Evaluation of laparoscopic surgery for small bowel obstruction and factors related to outcomes

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Abstract

Introduction: *In recent years, laparoscopic surgery (LS) has been performed for small bowel obstruction (SBO). However, the indications and short-term and long-term outcomes of LS for SBO have not yet been established.*
Aim: *To evaluate the usefulness of LS for SBO compared to open surgery (OS), as well as to identify risk factors for poor outcomes after LS.*
Material and methods: *A total of 105 patients who underwent surgery for SBO were divided into OS (n = 64) and LS (n = 41) groups, and propensity score-matched analysis was used to compare the short-term and long-term outcomes of the groups. Risk factors for conversion to OS, postoperative complications, and intraoperative bowel injury in LS were also identified.*
Results: *The incidences of surgical site infection and postoperative ileus were significantly lower in the LS group. The incidence of recurrent bowel did not differ significantly between the two groups. Prior bowel obstruction was a risk factor for conversion of LS to OS (odds ratio (OR) = 24.79, p = 0.0025). Bowel diameter was a risk factor for postoperative complications (OR = 1.50, 95% CI: 1.01–2.22) and for bowel injury (OR = 1.33, 95% CI: 1.05–1.67).*
Conclusions: *LS for SBO had better postoperative short-term outcomes than OS. The outcomes of LS for SBO were significantly affected by prior bowel obstruction and bowel diameter.*

Key words: *small bowel obstruction, laparoscopic surgery, outcome, risk factors.*

Introduction

Methods of treatment of small bowel obstruction (SBO) vary from patient to patient, and some respond well to decompression and other conservative therapies. Unfortunately, there are not a few cases that have ultimately required surgical treatment [1–3]. Open surgery (OS) has conventionally been the first-choice surgical treatment because of the risk of bowel injury and surrounding organs due to severe intraperitoneal adhesions. Recent advances in laparoscopic techniques [4, 5] and instruments [6] have enabled the development of standardized procedures for all types of abdominal diseases. As a result, laparoscopic surgery (LS) has gradually changed from being used as a diagnostic method for SBO to being used as a therapeutic method, and it is now expected to be used as a minimally invasive therapeutic technique that has been performed in many institutions. The advantages of LS, such as shortening of postoperative hospitalization and reduction of postoperative complications, have been reported

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[7, 8]. However, LS for SBO is technically more difficult than OS, and it is more difficult to develop the operative field and use forceps than in LS for other abdominal diseases, and problems related to conversion to OS and intraoperative bowel injury due to these problems have been reported [9, 10]. Therefore, no consensus on its outcomes and indications has yet been reached [11–14]. In this study, the usefulness of LS for SBO was evaluated by comparing its outcomes with those of conventional OS, and risk factors associated with negative outcomes such as conversion to OS, postoperative complications, and intraoperative bowel injury in LS were evaluated to overcome the problems of LS for SBO.

Aim

The aim of this study was to evaluate the impact of LS on postoperative complications and postoperative ileus, as well as to identify risk factors for conversion, postoperative complications, and bowel injury in the LS group.

Material and methods

Study design

The subjects of this study were 105 patients who underwent either LS (41 patients) or OS (64 patients) between October 2012 and June 2018 for SBO, excluding cases diagnosed as having SBO due to malignant diseases such as peritoneal metastasis after radical surgery for abdominal malignant tumor, small intestinal cancer, and malignant lymphoma by definitive diagnosis after surgery, and SBO due to an incarcerated inguinal or obturator/femoral/any abdominal hernia. Patient attributes, operative time, blood loss, conversion to OS, intraoperative and postoperative complications, date of first passage of gas, date of resumption of eating, and duration of hospital stay were recorded in a database. All patients underwent OS or LS after having received a sufficient explanation of each method and its risks, and they provided their informed consent. The study protocol was approved by the Institutional Review Board for Clinical Research, Tokai University (18R-197) and was performed in accordance with its guidelines and regulations. All patients provided written, informed consent for the use of their clinical data. The primary outcomes of the study were postoperative complications and postoperative ileus. Postoperative complications were divided according to the time of their occurrence as short-term if they occurred between the completion of surgery and initial postoperative discharge or long-term if they occurred after initial postoperative discharge. The two groups were matched by propensity scores, and their postoperative short-term and long-term outcomes were compared. Postoperative complications were defined as those of Clavien-Dindo classification (CD) grade II or higher [15]. Postoperative ileus and recurrent bowel obstruction were defined as requiring fasting, intravenous fluids, and decompression, and they were diagnosed by abdominal signs and abdominal computed tomography (CT), plain radiography, and ultrasound. Intraoperative bowel injury was defined as cases of full-thickness bowel injury requiring small bowel resection and anastomosis, and cases where serosal muscular suture was performed only for serosal muscular layer bowel injury. Conversion to OS was defined as the use of an additional skin incision measuring ≥ 5 cm. Risk factors for conversion to OS, postoperative complications, and intraoperative bowel injury were also analyzed for all patients in the LS group. The factors investigated as potential risk factors for conversion to OS and intraoperative bowel injury during LS were sex, age, American Society of Anesthesiologists Physical Status Classification (ASA-PS) ≥ 3, body mass index (BMI) ≥ 25 kg/m^2, number of prior operations, prior OS, prior bowel obstruction, maximum dilated small bowel diameter on preoperative abdominal CT, cause of SBO (adhesion, isolated band, torsion, or internal hernia) based on intraoperative findings, and long-tube placement. The factors investigated as potential risk factors for postoperative complications were those listed above with the addition of conversion to OS and intraoperative bowel injury in all LS cases.

