Safety and Feasibility of Laparoscopic Surgery for Small Bowel Obstruction

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Purpose: Laparoscopic adhesiolysis is increasingly used to treat patients with small bowel obstruction (SBO), however, its safety of laparoscopic surgery (LS) with bowel resection in SBO is unclear. The purpose of the present study was to compare the perioperative outcomes of LS with those of open surgery (OS) for SBO and to evaluate the risk factors of 30-day postoperative morbidity and recurrence.

Methods: We retrospectively reviewed medical records of patients who had been diagnosed with SBO and underwent surgery at four Hallym-University-affiliated hospitals between January 2013 and December 2016. The rates of 30-day postoperative complications and recurrence were compared between groups using univariate and multivariate analysis. Propensity score matching was performed to compare the outcome.

Results: A total of 117 patients with SBO were included in the present study, of which 86 underwent OS and 31 underwent LS. Time to water intake, time to soft diet, and postoperative hospital stay were significantly shorter in the LS group ($p=0.002$, 0.003 , and 0.027 , respectively). The complication ($p=0.249$) and recurrence rate ($p=0.679$) were similar between the two groups. Propensity score matching analysis demonstrated that laparoscopic surgery showed quicker recovery and similar complication and recurrence rate. In multivariate analysis, LS was not associated with either complications ($p=0.806$) or recurrence ($p=0.956$).

Conclusion: LS is associated with several perioperative advantages for the treatment of SBO without affecting the risk of 30-day postoperative complications or recurrence. Therefore LS can be a safe and feasible option for treating SBO.

Keywords: Small bowel obstruction, Laparoscopic surgery, Complication

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INTRODUCTION

Small bowel obstruction (SBO) is one of the most common conditions requiring emergency surgical admission. Postoperative intra-abdominal adhesion occurs in 60%~80% of patients

with SBO.¹⁻⁴ Conventional laparotomy with adhesiolysis or resection of nonviable small intestine is the standard surgical approach for SBO if conservative treatment fails, or complications such as bowel necrosis are suspected. However, a potential problem with laparotomy for SBO is that open surgery (OS)

causes even more adhesions.

Recently, laparoscopic surgery (LS) has been considered as an alternative treatment for SBO, because it is associated with fewer postoperative adhesions than open surgery.⁵⁻⁸ However, there is considerable controversy regarding the potential adverse effect of laparoscopic surgery in SBO because of the difficulty in manipulating the distended bowel and the narrow working space, which may increase the risk of iatrogenic bowel perforation.^{3,4}

Bastug et al. first reported successful laparoscopic adhesiolysis in 1991.⁹ Since then, with the recent technical advances and increased experience in LS, many previous studies have shown the safety, feasibility, and potential superiority of a laparoscopic approach for the treatment of SBO.¹⁰⁻¹⁷ Moreover, some studies have reported long-term outcomes, such as the frequency and management of recurrence after LS.¹⁸⁻²⁰ Despite many studies have been reported on safety of laparoscopic adhesiolysis in SBO, prospective randomized trials comparing LS and OS in the treatment of SBO have not been published. Accordingly, the proper surgical approach depends on the condition of the patient and the surgeon's discretion.

The purpose of the present study is to compare the rates of 30-day postoperative complications and recurrence rates of LS with those of OS for SBO and to evaluate the risk factors for SBO complications and recurrence. And propensity score matching analysis was performed to compare the outcome between the two groups.

MATERIALS AND METHODS

A retrospective review was performed of patients diagnosed with SBO who underwent surgery at four Hallym-University-affiliated hospitals (Kangnam Sacred Heart Hospital, Kangdong Sacred Heart Hospital, Chuncheon Sacred Heart Hospital, and Dongtan Sacred Heart Hospital) between January 2013 and December 2016. The patients were divided into two groups according to whether they underwent LS or OS. The type of surgery was selected according to the surgeon's discretion and the patients' clinical status.

The diagnosis of SBO was determined based on medical history and physical examinations combined with imaging studies, including plain erect/supine abdominal X-ray and abdominal computed tomography. We excluded patients with incomplete data and those aged <18 years or >80 years. We also excluded patients with non-adhesion-related causes of bowel obstruction, such as a solid tumor, disseminated malignancy, and internal hernia.

