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ORIGINAL ARTICLE

Comparative analysis of outcomes after multiport and single-port laparoscopic colectomy in emergency situations: Is single-port laparoscopic colectomy safe and feasible?

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KEYWORDS
colorectal disease;
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Summary *Background/Objective:* Although consensus has been reached on the superiority of laparoscopy for a majority of conditions underlying acute abdominal pain, the safety and feasibility of single-port laparoscopic colectomy (SPLC) in emergency situations have not been determined.
Methods: A prospective electronic database of all emergency patients who underwent either multiport laparoscopic colectomy (MPLC) or SPLC between April 2006 and December 2014 was used to compare the surgical outcomes of these operative methods.
Results: During the study period, 31 MPLCs and 76 SPLCs were performed. These two operative methods resulted in similar operating times, transfusion amounts, lengths of stay, postoperative complications, attainment of lymph nodes, and proximal and distal cut margins. However, the SPLC group had a shorter time to first flatus (2.8 ± 1.9 days vs. 3.8 ± 1.5 days, $p = 0.005$), earlier reinitiation of free oral fluids (3.2 ± 2.1 days vs. 4.4 ± 1.8 days, $p = 0.002$), and lesser requirement of narcotic analgesics (2.5 ± 3.9 times vs. 4.7 ± 4.8 times, $p = 0.017$).
Conclusion: SPLC could be a safe and effective alternative to MPLC, even in emergency situations when performed by surgeons who have overcome the learning curve associated with

Conflicts of interest: All authors declare that they have no financial conflicts of interests to disclose.

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single-port laparoscopic techniques. The tendency toward earlier returns to bowel function and decreased incidence of postoperative analgesic use would be potential benefits of SPLC in emergency situations.

1. Introduction

Over the past few decades, laparoscopic surgery has revolutionized the surgical management of patients. Besides cosmetic advantages, laparoscopic surgery allows a better environment for postoperative recovery, including minimal pain, a lesser chance of postoperative complications, shorter hospital stay, and quicker return to daily activities.[1–3] Moreover, several studies have reported that laparoscopic surgery provides better oncologic outcomes.[1,4–6] Available evidence also clearly demonstrates the superiority of laparoscopic surgery in various emergency situations.[4,7–9] The European Association for Endoscopic Surgery has recommended that laparoscopic surgery should first be considered for the majority of conditions underlying acute abdominal pain, owing to its diagnostic and therapeutic advantages.[8]

Recently, efforts to maximize the advantages of laparoscopic surgery have led to the introduction of single-port laparoscopic surgery (SPLS). Currently, although several studies are still underway on the advantages of SPLS, consensus has been reached regarding the cosmetic superiority and effect of SPLS in reducing wound morbidity.[10–14] Patients, including those requiring emergency surgery, also prefer favorable cosmesis and quality of life, as long as their safety is guaranteed. At present, it remains to be determined whether SPLS is safe and feasible even in emergency patients. Because of certain technical difficulties, SPLS has not been widely applied in emergency patients. However, recent advances in surgical techniques and increasing experience have helped overcome the limitations of SPLS to a certain degree. Therefore, in this study, we aimed to investigate the safety and feasibility of single-port laparoscopic colectomy (SPLC) by comparing the surgical outcomes of SPLC and multiport laparoscopic colectomy (MPLC) in emergency situations.

2. Methods

2.1. Study design and data collection

This study was an analysis of a prospective database of patients who underwent laparoscopic colectomy (MPLC or SPLC) between April 2006 and December 2014 at the Department of Surgery, Daejeon St. Mary's Hospital, Daejeon, Korea. The Ethics Committee of this institution approved this study (IRB code: DC13RISI0026).

In our study, emergency colectomy included both emergent and urgent colectomies. The procedure was considered emergent if a patient was scheduled for surgery immediately after evaluation by the staff surgeon, and the procedure was booked as an emergency mandating that the operating room staff have a team available as soon as possible.[15,16] The procedure was considered urgent if a patient was unable to be discharged because of their deteriorating condition and then underwent surgery. The diagnoses that require emergency or urgency colectomies included bowel obstruction, perforated viscus, fulminant colitis, ischemia, or uncontrollable gastrointestinal hemorrhage.[16] Of 437 laparoscopic colectomies during the study period, 113 were considered emergency colectomies. Of these, 107 patients were finally included as participants in this study, after excluding six patients who underwent combined operations (i.e., colectomy with cholecystectomy) under the same anesthesia.

In our institution, the first SPLS was performed in October 2008, and on the basis of accumulating experience, SPLS has been considered the first treatment in all patients requiring emergency colectomies since March 2009. Therefore, the inclusion criteria for emergency SPLC were identical to those for emergency MPLC. The exclusion criteria for SPLC included advanced local disease (tumor size $>$ 12 cm at preoperative evaluation), unresectable metastatic lesion, morbid obesity [body mass index (BMI) $>$ 35 kg/m^2], American Society of Anesthesiologists physical status classification score of IV or V, or severe medical illness such as a recent history of myocardial infarction.

