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Oncologic Outcomes of Self-Expandable Metallic Stent as a Bridge to Surgery and Safety and Feasibility of Minimally Invasive Surgery for Acute Malignant Colonic Obstruction

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ABSTRACT

Background. Although self-expandable metal stents (SEMS) are widely used as a bridge to surgery (BTS) in patients with malignant colorectal cancer obstruction, there has been some debate about their effect on long-term oncological outcomes. Furthermore, data on the safety and feasibility of minimally invasive surgery (MIS) combined with stent placement are scarce. We aimed to determine the long-term oncological outcomes of SEMS as a BTS, and the short-term outcomes of SEMS used with minimally invasive colorectal surgery.

Methods. Data from patients who were admitted with malignant obstructing colon cancer between January 2006 and December 2015 were retrospectively reviewed; 71 patients underwent direct surgery and 182 patients underwent SEMS placement as a BTS. Long-term and short-term outcomes of the groups were compared. In a subgroup analysis of the BTS group, the short-term outcomes of conventional open surgery and MIS were compared.

Results. There were no differences in long-term oncologic outcomes between groups. The primary anastomosis rate was higher in the stent group than in the direct surgery group. In the stent group, postoperative complication rates were lower in the minimally invasive group than in the open surgery group. Time to flatus and time to soft diet resumption were shorter in the minimally invasive group, as was length of hospital stay.

Conclusions. Elective surgery after stent insertion does not adversely affect long-term oncologic outcomes. Furthermore, MIS combined with stent insertion for malignant colonic obstruction is safe and feasible.

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Malignant colonic obstruction (MCO) is a surgical and medical emergency occurring in approximately 10–22% of colon cancer patients with acute obstructive symptoms.[1,2] Although immediate surgery is effective for decompression, rates of mortality and morbidity are higher in emergency surgery (ES) than in elective surgery.[3] As an alternative to ES for MCO, placement of a self-expandable metallic stent (SEMS) was proposed for patients requiring emergent decompression.[4,5] SEMS has been widely used for definitive palliative treatment in incurable or inoperable patients with disseminated disease or as a bridge to surgery (BTS) for those with potentially resectable disease.[6] Successful SEMS placement enables a thorough oncologic workup of patients, facilitating enhancement of their general condition and primary anastomosis without stoma creation.[7] However, despite the advantages of SEMS placement, there is the possibility of silent perforation causing dissemination of tumor cells in the peripheral circulation or peritoneal dissemination, thereby worsening oncologic outcomes.[8] Consequently, its effect on clinical outcomes, especially long-term oncologic safety, remains controversial.[9–11]

After the introduction of laparoscopic colon resection in 1991,[12] its advantages over conventional open surgery have been well-established in terms of short-term outcomes.[13–15] Despite the preference for minimally invasive surgery (MIS), it is considered to be more difficult and less successful for MCO, owing to constrained surgical field

visibility caused by the distended bowel and the potential hazard of injury to fragile bowels. However, a subsequent planned MIS may be performed if the tumor is thoroughly evaluated and bowel preparation is possible after SEMS insertion. Despite the potential benefits of the combination of these two minimally invasive techniques, few studies have reported on their safety and feasibility.

This study aimed to determine the oncological safety of SEMS as a bridge to MIS compared with ES in patients with MCO and to evaluate the safety and feasibility of MIS after SEMS placement.

MATERIALS AND METHODS

Patients

This was a single-institution, retrospective review of prospectively maintained medical data of patients with acute MCO from January 2006 to December 2015. The study period was selected to include patients with colon cancer who underwent MIS and to enable a survival analysis with a follow-up period of at least 2 years. We included patients with potentially curable histologically proven colon adenocarcinoma who underwent surgical resection on an intention-to-treat basis. Patients were excluded if they had overt perforation, stage IV cancer, or rectal cancer. Finally, 253 patients were enrolled in this study.

Definitions

Colonic obstruction was defined as the presence of symptoms of obstruction, such as abdominal distension, pain, and failure to pass gas or feces, with radiological evidence by plain abdominal x-rays or abdominal computed tomography (CT), or failure of the endoscope to pass through the cancer. The right colon was defined as the colon from the cecum to the splenic flexure, and the left colon was defined as the colon from the descending colon to the rectosigmoid junction. Technical success was defined as successful deployment of the SEMS through the obstructive lesion, with radiological confirmation of a well-expanded stent and visible stool passage. Clinical success was defined as significant colonic decompression on abdominal radiography or CT and relief of obstructive symptoms without SEMS-related complications.