Patient characteristics and perioperative variables were compared between the LS and OS groups. The patients' characteristics included age, sex, American Society of Anesthesi-

ologists score (ASA), body mass index (BMI), previous surgeries, duration from symptom onset to surgery, white blood cell count, neutrophil proportion, and serum C-reactive protein concentration. Previous surgeries were divided into major and minor operations according to the site and type of operation.²¹ Open cholecystectomy, colorectal surgery due to malignancy or diverticulitis, total abdominal hysterectomy, small bowel resection anastomosis due to trauma or stab wound, total or subtotal gastrectomy, and Whipple's operation were regarded as major operations, while appendectomy, cesarean section, laparoscopic adnexal surgery, laparoscopic cholecystectomy, and laparoscopic primary repair due to gastric or duodenal ulcer perforation were regarded as minor operations.

Surgical variables included operation time, surgical approach (LS versus OS), procedure type, and reason for conversion to OS. Procedure type was divided into three groups according to the aggressiveness of the method: bowel resection, adhesiolysis, and band ligation. If more than one procedure was performed, we used the more aggressive procedure. Receiving an additional incision larger than that necessary for specimen retrieval was defined as conversion to OS. Patients who underwent LS for bowel resection via an incision less than 5 cm were included in the LS group.

Postoperative outcomes included the time to flatus, time to water intake, time to soft diet intake, and the length of the postoperative hospital stay. Postoperative complications were defined as any condition that prolonged hospitalization or required an additional procedure. Ileus, bowel perforation, pneumonia, wound dehiscence, intra-abdominal abscess, and septic shock were considered complications. The study was approved by the Institutional Review Board of Dongtan Sacred Heart Hospital (IRB number, 2017-141).

The primary outcome of this study was the rate of postoperative complications. The secondary outcomes were indicators of postoperative recovery, including time to flatus, time to soft diet, and the length of the postoperative hospital stay, and risk factors for postoperative complications and recurrence.

Continuous variables, presented as means and standard deviations, were compared using Student's *t* test or the Mann-Whitney U test. Categorical variables, presented as numbers and percentages of patients, were analyzed using the χ^2 test or Fisher's exact test. To remove the effect of selection bias on the outcomes, we matched two groups with propensity score calculated by age, sex, operation type and operation history using binary logistic regression.

Multivariate logistic regression analysis was used to identify independent predictors of postoperative complications and bowel resection. Confounding factors evaluated in the multivariate analysis included factors previously reported to be associated with postoperative complications and bowel resection.

Table 1. Patient demographic characteristics

Variables	Unmatched			PS-Matched		
	Open (n = 86)	Laparoscopy (n = 31)	<i>p</i>	Open (n = 23)	Laparoscopy (n = 23)	<i>p</i>
Age (years)	60.9 (18.7)	46.1 (18.3)	<0.001	50.9 (19.1)	50.3 (18.5)	0.969
Male	45 (52.3%)	13 (41.9%)	0.321	9 (39.1%)	9 (39.1%)	1.000
ASA score			0.211			0.665
1 and 2	65 (75.6)	27 (87.1)		21 (91.3)	19 (82.6)	
3 and 4	21 (24.4)	4 (12.9)		2 (8.7)	4 (17.4)	
Body mass index (kg/m ²)	21.7 (4.4)	22.6 (2.5)	0.395	24.1 (3.8)	23.0 (3.7)	0.315
Operation history			0.550			0.797
None	24 (27.9%)	9 (29.0%)		7 (27.3%)	8 (28.1%)	
Minor	34 (39.5%)	15 (48.4%)		10 (39.8%)	13 (46.9%)	
Major	28 (32.6%)	7 (22.6%)		6 (31.8%)	2 (25.0%)	
Symptom to operation time (days)	4.0 (4.5)	4.9 (7.0)	0.511	3.7 (4.1)	6.2 (7.7)	0.163
White blood cell count ($\times 10^3/\mu\text{L}$)	12.2 (14.5)	9.9 (3.7)	0.383	9.9 (5.1)	9.58 (4.2)	0.839
Neutrophil ratio (%)	77.4 (16.0)	75.8 (14.4)	0.625	74 (16.9)	72 (15.2)	0.634
CRP (mg/L)	66.4 (95.3)	16.3 (32.7)	<0.001	62.3 (78.5)	19.7 (37.2)	0.033

Data presented are numbers of patients (percentage) or means (standard deviations). CRP = c-reactive protein; ASA score = American Society of Anesthesiologists score.