Conversion was defined as completion of any part of a procedure using an open technique for reasons other than specimen delivery or construction of an intestinal anastomosis. Pathological margin lengths were measured in formalin-fixed specimens. Urinary retention was defined as the need for prolonged catheterization ($\geq$ 5 days) or as the reinsertion of a Foley catheter because of an inability to void. Intestinal obstruction was defined as the need for a nasogastric tube for 10 days or reinsertion of a nasogastric tube after starting oral diet.[17]

2.2. Operative procedure

Under general anesthesia, the patient was placed in the supine or modified lithotomy position, as necessary. An operating surgeon and a camera assistant stood on the right side of the patient, and the other assistant stood on the left side. In most patients, a 2- to 3-cm vertical incision was made on the umbilicus. At the beginning of the SPLC, we used a homemade single port composed of a wound retractor (Alexis wound retractor; Applied Medical, Rancho Santa Margarita, CA, USA), a surgical glove, two pipes (5-mm threaded cannulas and seals; Applied Medical), and a 10-mm trocar (Xcel; Ethicon Endosurgery, Cincinnati, OH, USA). Recently, we started using a commercially available ready-made single port (OCTO port; Dalim, Seoul, Korea).

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We have previously reported the details of the SPLC procedures.[10,18] Specifically, to avoid the "chopstick" or "swordfighting" effect caused by the parallel alignment of the instruments during SPLS,[19,20] we introduced the inverse triangulation method.[18,21] Inverse triangulation refers to the formation of an inverted triangle, as viewed by the operator (Figure 1); the three angles are formed by one incision point and two instrument ends. The two instrument ends do not meet, but assist each other by creating tension. The surgeon's right hand controls the left-sided instrument and vice versa. Using this inverse triangulation method, the surgeon could create tension in the direction that he wants.

2.3. Statistical analysis

Numerical data are presented as mean and standard deviation or as median and range. Differences in operating times and time period groups were analyzed using the independent t test and/or analysis of variance, after verifying their normal distribution. All p values were two-tailed, and p values < 0.05 were considered statistically significant. Statistical analyses were performed using SPSS version 15.0 (SPSS Inc., Chicago, IL, USA).

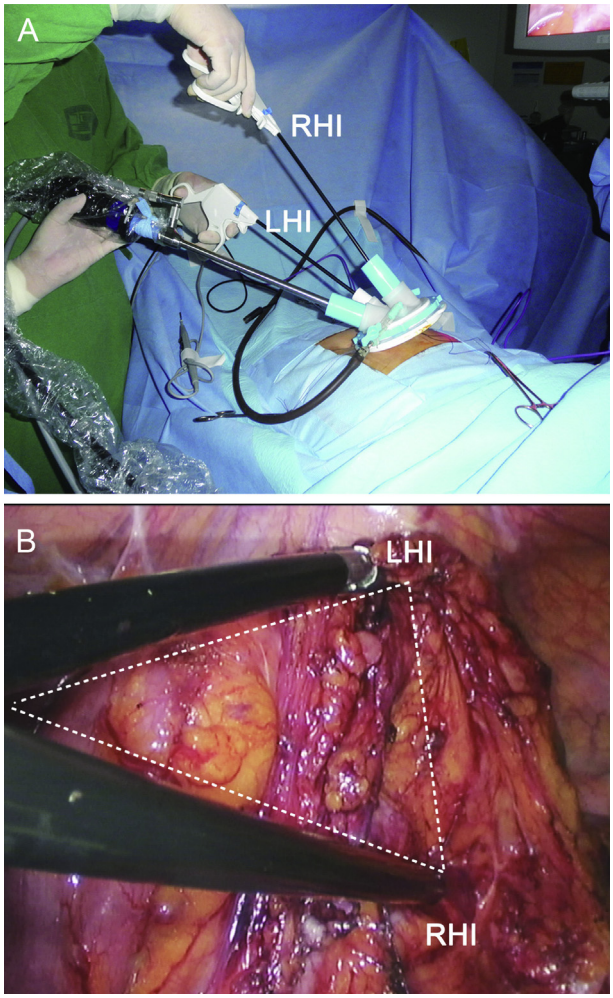

Figure 1 Inverse triangulation technique. A single-port setting is made using an OCTO port (Dalim, Seoul, Korea). The operating surgeon controls two laparoscopic instruments using a bimanual maneuver. (A) The surgeon's right hand controls the left-sided instrument and vice versa. (B) This results in the two instrument ends crossing over each other, with their counter placement producing tension. LHI = left-handed instrument; RHL = right-handed instrument.

3. Results

3.1. Patient characteristics

Of the 107 emergency laparoscopic colectomies, 31 (29.0%) were MPLCs and 69 (71.0%) were SPLCs. There were 46 men and 61 women, and the median patient age was 70 years (range, 21—94 years). The causes of emergency colorectal surgery were peritonitis (38.3%), colonic obstruction (29.9%), colonic perforation (24.3%), and bleeding (7.5%). Malignant lesions comprised 57.9% (62/107) of all lesions. We first compared the baseline characteristics of the two groups (Table 1). The two operative groups were comparable in baseline and preoperative characteristics, including age, sex, BMI, comorbidities, and causes of operation. The two groups also showed no significant difference in the history of prior laparotomy ($p = 0.099$). Figure 2 shows an example of a successful single-port colectomy in a patient with prior laparotomy.

Table 2 lists the locations of the lesions and the corresponding operations. In the MPLC group, the most common sites (in declining order) of the primary lesions were the ascending colon (64.5%), sigmoid colon (22.6%), and multiple locations (6.5%); by contrast, in the SPLC group, the most common sites were the sigmoid colon (47.3%), ascending colon (25.0%), and rectum (12.0%). Because the locations of the primary lesions were different, the most commonly performed operations were also different between the two groups; in the MPLC group, the most commonly performed operations were right hemicolectomy (41.9%), ileocecectomy (22.6%), and sigmoidectomy (9.7%) and in the SPLC group, they were Hartmann's procedure (35.5%), right hemicolectomy (25.0%), and sigmoidectomy (19.7%). Of the patients who underwent total colectomy, transanal transabdominal resection, and sigmoidectomy, three patients required temporal ileostomy, and all of them underwent SPLC using the predetermined colostomy site as a single access site.