Preoperative management and surgical procedure

LS was indicated for all patients with SBO other than those with extensive intestinal necrosis and those with unstable respiratory and circulatory dynamics, and since 2017, it has been regarded as the first-choice treatment. Whenever possible, a long tube was placed, intestinal decompression was performed before surgery, and the stenotic area was evaluated using a water-soluble gastrointestinal contrast agent. In the surgical procedure, the umbilicus was the first-choice insertion site for the first 12-mm trocar, but if preoperative abdominal contrast-enhanced CT or ultrasound suggested that severe adhesions might be present at this site, the left or right abdomen was used instead, and the open method was selected. Pneumoperitoneum was induced, and the severity of intraperitoneal adhesions was assessed, after which 5-mm trocars were inserted on the basis of forming a triangle with the culprit lesion at the center. When extending the operation field was difficult, further 5-mm trocars were added as necessary. If small bowel resection was required, the 12-mm trocar insertion wound was extended to perform mini-open surgery, through which the small bowel was brought outside the body for resection and anastomosis.

Statistical analysis

Comparisons between the two groups before propensity score (PS) matching were performed using the Mann-Whitney test to compare continuous variables and Pearson's χ^2 test to compare categorical variables. For PS matching, preoperative variables in the LS and OS groups were first compared by univariate analysis, after which multiple logistic regression analysis was performed using only those factors identified as significant. These factors were used to calculate propensity scores, and the LS and OS groups were then matched 1 : 1 using a caliper set at 0.2. Comparisons between the two groups after PS matching were performed using the Wilcoxon signed-rank test to compare continuous variables and McNemar's test to compare categorical variables. Risk factors were identified by the stepwise backward selection method. JMP software for Windows, version 13.0 (SAS Institute, Cary, NC, USA) was used for all statistical analyses, and $p < 0.05$ was regarded as significant.

Results

Patient characteristics of the baseline and propensity-matched cohorts

Table I shows a comparison of the attributes of all patients in the OS and LS groups. The LS group contained significantly fewer patients with ASA-PS ≥ 3 and patients with prior open surgery compared with the OS group. The rate of long-tube placement was also significantly higher in the LS group, and internal hernia and isolated band were also significantly more common causes of SBO. Multivariate logistic analysis using ASA-PS ≥ 3, prior open surgery, long-tube placement, and internal hernia or isolated band as the cause of SBO as covariates identified prior open surgery (odds ratio (OR) = 0.20, 95% confidence interval (CI): 0.06–0.67), long-tube placement (OR = 5.19, 95% CI: 1.61–16.65), and internal hernia (OR = 14.25, 95% CI: 2.29–88.65) as significant factors (Table II). After propensity score matching, 26 matched pairs were selected (Table I). The standardized difference score after propensity matching was –0.07 for prior open surgery, –0.07 for long-tube placement, and 0.09 for internal hernia (Table II). The area under the curve (AUC) of the receiver operating characteristic (ROC) curve was 0.79, indicating moderate accuracy.