Of the confounding factors, continuous variables, including age, BMI, white blood cell count, neutrophil proportion, and serum CRP concentration, were categorized using their mean values. The time from symptom onset to surgery was categorized into three periods: ≤ 1 , 1–7, and >7 days. *p* values <0.05 were considered statistically significant.

RESULTS

A total of 117 patients with SBO underwent surgery: OS in 86 and LS in 31. The patient demographic characteristics are summarized in Table 1. Patients in the LS group were younger than those in the OS group (46.1 vs. 60.9 years, $p<0.001$). There were no significant differences between the two groups in terms of sex, ASA, BMI, surgical history, symptom to operation time, white blood cell count, or neutrophil proportion. Propensity score matching yielded 23 pairs of matched LS and OS patients. With propensity score matching, the two patient groups were well-matched in other characteristics including BMI, previous operation type, symptom to operation time, white blood cell count and neutrophil ratio (Table 1).

Table 2 presents the perioperative outcomes. In the OS group, bowel resection was performed most frequently, followed by adhesiolysis and bandlysis. In the LS group, adhesiolysis was performed most frequently, followed by bandlysis

and bowel resection. There was no significant difference in operation time between the two groups (115.3 vs. 112.4 minutes, $p=0.844$). Time to water intake, time to soft diet, and postoperative hospital stay were significantly shorter in the LS group ($p=0.002$, 0.003 , and 0.027 , respectively). The postoperative complication rate was similar between the two groups (33.7% vs. 22.6%, $p=0.249$). Postoperative ileus occurred in 22 (25.6%) patients in the OS group and 6 patients (19.4%) in the LS group. Bowel perforation was observed in one patient (3.2%) in the LS group. Conversion to OS was required in four patients because of severe adhesions in three patients and bowel perforation in one patient. The mean follow-up periods were 18.2 and 14.0 months in the OS and LS groups, respectively. Recurrence (8% vs. 3.2%, $p=0.679$) and re-operation (3.4% vs. 6.5%, $p=0.604$) rates were similar between the groups.

With propensity score matching, the time to water intake (5.5 vs. 3.4 days, $p=0.015$), time to soft diet intake (7.2 vs. 4.8 days, $p=0.034$) were significantly shorter in the LS group than in the OS group, and the length of hospital stay tended to be shorter in LS than in OS ($p=0.086$) (Table 3). The matching analysis also did not show a difference in the postoperative complication rate, recurrence and reoperation between the groups ($p=0.345$, $p=1.000$, and $p=0.489$, respectively).

Univariate analysis revealed male sex ($p=0.028$), bowel resection ($p=0.005$), and previous major surgeries ($p<0.001$) as

Table 2. Perioperative outcome

Outcome	Open (n = 86)	Laparoscopy (n = 31)	p
Operation type			0.005
Bowel resection	43 (50%)	5 (16.1%)	
Adhesiolysis	25 (29.1%)	15 (48.4%)	
Bandlysis	18 (20.9%)	11 (35.5%)	
Operation time (minutes)	115.3 (69.1)	112.4 (68.9)	0.844
Open conversion	4	N/A	
Time to water intake (days)	5.72 (3.6)	3.52 (2.7)	0.002
Time to soft diet (days)	7.22 (4.0)	4.77 (3.5)	0.003
Time to gas out (days)	1.38 (2.5)	2.10 (2.3)	0.167
Hospital day	18.9 (23.0)	12.5 (8.5)	0.027
Complication	29 (33.7)	7 (22.6)	0.249
Post-operative ileus	22(25.6)	6 (19.4)	0.486
Bowel perforation	0 (0)	1 (3.2)	0.265
Pneumonia	3 (3.4)	1 (3.2)	1.000
Etc	4 (4.5)	0 (0)	0.572
Recurrence	7 (8.0)	1 (3.2)	0.679
Re-operation	3 (3.4)	2 (6.5)	0.604

Data presented are numbers of patients (percentage) or means (standard deviations).

risk factors for postoperative complications (Table 4). In the multivariate analysis, male sex ($p=0.016$) and previous major surgeries ($p=0.011$) remained significant risk factors for postoperative complications. LS was not associated with complications in either the univariate or multivariate analysis.