3.2. Operative outcomes

Next, we compared the operative variables between the two groups. Operating times were similar for the MPLC and SPLC groups (220 ± 93 minutes vs. 234 ± 75 minutes, $p = 0.518$). We also divided the SPLC group into Period 1 (from 2009 to 2011; $n = 26$), Period 2 (from 2011 to 2012; $n = 25$), and Period 3 (from 2013 to 2014; $n = 25$), according to chronological order (Figure 3). Each period was similar in terms of age, sex, and BMI. We found that there were significant differences in the operating times between the periods (244 ± 65 minutes, 234 ± 72 minutes, and 214 ± 100 minutes, respectively; $p = 0.035$).

The SPLC and MPLC groups were similar in terms of estimated blood loss, units of packed red blood cells

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Table 1 Patient demographics and baseline characteristics in patients who underwent laparoscopic colectomies in emergency situations.

Patient characteristics	Total patients ($n = 107$)	MPLC ($n = 31$)	SPLC ($n = 76$)	p
Age (y)				0.676
Median (range)	70.0 (21–94)	71.0 (21–94)	65.0 (25–88)	
Mean ± SD	65.2 ± 15.9	65.7 ± 16.7	64.2 ± 14.4	
20–40	8 (7.5)	2 (6.5)	6 (7.9)	
40–60	25 (23.4)	7 (22.5)	18 (23.7)	
60–80	56 (52.3)	18 (58.1)	38 (50.0)	
≥80	18 (16.8)	4 (12.9)	14 (18.4)	
Sex				1.000
Male	46 (43.0)	13 (41.9)	33 (43.4)	
Female	61 (57.0)	18 (58.1)	43 (56.6)	
BMI, kg/m^2				0.293
Median (range)	22.3 (15.0–32.1)	22.6 (16.5–32.1)	22.1 (15.0–31.6)	
Mean ± SD	22.4 ± 3.4	22.9 ± 3.6	22.2 ± 3.3	
<20	26 (24.3)	6 (19.4)	20 (26.3)	
20–25	56 (52.3)	17 (54.8)	39 (51.3)	
≥25	25 (23.4)	8 (25.8)	17 (22.4)	
Comorbidity				0.390
CCI = 0	80 (74.8)	24 (77.4)	56 (73.7)	
CCI ≥ 1	27 (25.2)	7 (22.6)	20 (26.3)	
ASA fitness grade				0.623
I	21 (19.6)	8 (25.8)	13 (17.1)	
II	48 (44.9)	13 (41.9)	35 (46.1)	
III	35 (32.7)	8 (25.8)	27 (35.5)	
IV	3 (2.8)	2 (6.5)	1 (1.3)	
Previous abdominal surgery	30 (28.0)	5 (16.7)	25 (32.9)	0.099
Cause of operation				0.408
Peritonitis	41 (38.3)	16 (51.6)	23 (30.3)	
Colonic obstruction	32 (29.9)	9 (29.0)	22 (28.9)	
Colonic perforation	26 (24.3)	4 (12.9)	25 (32.9)	
Bleeding	8 (7.5)	2 (6.5)	6 (7.9)	
Malignant lesion				0.090
No	45 (42.1)	9 (29.0)	36 (47.4)	
Yes	62 (57.9)	22 (71.0)	40 (52.6)	

Data are presented as n (%), unless indicated otherwise.
ASA = American Society of Anesthesiologists; BMI = body mass index; CCI = Charlson comorbidity index; MPLC = multiport laparoscopic colectomy; SD = standard deviation; SPLC = single-port laparoscopic colectomy.

transfused, and incidence of intraoperative complications (Table 3). Two patients in the MPLC group experienced open conversion, and four patients in the SPLC group experienced addition of another port(s). The causes of open conversion were adhesion ($n = 1$) and bleeding tendency ($n = 1$) in the MPLC group, and the causes of adding another port(s) were adhesion ($n = 2$) and severe fecal contamination ($n = 2$) in the SPLC group. There were no significant differences in the overall incidences of open conversion or addition of another port(s) between the two groups. Figure 4 shows a representative illustration of SPLC in patients with intestinal obstruction.

3.3. Pathological outcomes

Malignant lesions were found in 71.0% (22/31) of patients in the MPLC group and in 52.6% (40/76) of patients in the SPLC group. We analyzed the pathologic features in those patients with malignancy (Table 4). The two groups were similar in terms of tumor differentiation, T stage (tumor depth), lymph node metastasis, and the largest tumor diameter. Moreover, there were no differences in the number of harvested lymph nodes and the attainment of proximal and distal cut margins. However, in the SPLC group there were more patients with advanced TNM stages ($p = 0.036$) and higher incidences of lymphovascular invasion ($p = 0.028$).