Short-term outcomes in the matched cohort

Table III shows a comparison of the short-term outcomes for the two groups. Operative time was longer for LS than for OS, but no significant difference was observed. Blood loss was significantly lower (25 ml vs. 77.5 ml, $p = 0.0293$), and postoperative hospital stay was significantly shorter (10.5 days vs. 14 days, $p = 0.0245$) in the LS group than in the OS group. The incidence of postoperative complications was also significantly lower in the LS group (15.3% vs. 42.3%, $p = 0.0297$). In terms of postoperative complications, the incidences of SSI (3.8% vs. 42.3%, $p = 0.0153$) and postoperative ileus (0% vs. 11.5%, $p = 0.0372$) were significantly lower in the LS group. Bowel injuries tended to be more common in the LS group than in the OS group (30.7% vs. 19.2%, $p = 0.2941$), but the difference was not significant.

Long-term outcomes in the matched cohort

The only long-term postoperative complication evaluated was the incidence of recurrent bowel obstruction, and this did not differ significantly between the two groups (Table III). There was no significant difference between the two groups in the observation period.

Details of surgical outcomes of LS for SBO

For all cases of LS, the conversion rate to OS was 21.9%. The reason for conversion to OS was

Table I. Patient characteristics

Parameter	Unmatched			PS-matched		
	Laparoscopic (*n* = 41)	Open (*n* = 64)	*P*-value	Laparoscopic (*n* = 26)	Open (*n* = 26)	*P*-value
Sex (male) (%)	28 (68.2)	37 (57.8)	0.2807	16 (61.5)	16 (61.5)	1.0000
Age [years][a]	71 (24–89)	72 (26–97)	0.2000	73 (34–89)	69 (26–85)	0.2338
ASA-PS ≥ 3 (%)	12 (29.2)	36 (56.2)	0.0068*	12 (46.1)	13 (50.0)	0.7814
BMI ≥ 25 kg/m^2 (%)	2 (4.8)	4 (6.2)	0.7676	2 (7.6)	1 (3.8)	0.552
Prior surgery ≥ 2 (%)	12 (29.2)	22 (34.3)	0.5854	11 (42.3)	8 (30.7)	0.3876
Prior open surgery (%)	21 (51.2)	53 (82.8)	0.0005*	20 (76.9)	19 (73.0)	0.7488
Prior laparoscopic surgery (%)	6 (14.6)	4 (6.2)	0.1533	1 (3.8)	3 (11.5)	0.2980
CT maximum bowel diameter [mm][a]	36.7 (21.4–53.3)	35.85 (20–69.2)	0.6110	36.75 (21.5–53.3)	35.6 (20.0–51.5)	0.7734
Prior bowel obstruction (%)	5 (12.2)	10 (15.9)	0.6241	5 (19.2)	5 (19.2)	1.0000
Long-tube placement (%)	27 (65.8)	28 (43.7)	0.0269*	16 (61.5)	17 (65.3)	0.7734
Etiology of SBO:						
Adhesion (%)	15 (36.5)	23 (35.9)	0.9463	13(50.0)	13 (50.0)	1.0000
Isolated band (%)	32 (50.0)	10 (24.3)	0.0090*	9 (34.6)	9 (34.6)	1.0000
Torsion (%)	2 (4.8)	7 (10.9)	0.2792	1 (3.8)	2 (7.6)	0.5520
Internal hernia (%)	14 (34.1)	2 (3.1)	0.0001*	3 (11.5)	2 (7.6)	0.6381
White blood cell count [mm^3][a]	6500 (3200–14200)	8300 (2500–29500)	0.0992	6300 (3200–14200)	7850 (2900–29500)	0.4640
C-reactive protein [mg/dl][a]	0.47 (0.01–24.51)	0.52 (0.01–35.50)	0.7032	0.62 (0.01–24.54)	0.52 (0.01–19.23)	0.9489

*PS – propensity score, ASA-PS – American Society of Anesthesiologists physical status classification, BMI – body mass index, CT – computed tomography, SBO – small bowel obstruction, [a] Values shown as medians (range), *p < 0.05.*

Table II. Factors affecting surgical method selection

Variable	Odds ratio	95% CI	*P*-value	Std diff score
ASA-PS ≥ 3	0.55	0.21–1.45	0.2329	–0.07
Prior open surgery	0.20	0.06–0.67	0.0092*	0.08
Long-tube placement	5.19	1.61–16.65	0.0056*	–0.07
Isolated band	1.30	0.43–3.92	0.6351	0.00
Internal hernia	14.25	2.29–88.65	0.0001*	0.09