Treatment

Endoscopic SEMS placement was performed by experienced endoscopists under fluoroscopic guidance.[16] After identifying the obstructive lesion with flexible colonoscopy, a guidewire was passed through the narrowed lumen of the obstructed colon. A metallic stent was inserted through the working channel of the endoscope over the guidewire. Based on the length of the stenosis, allowing for at least 2 cm of extra space on each side of the obstruction, a Wallflex uncovered stent (25 mm in diameter; Boston Scientific, Marlborough, MA, USA), Niti-S uncovered D-type stent (24 mm; Taewoong Medical, Seoul, Korea), Hanaro covered stent (20 mm; MI Tech, Seoul, Korea) was used, at the discretion of the endoscopist. After accurate localization of the lesion, the stent was placed using the delivery system. Abdominal radiography was performed on the day of and the day after stenting to assess stent patency, expansion, and possible complications. In the event of technical or clinical failure after stenting, the patient underwent ES. Type of surgery, extent of resection, and primary anastomosis were determined by the surgeon according to preoperative findings, patient condition, and SEMS availability. No strict treatment guidelines exist for MCO. Stent placement was attempted before ES in patients without signs of perforation or strangulation.

Study Outcomes

Primary outcomes of this study were long-term oncologic outcomes, including the disease-free survival (DFS) and overall survival (OS) of the ES and BTS groups.

Secondary outcomes were short-term clinical outcomes, not only of the ES and BTS groups but also of the conventional open surgery and bridge to MIS groups, including morbidity and mortality, temporary stoma creation rate at discharge, definitive stoma rate at 1 year after diagnosis, time to flatus, time to soft diet resumption, and hospitalization period.

Statistical Analysis

Categorical data were evaluated using either the Chi square or Fisher exact tests, whereas numerical data were evaluated using the Student's t test or Mann–Whitney U test. Numerical variables were dichotomized according to clinical importance or the median value of each variable for cut-off. DFS and OS were analyzed using Kaplan–Meier estimate curves, and differences were examined using log-rank tests. Cox proportional hazards analysis was used to evaluate the risk factors for DFS and OS, adjusting for various confounders. All p values were two-sided, and $p < 0.05$ was considered statistically significant. All statistical analyses were performed using SPSS version 23.0 (IBM Corporation, Armonk, NY, USA).

RESULTS

Baseline Patient Characteristics

Among 253 patients with acute MCO, 71 patients underwent ES and 182 underwent SEMS as a BTS (Table 1). ES was performed more frequently in patients with right-sided colon cancer (40.8 vs. 24.2%, $p = 0.009$). In the BTS group, 57.6% of patients underwent MIS (54.9% laparoscopic, 2.7% robotic), whereas 76.1% underwent open surgery in the ES group ($p < 0.001$). Open conversion laparoscopic surgery was required in three patients in the BTS group as a result of severe adhesions from a previous abdominal operation in two patients and limited surgical field visibility due to a distended bowel in one patient. In the ES group, conversion to open was required in two patients as a result of limited surgical field visibility due to a distended bowel.

Stent-Related Outcomes

The technical success rate of SEMS placement was 93.9% (171/182). Stents could not be deployed in 11 patients, with inability to pass the guidewire in seven patients and colonic perforation during stent insertion in four patients. All 11 patients with unsuccessful SEMS placement underwent emergency operations, and the outcomes of seven patients in whom a stent was not deployed and four patients with colonic perforation were classified into the BTS group. The clinical success rate was 92.9% (159/171), with five patients showing no stent effects despite successful stent insertion. Among seven stent-related complications, three involved migration and four involved perforation that was identified in the resected specimen after elective surgery. The mean time interval from stent placement to elective surgery was 10.8 days.

Surgical Outcomes

There was a significant difference in the primary anastomosis rate between groups (77.5 vs. 91.2%, $p = 0.004$), and significantly fewer permanent stomas were created in the BTS group (18.3 vs. 2.7%, $p = 0.049$). Time to first flatus and soft diet resumption after operation was faster in the BTS group and led to a shorter postoperative hospital stay compared with that in the ES group (12 vs. 9 days, $p < 0.001$). There was no difference in postoperative mortality, overall complications, or major complications, classified using the Clavien–Dindo method, between groups. Adjuvant chemotherapy was administered to 142 patients (78.0%) in the BTS group and 53 patients (74.6%) in the ES group, with no significant difference according to stage.

