which may be mitigated by decreased overall hospital costs by shortening length of stay. We plan on using our data from this study to perform a cost analysis to determine the impact of laparoscopy on hospital expenses. We also plan performing an analysis of outcomes based on surgeon experience by stratifying years of experience into quartiles.

Declarations

Disclosures Ryan L. Chin, Diego L. Lima, Xavier Pereira, Gustavo Romero-Velez, Patricia Friedmann, Gbalekan Dawodu, Katie Sterbenz, Jaclyn Yamada, Prashanth Sreeramoju, Vance Smith, and Flavio Malcher have no conflicts of interest or financial ties to disclose.

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