*CI – confidence interval, Std diff – standardized difference. *P < 0.05, A standardized difference score (Std diff score) of < 0.1 suggests adequate variable balance after propensity matching.*

Table III. Comparison of outcomes after propensity score matching

Variable	PS-matched		
	Laparoscopic (*n* = 26)	Open (*n* = 26)	*P*-value
Short-term outcomes:			
Operative time [min][a]	121 (46–252)	98 (30–288)	0.0558
Blood loss [ml][a]	25 (2–480)	77.5 (5–1960)	0.0293*
Conversion (%)	6 (23.0)		
Bowel injury (%)	8 (30.7)	5 (19.2)	0.2941
Time to first bowel movement [days][a]	2 (1–6)	3 (1–6)	0.0977
Time to resumption of soft diet [days][a]	5 (1–21)	5 (2–22)	0.5216
Count of analgesic use [times][a]	1.5 (0–23)	2.5 (0–39)	0.1590
Postoperative hospital stay [days][a]	10.5 (4–90)	14 (7–60)	0.0245*
Overall complications (%)	4 (15.3)	11 (42.3)	0.0297*
SSI (%)	1 (3.8)	7 (26.9)	0.0153*
Aspiration pneumonia (%)	1 (3.8)	1 (3.8)	1.0000
Anastomotic leakage (%)	1 (3.8)	0 (0)	0.2357
Port site hernia (%)	1 (3.8)	0 (0)	0.2357
Postoperative ileus (%)	0 (0)	3 (11.5)	0.0372*
Long-term outcomes:			
Recurrence (%)	0 (0)	1 (3.8)	0.2357
Observation period [days][a]	127 (16–1300)	315.5 (9–1779)	0.1053

*SSI – surgical site infection, [a]Values shown as medians (range), *$p < 0.05$.*

severe adhesions in 4 cases, difficulty securing the operative field in 3 cases, and wide-range necrosis in 2 cases. The intraoperative bowel injury rate was 21.9%. Full-thickness bowel injury was seen in 5 cases, and serosal muscular layer bowel injury was seen in 4 cases. The overall complication rate was 14.6% (Table IV).

Risk factors for conversion, postoperative complications, and bowel injury

Prior bowel obstruction was a risk factor for conversion to OS (OR = 24.79, 95% CI: 2.28–131.1). Bowel diameter was a risk factor for postoperative complications (OR = 1.50, 95% CI: 1.01–2.22) and for bowel injury (OR = 1.33, 95% CI: 1.05–1.67) (Table V).

Discussion

LS for abdominal disease has now been standardized, like cholecystectomy, appendectomy, colectomy, and gastrectomy, etc., with advances in laparoscopic techniques and instruments. Reports of the use of LS for SBO, for which OS has conventionally been the first-choice treatment, have also been increasing in recent years. LS was initially used as a diagnostic tool in the treatment of SBO [16], but today it is also used as a method of treatment. However, there is as yet no consensus on the indications for LS for SBO or on its short-term and long-term postoperative outcomes [11–14]. In the present study, length of hospital stay was shorter, and the incidence of complications was lower for LS than for OS, and postoperative ileus and SSI were significantly decreased in LS. These results suggest that LS may be superior to open surgery in terms of short-term postoperative outcomes, and that its advantages as a minimally invasive procedure may also be applicable to SBO surgery. Some studies have found that LS for SBO may reduce the rates of postoperative ileus compared with OS [17]. In

Table IV. Details of surgical outcomes of LS for SBO

Parameter	Total (*n* = 41)
Operative time [min][a]	120 (38–311)
Blood loss [ml][a]	7 (2–480)
Conversion (%)	9 (21.9)
Severe adhesion	4
Difficulty securing operative field	3
Wide-range necrosis	2
Intraoperative bowel injury (%)	9 (21.9)
Full-thickness bowel injury	5
Serosal muscular layer bowel injury	4
Overall complication (%)	6 (14.6)
SSI	2
Anastomotic leakage	1
Abscess	1
Port site hernia	1
Aspiration pneumonia	1

[a]Values shown as medians (range).