Oncologic Outcomes

Patients were followed-up for a median duration of 53.4 and 60.4 months in the ES and BTS groups, respectively. Kaplan–Meier survival analyses showed no significant difference in 5-year DFS (51.6 vs. 63.3%, $p = 0.108$) and 5-year OS (70.3 vs. 81.7%, $p = 0.141$) between the two groups (Fig. 1). Cox proportional hazard analysis revealed that using SEMS as a BTS was not a risk factor for poor DFS or OS in both univariate and multivariate analyses (Table 2).

There was no significant difference in overall tumor recurrence between the ES and BTS groups during the follow-up period (31.0 vs. 26.4%, $p = 0.532$). After surgery, the majority of recurrences were systemic without significant differences between the groups (Table 3). Four patients had perforation from failed SEMS placement, and four patients had confirmed incidental perforation at elective surgery. Among these eight patients with stent-related perforation, one patient (25%) with stage III cancer and perforation from failed SEMS placement had a systemic recurrence presenting as peritoneal carcinomatosis 11 months after ES, despite having received adjuvant chemotherapy.

Baseline Characteristics of Patients with Self-Expandable Metal Stent (SEMS) Insertion

Demographics and baseline characteristics of patients who underwent SEMS placement as a BTS are summarized in Table 4. Median time to surgery after SEMS placement was 8 days for open surgery and MIS. There was no significant difference in demographic and pathologic characteristics, including tumor stage, tumor differentiation grade, and total number of retrieved lymph nodes; however, tumor size was larger in the open surgery group (7.0 vs. 6.0 cm, $p = 0.004$).

Surgical Outcomes Between Open Surgery and Minimally Invasive Surgery After SEMS Insertion

There was no significant intergroup difference in intraoperative blood loss or operation time (Table 4). The rates of primary anastomosis, stoma creation, and permanent stoma were not different between groups.

The overall complication rate was higher in the open surgery group (44.2 vs. 18.1%, $p < 0.001$); however, major complication and mortality rates were not different between groups. Postoperatively, the two groups had significantly different times to first flatus (4 vs. 3 days, $p < 0.001$) and times to soft diet resumption (6.0 vs. 4.0 days, $p < 0.001$), with a shorter hospital stay in the MIS group (13 vs. 8 days, $p < 0.001$).

TABLE 1 Baseline clinicopathologic characteristics and surgical outcomes of patients with acute malignant colonic obstruction

Characteristics	ES (n = 71)	BTS (n = 182)	p Value
Patient demographics			
Age, years (mean ± SD)	63.9 ± 14.9	65.2 ± 12.4	0.478
Sex			> 0.99
Male	42 (59.2)	107 (58.8)	
Female	29 (40.8)	75 (41.2)	
ASA			0.116
I–II	57 (80.3)	127 (69.8)	
III–IV	14 (19.7)	55 (30.2)	
BMI, kg/m^2 (mean ± SD)	22.3 ± 3.4	22.7 ± 7.9	0.716
Previous abdominal operation	8 (11.3)	3 (18.1)	0.193
PreCEA, ng/mL (IQR)	2.85 (1.65–9.97)	3.43 (1.79–7.58)	0.272
Tumor location			0.009
Right	29 (40.8)	44 (24.2)	
Left	42 (59.2)	138 (75.8)	
Operation method			< 0.001
Open	54 (76.1)	77 (42.3)	
Laparoscopic	17 (23.9)	100 (54.9)	
Robotic	0 (0.0)	5 (2.7)	
Conversion to open	2/17 (11.8)	3/105 (2.9)	0.142
Operation time, min (IQR)	225.0 (182.0–284.0)	223.5 (172.0–272.0)	0.357
Blood loss, mL (IQR)	100 (10–300)	50 (0–200)	0.029
Pathologic results			
TNM stage			0.576
I	0 (0.0)	0 (0.0)	
II	37 (51.1)	86 (47.3)	
III	34 (47.9)	96 (52.7)	
T classification			0.145
pT1, T2	0 (0.0)	0 (0.0)	
pT3	49 (69.0)	142 (78.0)	
pT4	22 (31.0)	40 (22.0)	
N classification			0.689
pN0	37 (52.1)	86 (47.3)	
pN1	20 (28.2)	61 (33.5)	
pN2	14 (19.7)	35 (19.2)	
Tumor differentiation grade			0.482
WD/MD	62 (87.32)	166 (91.2)	
PD/MCN/SRC	9 (12.7)	16 (8.8)	
LN retrieval < 12	4 (5.6)	5 (2.7)	0.452
Resection margin involvement	0 (0.0)	0 (0.0)	< 0.999
Lymphovascular invasion	17 (23.9)	64 (35.2)	0.1
Tumor size, cm (IQR)	5.9 (5.0–7.0)	6.5 (5.5–7.0)	0.004
Postoperative outcomes			
Primary anastomosis without stoma	55 (77.5)	166 (91.2)	0.004
Permanent stoma	13 (18.3)	5 (2.7)	< 0.001
Postoperative complications	28 (39.4)	53 (29.1)	0.134
Wound infection	7 (25.0)	10 (18.9)	0.572
Wound dehiscence	0 (0.0)	2 (3.8)	0.542
Postoperative bleeding	2 (7.1)	0 (0.0)	0.117
Urinary complication	1 (3.6)	5 (9.4)	0.422
Intra-abdominal fluid collection	3 (10.7)	11 (20.8)	0.359