3.4. Postoperative outcomes

Table 5 shows the comparison of postoperative outcomes between the MPLC and SPLC groups. The SPLC group experienced faster gastrointestinal recovery, as indicated by a shorter time to first flatus ($p = 0.05$) and an earlier reinitiation of free oral fluids ($p = 0.02$). Moreover, the SPLC group required fewer instances of intravenous

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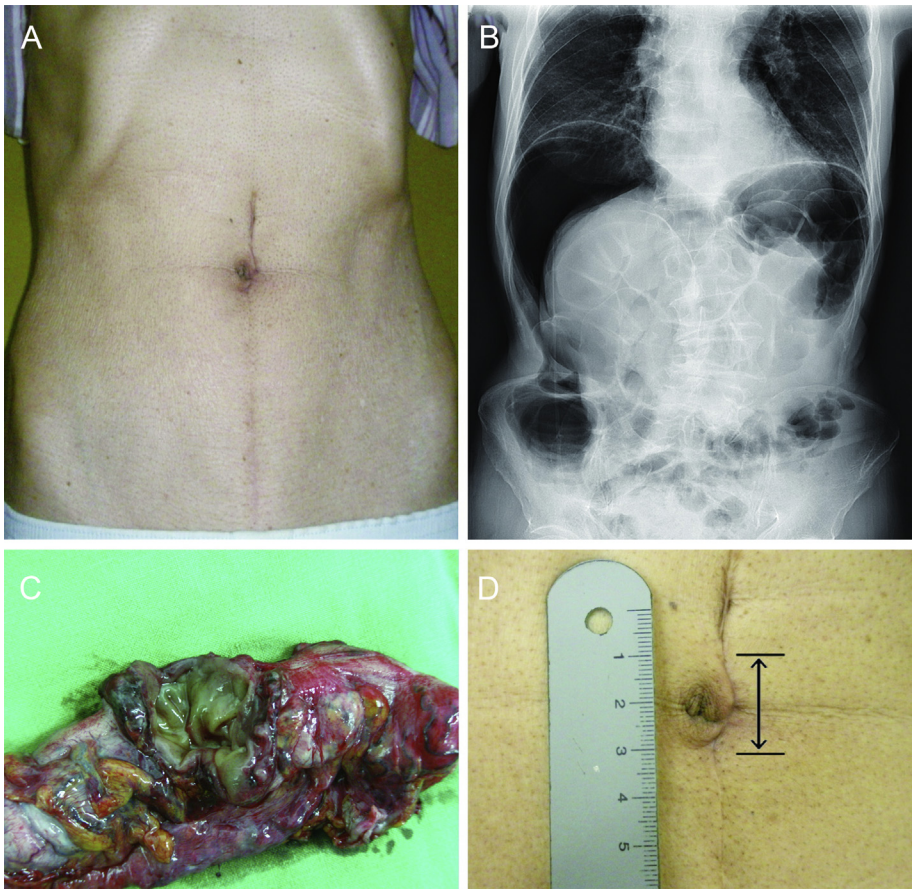

Figure 2 Single-port laparoscopic colectomy in patients with a history of prior laparotomy. (A) A 77-year-old man with a history of prior laparotomy was transferred to our department, (B) because of iatrogenic colonic perforation that occurred during colonofibroscopy. The patient underwent single-port sigmoidectomy. (C) A specimen of the sigmoid colon. (D) Postoperative wound.

Table 2 Lesion locations and corresponding operations in patients who underwent laparoscopic colectomies in emergency situations.

Lesion locations and operation titles	Total patients ($n = 107$)	MPLC ($n = 31$)	SPLC ($n = 76$)	p
Ileocecectomy	9 (8.5)	7 (22.6)	2 (2.7)	0.002
Right Hemicolectomy	33 (30.9)	13 (41.9)	20 (26.3)	0.165
Left Hemicolectomy	4 (3.7)	0 (0.0)	4 (5.3)	0.321
Sigmoidectomy (including anterior resection)	18 (16.8)	3 (9.7)	15 (19.7)	0.263
Low anterior resection	10 (9.3)	4 (12.9)	6 (7.9)	0.471
Abdominoperineal resection	1 (0.9)	0 (0.0)	1 (1.3)	1.000
Hartmann's procedure	28 (26.2)	1 (3.2)	27 (35.5)	< 0.001
TATAR	1 (0.9)	1 (3.2)	0 (0.0)	0.290
Total colectomy	3 (2.8)	2 (6.5)	1 (1.3)	0.201

Data are presented as n (%).
MPLC = multiport laparoscopic colectomy; SPLC = single-port laparoscopic colectomy; TATAR = transanal transabdominal resection.

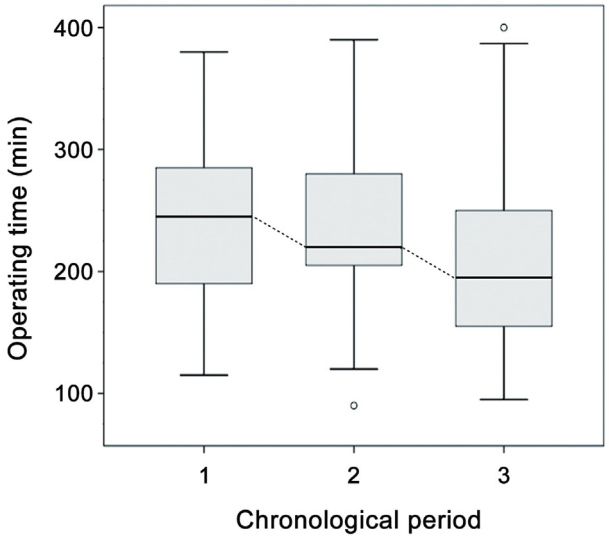

Figure 3 Operating times for the 76 consecutive emergency single-port laparoscopic colectomies (SPLCs) divided chronologically into three periods. The operating times by period were 244 ± 65 minutes, 234 ± 72 minutes, and 214 ± 100 minutes, respectively ($p = 0.035$).