Table V. Multivariate analysis of risk factors for conversion, postoperative complications, and intraoperative bowel injury

Risk factors	Odds ratio	95% CI	*P*-value
Conversion risk factors:			
Prior bowel obstruction	24.79	2.28–269.60	0.0025*
Risk factors for postoperative complications:			
Bowel diameter	1.50	1.01–2.22	0.0001*
Risk factors for intraoperative bowel injury:			
Bowel diameter	1.33	1.05–1.67	0.0001*

*CI – confidence interval, *p < 0.05.*

the present study as well, LS helped prevent the short-term complication of postoperative ileus. On the other hand, in the present study, LS was equivalent to OS in recurrence of SBO, as reported so far, and it could not be demonstrated that it was superior. Major issues with the use of LS for SBO are conversion to OS and intraoperative bowel injury. The conversion rate of LS for SBO has been reported to be 29–33.6% [7, 18] so far and was 21% in the present study. Prior studies have found that factors increasing the risk of conversion to OS include bowel diameter ≥ 4 cm [19] and three or more prior open abdominal procedures [20], but the only risk factor identified in the present study was prior bowel obstruction (1.6 times). Possible reasons for conversion to OS are severe adhesions and difficulty extending the operative field. Many patients with prior bowel obstruction have severe or multiple adhesions, making it difficult to observe and grasp the course of the bowel laparoscopically, and this was a common reason for conversion. In such patients, preoperative intestinal decompression may also have been poor, leaving the bowel markedly dilated and making it difficult to secure the operative field, and this may also be a risk factor for conversion to OS. To overcome these disadvantages of LS, we carry out preoperative long-tube placement as much as possible in both emergency and elective procedures. The long tube is reportedly superior to the gastric tube in the treatment of SBO [21–23]. In the case of SBO in which the presence of intestinal necrosis has been ruled out, after long-tube insertion, we start by providing medical treatment and assess its effectiveness on day 7 after its placement. If it has been ineffective, the long tube is left in place until surgery, and intestinal decompression is performed as much as possible. The advantage of long-tube placement is that, because it is more difficult to explore the entire bowel during LS than during OS, preoperative contrast enhancement can be performed to identify the responsible lesion, and a search for the responsible lesion can also be performed intraoperatively using the long tube as a guide, reducing the burden during LS. Small bowel diameter is a risk factor for postoperative complications, and although long-tube placement was not found to have had any effect in the present study, preoperative intestinal decompression to reduce the diameter of the small bowel and confirm its course by preoperative contrast enhancement may help reduce the incidence of postoperative complications. Bowel injury is reportedly more common in LS than in OS [9]. In some cases, not only must serosal muscular layer bowel injury be repaired, but bowel resection may be required when the intestinal tract is extensively damaged across all layers. In the previous reports [9, 10, 17, 18], the incidence rate was high, at 4.8–37%. In the present study, there was no significant difference in the incidence of bowel injury, but the rate did tend to be higher for LS, and small bowel diameter was a risk factor for bowel injury. Compared with OS, bowel dilation does make it more difficult to secure a space for manipulation in LS, and accidental bowel injury is more likely to occur. Intestinal decompression is the best way to prevent these problems, and a long tube should be placed. In addition, there have been reports of delayed intestinal damage in LS, and greater caution is required in LS than in OS. In order to avoid intestinal damage, we use bipolar scissors (AESCULAP AdTec single use bipolar B.BRAUN, Melsungen, Germany) when removing intestinal adhesions.

Another important issue with LS for SBO is its greater technical difficulty compared with OS. Differences in surgeons' familiarity with LS for SBO have a major effect on surgical outcomes [24], and it has been claimed that this technique should only be used by surgeons who are proficient in it [10, 25]. Studies have identified a learning curve in skill acquisition in LS [26, 27]. To shorten this learning curve, surgical procedures must be standardized. However, LS for SBO is difficult to standardize, and before performing this procedure, surgeons must therefore become proficient in the standardized laparoscopic surgical procedures for other disorders, such as those of the stomach and colon; in particular, they should learn how to handle the bowel with forceps and how to extend the operative field.

The limitations of this study are its retrospective, non-randomized, and single-center design. In addition, despite the considerable sample size of the entire study population, it might still be too small for adequate subgroup analyses. Despite all these limitations, this study strongly suggests that LS has some advantages for SBO. Data from prospective, randomized, controlled trials of LS for this indication are needed.

Conclusions

LS is a useful approach for SBO, and preoperative decompression, patient selection, and the gradual expansion of indications may enable more patients to benefit from the advantages of this minimally invasive treatment.

Conflict of interest

The authors declare no conflict of interest.

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