TABLE 1 continued

Characteristics	ES (n = 71)	BTS (n = 182)	p Value
Ileus/obstruction	8 (28.6)	18 (34.0)	0.803
Anastomotic leakage	4 (14.3)	5 (9.4)	0.712
Postoperative pneumonia	1 (3.6)	2 (3.8)	> 0.999
Others	2 (7.1)	0 (0.0)	0.117
Major complication (G ≥ 3)	11 (15.5)	20 (11.0)	0.393
Postoperative mortality	0 (0.0)	1 (0.5)	> 0.999
Time to first flatus, days (IQR)	4 (4–5)	3 (3–4)	< 0.001
Time to soft diet, days (IQR)	6 (6–7)	5.0 (4–6)	< 0.001
LOS, days (IQR)	12 (9–16)	9 (7–14)	< 0.001
Adjuvant chemotherapy	53 (74.6)	142 (78.0)	0.618
Stage II	23/37 (62.2)	54/86 (62.8)	> 0.999
Stage III	30/34 (88.2)	88/96 (91.7)	0.731
Time to chemotherapy, days (IQR)[a]	30 (21–36)	30 (23–38)	0.264
Stage II	26 (14–42)	31.5 (24–40)	0.047
Stage III	31.0 (27.0–35.0)	29.5 (22.0–36.5)	0.266

Data are expressed as n (%) unless otherwise specified

ES emergency surgery, *BTS* bridge to surgery, *SD* standard deviation, *ASA* American Society of Anesthesiologists physical status score, *BMI* body mass index, *IQR* interquartile range, *PreCEA* preoperative carcinoembryonic antigen, *TNM* American Joint Committee on Cancer pathologic staging 8th edition, *LN* lymph node, *LOS* length of hospital stay after operation, *WD* well-differentiated, *MD* moderately differentiated, *PD* poorly differentiated, *MCN* mucinous, *SRC* signet ring cell