A neutrophil proportion $>77\%$ was independently associated with SBO recurrence in the multivariate analysis ($p=0.044$) (Table 5). LS was not a risk factor for SBO recurrence in either the univariate or multivariate analysis.

DISCUSSION

The present study revealed several advantages of LS for the treatment of SBO, including a shorter time to flatus, shorter time to soft diet intake, and shorter postoperative hospital stay, without an increase in the risk of complications, compared with OS. In a sensitivity analysis, patients in the LS group showed a quicker recovery compared with those in the OS group. Independent factors associated with postoperative complications were male sex ($p=0.01$) and prior major surgeries ($p=0.011$). Moreover, a neutrophil proportion $>77\%$ was an

Table 3. Perioperative outcomes of propensity score matched analysis

Outcome	Open (n = 23)	Laparoscopy (n = 23)	p
Operation type			0.798
Bowel resection	4 (17.4)	4 (17.4)	
Adhesiolysis	13 (56.5)	11(47.8)	
Bandlysis	6 (26.1)	8 (34.8)	
Operation time (minutes)	115 (76.17)	110 (76.4)	0.584
Time to water intake (days)	5.5 (3.2)	3.4 (2.3)	0.015
Time to soft diet (days)	7.2 (4.1)	4.8 (3.2)	0.034
Time to gas out (days)	0.9 (2.54)	1.5 (1.7)	0.336
Hospital day	12.5 (6.8)	9.3 (5.5)	0.086
Complication	9 (39.1)	6 (26.1)	0.345
Post-operative ileus	7 (30.4)	5 (21.7)	0.738
Bowel perforation	0 (0)	1 (4.3)	1.000.
Pneumonia	0 (0)	1 (4.3)	1.000
Etc	2 (8.7)	0 (0)	0.489
Recurrence	1 (4.3)	1 (4.3)	1.000
Re-operation	0 (0)	2 (8.7)	0.489

independent risk factor for recurrence ($p=0.044$).

Postoperative intra-abdominal adhesions account for 60%~80% of SBO cases.¹⁻⁴ The initial treatment of SBO is conservative management, including decompression of the distended bowel using a Levin tube, hydration, and antibiotics. If conservative treatment fails, or if signs of strangulation or peritonitis are suspected, conventional laparotomy is the standard surgical treatment for SBO. However, laparotomy treatment of SBO has been associated with substantial morbidities including wound infections, increased postoperative pain, prolonged ileus, and reduced postoperative pulmonary function.² In addition, the estimated rate of obstruction recurrence is 12%~17%.^{1,22,23}

Since the first report of Bastug et al. for successful laparoscopic adhesiolysis in 1991,⁹ technological developments and increased experience with LS have led to a number of studies reporting advantages of LS, including a shorter postoperative hospital stay, fewer complications, and less postoperative pain.¹⁰⁻¹⁷ Kim et al. reported significant reductions in return of bowel function (4.3 vs. 6.6 days, $p=0.02$), and hospital stay (8.1 vs. 15.2 days, $p=0.04$).¹⁷ Moreover, in a systematic review comparing laparoscopic adhesiolysis with open adhesiolysis for SBO treatment, LS resulted in reduced risks of morbidity, mortality, and surgical site infection.²⁴ The present study

Table 4. Risk factor for complication.