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Table 3 Operative details in patients who underwent laparoscopic colectomies in emergency situations.

Operative variables	MPLC ($n = 31$)	SPLC ($n = 76$)	p
Overall operative time, min			0.518
Mean ± SD	220 ± 93	234 ± 75	
Median (range)	200 (45–440)	220 (105–500)	
Estimated blood loss, mL			0.275
Mean ± SD	479 ± 273	388 ± 428	
Median (range)	500 (50–1000)	300 (30–3000)	
PRC transfused patients	11 (35.3)	17 (22.4)	0.225
Kinds of Intraoperative complications	4 (12.9)	6 (7.9)	0.691
Major bleeding	2 (6.5)	2 (2.6)	
Injury to bowel	1 (3.2)	1 (1.3)	
Injury to other organ(s)	1 (3.2)	3 (3.9)	
Addition of another port	0 (0.0)	4 (5.3)	0.321
Open conversion	2 (6.5)	0 (0.0)	0.082
Reason of adding port(s) or changing to open surgery			
Adhesions	1 (3.2)	2 (2.6)	
Bleeding tendency	1 (3.2)	0 (0.0)	
Severe contamination by fecal materials	0 (0.0)	2 (2.6)	

Data are presented as *n* (%), unless indicated otherwise.
MPLC = multiport laparoscopic colectomy; PRC = packed red blood cells; SD = standard deviation; SPLC = single-port laparoscopic colectomy.

narcotic administration (2.5 ± 3.9 times vs. 4.7 ± 4.8 times, $p = 0.017$), although the total instances of analgesic administration did not reach statistical significance (3.8 ± 5.1 times vs. 5.7 ± 5.3 times, $p = 0.053$). There were no differences in the lengths of postoperative hospital stay, reoperation rates, and readmission rates between the two groups. The incidences of postoperative complications were also comparable (22.6% vs. 17.1%, $p = 0.587$). The most common complications were anastomosis site leakage ($n = 3$) and urinary retention ($n = 2$) in the MPLC group and intestinal obstruction ($n = 5$), urinary retention ($n = 4$), and anastomosis site leakage ($n = 3$) in the SPLC group.

There was one case of mortality (1.3%) following SPLC. The patient was a 74-year-old man who had been admitted for intestinal obstruction. We believe the cause of death might have been septic shock, judging from the acute exacerbation of clinical course and the vancomycin-resistant enterococci detected in the blood. In our study, five patients with stage IV colorectal cancer underwent SPLC. Their locations of primary lesions include ascending colon ($n = 1$), descending colon ($n = 1$), sigmoid colon ($n = 1$), and rectum ($n = 2$). Intestinal obstruction, which prevented patients from taking their meals, was the main reason for operation in all patients. Subsequently, they

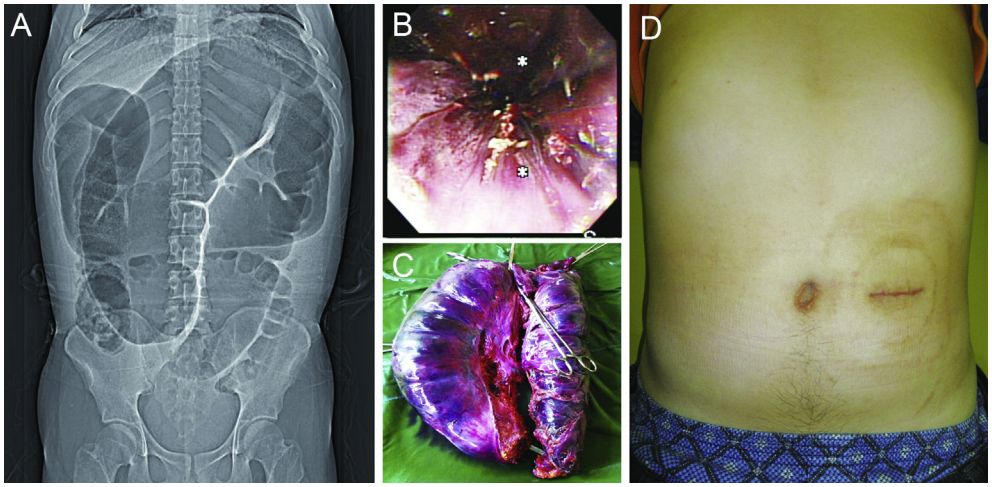

Figure 4 Single-port laparoscopic colectomy in patients with intestinal obstruction. A 21-year-old man visited the emergency department because of painful abdominal distension. (A) Plain abdominal radiography revealed the characteristic coffee bean shape of sigmoid volvulus. (B) Colonofibroscopy detected irreversible ischemia and necrosis of the colonic mucosa. The patient underwent single-port Hartmann's procedure through a predetermined stoma site. (C) A specimen of the gangrenous sigmoid colon. (D) Postoperative wound after colostomy repair.

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Table 4 Data related to tumor pathology in the cancer patients who underwent laparoscopic colectomies in emergency situations.

Pathologic characteristics	Cancer patients who underwent emergency MPLC ($n = 22$)	Cancer patients who underwent emergency SPLC ($n = 40$)	p
Histology type			0.081
Adenocarcinoma	22 (100.0)	34 (85.0)	
Other(s)	0 (0.0)	6 (15.0)	
Tumor differentiation			0.071
Well differentiated	2 (9.1)	0 (0.0)	
Moderately differentiated	19 (86.4)	35 (87.5)	
Poorly differentiated	1 (4.5)	5 (12.5)	
Tumor depth (T classification)			0.552
T1	1 (4.5)	1 (2.6)	
T2	3 (13.6)	3 (7.7)	
T3	17 (77.4)	34 (87.1)	
T4	1 (4.5)	1 (2.6)	
Lymph node metastasis			0.184
No	14 (63.6)	17 (42.5)	
Yes	8 (36.4)	23 (57.5)	
Tumor stage			0.036
I	3 (13.6)	3 (7.7)	
II	11 (50.0)	12 (30.8)	
III	8 (36.4)	19 (48.7)	
IV	0 (0.0)	5 (12.8)	
Largest tumor diameter (cm)			0.468
Median (range)	5.3 (2—13)	6.0 (1—13)	
Mean ± SD	5.8 ± 3.0	6.3 ± 2.6	
Lymph nodes in resected specimen			0.989
Median (range)	31.0 (4—60)	28.0 (1—85)	
Mean ± SD	30.4 ± 15.2	30.5 ± 19.7	
Proximal margin (cm)			0.236
Median (range)	11.3 (5.0—130.0)	13.0 (3.0—49.0)	
Mean ± SD	23.9 ± 29.5	16.0 ± 13.1	
Distal margin (cm)			0.303
Median (range)	11.0 (2—50)	15.5 (1—40)	
Mean ± SD	13.9 ± 11.4	17.6 ± 11.9	
Perineural invasion			0.769
No	17 (77.3)	29 (72.5)	
Yes	5 (22.7)	11 (27.5)	
Lymphovascular invasion			0.028
No	13 (59.1)	11 (27.5)	
Yes	9 (40.9)	29 (72.5)	

Data are presented as n (%), unless indicated otherwise.
MPLC = multiport laparoscopic colectomy; SD = standard deviation; SPLC = single-port laparoscopic colectomy.

underwent right hemicolectomy, left hemicolectomy, anterior resection, and Hartmann's procedure, respectively. All operations were successful, and their mean survival duration during follow-up period was 41 (14.0—54.0) months.

4. Discussion

Our results indicate that SPLC has similar surgical outcomes as MPLC in emergency situations, especially in terms of operating times and postoperative complications. Furthermore, SPLC required a lower dosage of postoperative analgesics and allowed faster postoperative recovery of gastrointestinal function. Therefore, it could be justified, or even preferred in specific situations, to implement the single-port approach in patients requiring emergency colectomies, when the surgeon is familiar with single-port laparoscopic techniques.

The value of this research lies in the fact that it showed the safety and feasibility of the single-port approach even in emergency patients. Currently, the role of SPLS in

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Table 5 Postoperative outcomes in patients who underwent laparoscopic colectomies in emergency situations.

Postoperative variables	MPLC ($n = 31$)	SPLC ($n = 76$)	p
Duration prior to first flatus (d)			0.005
Median (range)	4.0 (1–8)	2.0 (1–9)	
Mean ± SD	3.8 ± 1.5	2.8 ± 1.9	
Days prior free oral fluids			0.002
Median (range)	4.0 (1–10)	2.5 (1–8)	
Mean ± SD	4.4 ± 1.8	3.2 ± 2.1	
Duration prior solid diet (d)			0.214
Median (range)	6.0 (1–14)	4.0 (1–30)	
Mean ± SD	5.9 ± 2.6	4.9 ± 4.7	
Frequency of narcotic analgesics			0.017
Median (range)	3.5 (0–21)	1.0 (0–21)	
Mean ± SD	4.7 ± 4.8	2.5 ± 3.9	
Frequency of total analgesics			0.053
Median (range)	4.0 (0–21)	2.0 (0–21)	
Mean ± SD	5.7 ± 5.3	3.8 ± 5.1	
30-d mortality	0 (0.0)	1 (1.3)	1.000
Length of hospital stay (d)			0.366
Median (range)	14.0 (5–74)	9.0 (2–78)	
Mean ± SD	16.1 ± 12.9	13.5 ± 13.1	
Postoperative complications	7 (22.6)	13 (17.1)	0.587
Intestinal obstruction	1 (3.2)	5 (6.5)	
Anastomosis site leakage	3 (9.7)	3 (3.9)	
Urinary retention	2 (6.5)	4 (5.2)	
Pleural effusion	1 (3.2)	0 (0.0)	
Umbilical hernia	0 (0.0)	1 (1.3)	
Reoperation	3 (9.7)	3 (3.9)	0.374
Readmission	2 (6.5)	3 (3.9)	0.626

Data are presented as *n* (%), unless indicated otherwise.
MPLC = multiport laparoscopic colectomy; SD = standard deviation; SPLC = single-port laparoscopic colectomy.

emergency patients has not been determined yet. Concerning laparoscopic surgery, though, a number of studies have demonstrated its favorable role in emergency patients, including reduced postoperative pain, shorter hospital stays, and finally increased patient satisfaction while maintaining similar mortality and morbidity rates as open surgery.[15,22–24] The European Association for Endoscopic Surgery thus provided evidence-based guidelines, which include the statement that laparoscopic surgery is useful for the majority of conditions underlying acute abdominal pain.[8] SPLS has been spotlighted as a new alternative to conventional laparoscopy. However, the major drawback of SPLS is its attendant technical difficulties, which prevent its wide use in emergency patients.[25] Over time, SPLS experience has been accumulated, and several tools and techniques to facilitate the SPLS have been developed.[10,18,19,26] Recently, there has been an increasing number of reports on the SPLS experience in emergency patients.[25,27,28] Our study is noteworthy, because it is, as far as we know, the first study to compare MPLC and SPLC in emergency patients.