Variable	Univariate analysis		Multivariate analysis	
	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
Age >60 years	1.125 (0.525 ~ 2.414)	0.762	1.055 (0.353 ~ 3.154)	0.923
Male	2.383 (1.091 ~ 5.208)	0.028	3.543 (1.261 ~ 9.951)	0.016
BMI >22	0.771 (0.360 ~ 1.651)	0.503	1.579 (0.593 ~ 4.200)	0.360
ASA ≥3	1.624 (0.659 ~ 4.002)	0.290	1.342 (0.405 ~ 4.444)	0.630
Neutrophil >77%	0.964 (0.442 ~ 2.103)	0.927	2.008 (0.650 ~ 6.199)	0.266
CRP >52 (mg/L)	1.032 (0.420 ~ 2.538)	0.945	1.522 (0.508 ~ 4.588)	0.453
WBC >11.6 ($\times 10^3/\mu\text{L}$)	1.839 (0.828 ~ 4.082)	1.132	2.085 (0.670 ~ 6.493)	0.205
Major operation history	4.650 (2.001 ~ 10.808)	<0.001	3.781 (1.350 ~ 10.590)	0.011
Symptom to operation time				
<1 day	Reference			0.766
1 ~ 7 days	0.946 (0.396 ~ 2.262)	0.820	0.651 (0.206 ~ 2.064)	0.466
>7 days	0.657 (0.229 ~ 1.888)	0.436	0.786 (0.201 ~ 3.070)	0.729
Laparoscopic surgery	0.446 (0.173 ~ 1.149)	0.090	0.843 (0.216 ~ 3.290)	0.806
Bowel resection	3.059 (1.392 ~ 6.722)	0.005	1.660 (0.586 ~ 4.701)	0.340

OR = odds ratio; CI = confidence interval; BMI = body mass index; ASA score = American Society of Anesthesiologists score; CRP = c-reactive protein; WBC = white blood cell.

Table 5. Risk factor for recurrence

Variable	Univariate analysis		Multivariate analysis	
	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
Age >60 years	1.271 (0.302 ~ 5.345)	1.000	0.449 (0.024 ~ 8.331)	0.591
Male	3.288 (0.635 ~ 17.018)	0.163	3.344 (0.340 ~ 32.876)	0.300
BMI >22	0.508 (0.116 ~ 2.234)	0.472	0.531 (0.067 ~ 4.197)	0.548
ASA ≥3	2.373 (0.526 ~ 10.696)	0.365	33.036 (0.899 ~ 121.375)	0.057
Neutrophil >77%	2.875 (0.652 ~ 12.673)	0.148	15.815 (1.092 ~ 61.056)	0.044
CRP >52 (mg/L)	1.984 (0.835 ~ 4.716)	0.118	5.824 (0.485 ~ 79.974)	0.165
WBC >11.6 ($\times 10^3/\mu\text{L}$)	0.853 (0.194 ~ 3.753)	1.000	4.200 (0.253 ~ 69.784)	0.317
Major operation history	1.444 (0.326 ~ 6.403)	0.694	0.653 (0.072 ~ 5.944)	0.705
Symptom to operation time				
<1 day	Reference		Reference	0.245
1 ~ 7 days	0.863 (0.369 ~ 2.016)	0.733	0.069 (0.003 ~ 1.589)	0.095
>7 days	0.557 (0.200 ~ 1.550)	0.263	0.378 (0.031 ~ 4.606)	0.446
Laparoscopic surgery	0.376 (0.044 ~ 3.188)	0.679	0.917 (0.041 ~ 20.502)	0.956
Bowel resection	1.382 (0.312 ~ 6.122)	0.700	1.260 (0.151 ~ 10.519)	0.831

OR = odds ratio; CI = confidence interval; BMI = body mass index; ASA score = American Society of Anesthesiologists score; CRP = c-reactive protein; WBC = white blood cell; op = operation.

also showed a quicker recovery of bowel function and shorter postoperative hospital stay in the LS group than in the OS group.

However, bowel resection was performed more frequently in the OS group than in the LS group, which may have resulted in the faster recovery and shorter hospital stay in the LS group. Thus, we performed a matching the two group using propensity score calculated by age, gender and operation type. Results of the propensity score matched analysis also showed that LS was associated with a shorter time to water intake and time to soft diet. The length of hospital stay tended to be shorter in LS than in OS ($p=0.086$). These results are in agreement with those of previous studies.