Intestinal obstruction was one of the most challenging situations in emergency SPLC. In intestinal obstruction, the presence of a distended bowel loop renders the operative procedure both difficult and extremely inconvenient. Therefore, we preoperatively decompressed the distended bowel loop by transanal rectal tube use, anal trocar insertion, or endo-needle puncture aspiration. These methods make the operative environment more favorable for the single-port approach.

In our study, the presence of a previous laparotomy did not significantly interfere with emergency SPLC. Notably, our emergency SPLC group included approximately one-third (25/76) of the patients with a history of prior laparotomy. In our series, successful adhesiolysis was usually achieved by careful and meticulous dissection, beginning from the umbilicus, even in patients with periumbilical adhesions. The superiority of adhesiolysis using the single-port approach has been reported in several reports.[25,27,29] Multiport insertion can increase the potential risk of intestinal injury, especially in patients with adhesions. By contrast, the single-port approach only requires the secure insertion of a single port; thereafter, dissection can be safely expanded from the single-port site to the adherent tissue.

In our study, the operating time for SPLC was comparable to that for MPLC. There are several explanations for this. Because the SPLC procedures were followed by the MPLC procedures, the SPLC technique could be advanced with accumulating laparoscopic experience. Next, the locations of the primary lesions were different between the two groups. Most (64.5%) of the lesions in the MPLC group

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were located in the right colon, whereas most (47.3%) of those in the SPLC group were located in the sigmoid colon. Moreover, Hartmann's procedure was performed approximately 10 times more frequently in the SPLC group than in the MPLC group (35.5% vs. 3.2%, $p < 0.01$), rendering the direct comparison of operating times difficult. Despite the aforementioned limitations, the comparable operating times of the two procedures are very encouraging and suggest that the SPLS technique can be easily reproduced even in emergency situations by surgeons who are familiar with SPLS.

Unintentionally, Hartmann's procedure was more commonly performed in the SPLC group. The predetermined colostomy site was used as a single access site in all patients who had planned to undergo single-port Hartmann's procedure. Therefore, prior to the start of the surgery, it was determined whether primary anastomosis or Hartmann's procedure should be performed. We think that the higher incidence of Hartmann's procedure in the SPLC group might be partly associated with the advanced tumor histology in this group. In addition, it might be related to the operative feasibility of single-port Hartmann's procedure.[25,29] Single-port Hartmann's procedure is achieved through a 4- to 5-cm transverse incision in the left lower quadrant of the abdomen. This incision is larger than the transumbilical incisions made in most SPLC procedures, which provides a more comfortable operating environment. During the follow-up period, we performed 22 reversal operations (22/27, 81.5%) of the Hartmann's procedure through the stoma site[29] and planned to perform the reversal operations in other patients. Therefore, SPLC is believed to be a good option for staged operations.

This study has several limitations. Our study was a retrospective review of a relatively small number of patients, and therefore, our results should be confirmed by prospective trials with larger patient populations. Because selection bias cannot be completely avoided in all retrospective studies, we attempted to minimize the selection bias by assigning all the MPLC practices prior to the SPLC practices. Accordingly, the MPLC and subsequent SPLC groups were comparable in major demographic and preoperative characteristics in our study. Moreover, the MPLC approach has been largely abandoned at our institution since the adoption of SPLC, effectively eliminating any selection bias. In fact, the SPLC group contained a significantly greater proportion of patients with advanced cancer stage ($p = 0.036$) and cancer patients with higher incidences of lymphovascular invasion ($p = 0.028$), suggesting a reverse selection bias in favor of more advanced pathology. However, the surgical outcomes of the SPLC group were comparable, and even superior in certain variables, to the MPLC group in emergency situations. Therefore, we believe that our results could be a manifestation of the operative feasibility of SPLC in emergency situations.

SPLC showed similar surgical outcomes to MPLC in emergency situations, with regard to operating time, incidence of complications, requirement of total analgesics, and length of postoperative hospital stay. Among emergency patients with colorectal cancer, SPLC showed similar outcomes as MPLC, with respect to attainment of lymph nodes and surgical margins. Moreover, SPLC accelerated the recovery of postoperative gastrointestinal function. Therefore, we believe that SPLC is feasible and safe in emergency situations, when performed by surgeons who have overcome the learning curve associated with single-port laparoscopic techniques.

References

1. Braga M, Frasson M, Vignali A, Zuliani W, Civelli V, Di Carlo V. Laparoscopic vs. open colectomy in cancer patients: long-term complications, quality of life, and survival. *Dis Colon Rectum*. 2005;48:2217–2223.
2. Clinical Outcomes of Surgical Therapy Study Group. A comparison of laparoscopically assisted and open colectomy for colon cancer. *New Engl J Med*. 2004;350:2050–2059.
3. Fleshman J, Sargent DJ, Green E, et al. Laparoscopic colectomy for cancer is not inferior to open surgery based on 5-year data from the COST Study Group trial. *Ann Surg*. 2007;246:655–662. discussion 662–654.
4. Aly EH. Laparoscopic colorectal surgery: summary of the current evidence. *Ann R Coll Surg England*. 2009;91:541–544.
5. Kuhry E, Schwenk WF, Gaupset R, Romild U, Bonjer HJ. Long-term results of laparoscopic colorectal cancer resection. *Cochrane Database Syst Reviews*. 2008:CD003432.
6. Lacy AM, Delgado S, Castells A, et al. The long-term results of a randomized clinical trial of laparoscopy-assisted versus open surgery for colon cancer. *Ann Surg*. 2008;248:1–7.
7. Catani M, De Milito R, Romagnoli F, Romeo V, Modini C. Laparoscopic colorectal surgery in urgent and emergent settings. *Surg Laparosc Endosc Percutan Tech*. 2011;21:340–343.
8. Sauerland S, Agresta F, Bergamaschi R, et al. Laparoscopy for abdominal emergencies: evidence-based guidelines of the European Association for Endoscopic Surgery. *Surg Endosc*. 2006;20:14–29.
9. Zerey M, Hawver LM, Awad Z, et al. SAGES evidence-based guidelines for the laparoscopic resection of curable colon and rectal cancer. *Surg Endosc*. 2013;27:1–10.
10. Kim SJ, Ryu GO, Choi BJ, et al. The short-term outcomes of conventional and single-port laparoscopic surgery for colorectal cancer. *Ann Surg*. 2011;254:933–940.
11. Tsimoyiannis EC, Tsimogiannis KE, Pappas-Gogos G, et al. Different pain scores in single transumbilical incision laparoscopic cholecystectomy versus classic laparoscopic cholecystectomy: a randomized controlled trial. *Surg Endosc*. 2010;24:1842–1848.
12. Tugcu V, Ilbey YO, Mutlu B, Tasci AI. Laparoendoscopic single-site surgery versus standard laparoscopic simple nephrectomy: a prospective randomized study. *J Endourol/Endourol Soc*. 2010;24:1315–1320.
13. Weiss HG, Brunner W, Biebl MO, et al. Wound complications in 1145 consecutive transumbilical single-incision laparoscopic procedures. *Ann Surg*. 2014;259:89–95.
14. Yim GW, Jung YW, Paek J, et al. Transumbilical single-port access versus conventional total laparoscopic hysterectomy: surgical outcomes. *Am J Obstet Gynecol*. 2010;203, 26 e21–26.
15. Champagne B, Stulberg JJ, Fan Z, Delaney CP. The feasibility of laparoscopic colectomy in urgent and emergent settings. *Surg Endosc*. 2009;23:1791–1796.
16. Stulberg JJ, Champagne BJ, Fan Z, et al. Emergency laparoscopic colectomy: does it measure up to open? *Am J Surg*. 2009;197:296–301.
17. Kronberg U, Kiran RP, Soliman MS, et al. A characterization of factors determining postoperative ileus after laparoscopic colectomy enables the generation of a novel predictive score. *Ann Surg*. 2011;253:78–81.

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18. Kim SJ, Choi BJ, Lee SC. Successful total shift from multiport to single-port laparoscopic surgery in low anterior resection of colorectal cancer. *Surg Endosc*. 2014;28:2920—2930.
19. Froghi F, Sodergren MH, Darzi A, Paraskeva P. Single-incision Laparoscopic Surgery (SILS) in general surgery: a review of current practice. *Surg Laparosc Endosc Percutan Tech*. 2010; 20:191—204.
20. Piskun G, Rajpal S. Transumbilical laparoscopic cholecystectomy utilizes no incisions outside the umbilicus. *J Laparoendosc Adv Surg Tech A*. 1999;9:361—364.
21. Kim SJ, Choi BJ, Lee SC. Overview of single-port laparoscopic surgery for colorectal cancers: past, present, and the future. *World J Gastroenterol*. 2014;20:997—1004.
22. Agrusa A, Romano G, Di Buono G, Dafnomili A, Gulotta G. Laparoscopic approach in abdominal emergencies: a 5-year experience at a single center. *G Chir*. 2012;33:400—403.
23. Ballian N, Weisensel N, Rajamanickam V, et al. Comparable postoperative morbidity and mortality after laparoscopic and open emergent restorative colectomy: outcomes from the ACS NSQIP. *World J Surg*. 2012;36:2488—2496.
24. Marohn MR, Hanly EJ, McKenna KJ, Varin CR. Laparoscopic total abdominal colectomy in the acute setting. *J Gastrointest Surg*. 2005;9:881—886. discussion 887.
25. Hiro J, Inoue Y, Okugawa Y, et al. Single-port laparoscopic management of adhesive small bowel obstruction. *Surg Today*. 2014;44:586—590.
26. MacDonald ER, Brownlee E, Ahmed I. New tools for a new job—single-port laparoscopic surgery equipment. *Med Equip Insights*. 2009;2:1—7.
27. Moftah M, Sehgal R, Cahill RA. Single port laparoscopic colorectal surgery in debilitated patients and in the urgent setting. *Minerva Gastroenterol Dietol*. 2012;58:213—225.
28. Okamoto H, Wakana H, Kawashima K, Fukasawa T, Fujii H. Single-port laparoscopic adhesiolysis for torsion ileus. *Surg Laparosc Endosc Percutan Tech*. 2012;22:e217—e219.
29. Choi BJ, Jeong WJ, Kim YK, Kim SJ, Lee SC. Single-port laparoscopic reversal of Hartmann's procedure via the colostomy site. *Int J Surg*. 2015;14:33—37.

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