Although many studies have compared postoperative complications between LS and OS, the conclusions differ. Okamoto et al. demonstrated a lower rate of postoperative complications after LS than after laparotomy (7% vs. 56%, $p<0.05$).¹⁶ On the other hand, Hackenberg et al. reported similar overall complication rates between LS and OS (16% vs. 24%, $p=0.40$).²⁵ In the present study, the overall complication and postoperative ileus rates were similar between the two groups ($p=0.249$ and 0.486 , respectively). Possible explanations are that the definitions of complications and disease entities included as complications differ among studies. Several studies have reported risk factors for complications. Byrne et al. showed that age, male sex, smoking, and prior abdominal surgery were associated with overall complications. In addition, LS reduced the risk of complications by 60% ($p=0.002$).¹³ Suter et al. suggested accidental bowel perforation ($p=0.008$) and the need for conversion to OS ($p=0.009$) to be independent risk factors for postoperative complications.²⁶ In the present study, previous major surgeries and male sex were associated with postoperative complications. Potential issues in major surgeries are that complicated surgical procedures can result in extensive dissection, longer operation times, and more aggressive surgical trauma in tissues, which can increase the risk of complications.

Recent studies have reported rates of conversion to OS of 26%~51.9%, much higher than the 12.9% conversion rate reported in the present study.^{6,13-15,26,27} The reason for our low rate of conversion might be that laparoscopic-assisted procedures were not regarded as OS in this study. For such procedures, bowel resection with anastomosis was performed by mini-laparotomy using a less than 5 cm incision in the LS group.

One of the main concerns of LS for SBO is iatrogenic bowel perforation. The incidence of iatrogenic bowel perforation has been reported to range from 3.2% to 13.56%.^{3,6,16,18,26,28} Bailey et al. reported a higher reoperation rate due to iatrogenic bowel perforation in patients treated laparoscopically ($p<0.05$).²⁹ However, a systematic review showed that LS for SBO did not

increase the risk of bowel injury compared with OS (95% CI 0.24~2.46; $p=0.65$).³⁰ Although there was only one case (3.2%) of bowel perforation in the LS group, the incidence of bowel perforation in the present study was lower than those of previous studies. In LS, we insert the first trocar using Hasson's technique and then introduce the other trocars under direct camera visual guidance. Suter et al. recommended manipulation of the small bowel using atraumatic forceps, including fenestrated forceps or large intestinal Glasson graspers, and performance of bandlysis or adhesiolysis using scissors or a bipolar coagulator, rather than a monopolar coagulator.²⁶

A potential problem with performing LS for patients with SBO is the higher recurrence rate compared with that of OS. It is likely that occult pathologic lesions at other sites are overlooked because of the limited abdominal cavity and distended (small) bowel. However, several studies reported no difference in recurrence rate between LS and OS.^{15,19} The recurrence rate in the present study was also similar between the LS and OS groups (3.2% vs. 8.0%, $p=0.679$). Duron et al. in 2006 reported that adhesions or matted adhesions and surgical complications were independent risk factors for surgical recurrence.²⁰ Recently, Yao et al. showed more than three prior surgeries to be a risk factor for overall recurrence ($p=0.041$).¹⁹

There are several limitations to our study. First, this study was performed retrospectively, which means that selection bias may have existed. Thus, younger patients with severe adhesions were more likely to be selected for LS. To address these biases, we performed a matching analysis using propensity scores based on age, gender, and operation type. Second, the median follow-up period in the present study was relatively short compared with those of previous studies, ranging from 41 to 47 months.¹⁸⁻²⁰ To clarify that LS is appropriate for the treatment of SBO, a randomized control study with a long-term follow-up period is needed. Despite these limitations, we believed that the present study showed the safety and feasibility of LS for the treatment of SBO without increases in the complication or recurrence rates.

CONCLUSION

The present study revealed that LS is associated with several perioperative advantages for the treatment of SBO. Moreover, LS did not increase the risk of postoperative complications or recurrence. Therefore, LS can be performed safely in patients with SBO.

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