[a]Time to chemotherapy after operation

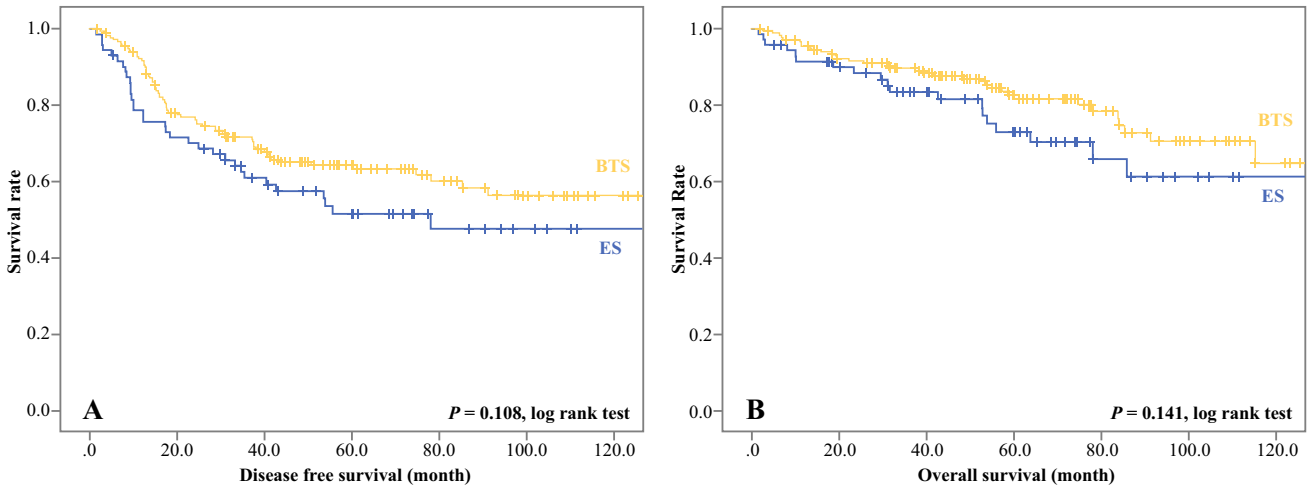

FIG. 1 Kaplan–Meier curves of 5-year (**a**) disease-free survival and (**b**) overall survival between the emergency surgery and bridge-to-surgery groups

DISCUSSION

In our study, the BTS group showed more favorable oncologic outcomes than the ES group in terms of DFS and OS. Additionally, SEMS insertion was not a prognostic factor for either DFS or OS on multivariate Cox regression analysis after adjusting for confounding factors. Previous results on the effects of SEMS on oncologic outcomes are inconsistent, and the randomized trials had small sample sizes and comparatively shorter follow-up periods.[9,17–20] Such inconsistent results may have resulted from the heterogeneity of patients with large-bowel obstruction and differences in SEMS insertion experience among endoscopists.[11,21] In one retrospective study, the most important

TABLE 2 Univariate and multivariate analyses of factors for disease progression and survival

	Disease-free survival				Overall survival			
	Univariate analyses		Multivariate analyses		Univariate analyses		Multivariate analyses	
	HR (95% CI)	*p* Value	HR (95% CI)	*p* Value	HR (95% CI)	*p* Value	HR (95% CI)	*p* Value
Age, years (< 65 vs. ≥ 65)	1.789 (1.177–2.718)	0.006	1.027 (1.010–1.046)	0.002	2.919 (1.561–5.458)	0.001	2.537 (1.341–4.799)	0.004
Sex (male vs. female)	0.876 (0.584–1.313)	0.521			0.899 (0.520–1.555)	0.704		
Tumor location (right vs. left)	0.720 (0.474–1.094)	0.123			0.625 (0.356–1097)	0.101		
BMI, kg/m^2 (< 25 vs. ≥ 25)	1.233 (0.711–2.135)	0.456			1.263 (0.595–2.679)	0.543		
ASA (< III vs. ≥ III)	1.788 (1.180–2.710)	0.006	1.629 (1.068–2.486)	0.024	2.543 (1.480–4.370)	0.001	2.120 (1.221–3.679)	0.008
PreCEA, ng/mL (< 5 vs. ≥ 5)	1.353 (0.908–2.016)	0.138			1.395 (0.815–2.388)	0.225		
Tumor grade (WD/MD vs. PD/MCN/SRC)	1.721 (0.960–3.086)	0.068			1.937 (0.911–4.115)	0.086		
LN retrieval (≥ 12 vs. < 12)	1.119 (0.411–3.044)	0.826			0.941 (0.229–3.865)	0.932		
pT (T3 vs. T4)	2.320 (1.537–3.503)	< 0.001	2.423 (1.591–3.689)	< 0.001	1.860 (1.054–3.281)	0.032		
pN (N0 vs. N1-2)	1.622 (1.083–2.428)	0.019	1.559 (1.038–2.344)	0.033	1.584 (0.916–2.741)	0.100		
LVI (no vs. yes)	1.696 (1.135–2.536)	0.010			1.650 (0.958–2.841)	0.071		
Adjuvant CTx (no vs. yes)	0.709 (0.452–1.110)	0.133			0.626 (0.339–1.156)	0.134		
Time to CTx (< 30 vs. ≥ 30 days)	1.227 (0.775–1.942)	0.383			1.035 (0.554–1.934)	0.914		
Operation method (open vs. MIS)	0.753 (0.503–1.127)	0.168	0.671 (0.447–1.007)	0.054	0.659 (0.377–1.152)	0.144	0.815 (0.454–1.464)	0.493
Type of surgery (ES vs. BTS)	0.711 (0.468–1.080)	0.711	0.733 (0.468–1.148)	0.175	0.827 (0.475–1.438)	0.501	0.660 (0.362–1.203)	0.175

ES emergency surgery, *BTS* bridge to surgery, *ASA* American Society of Anesthesiologists physical status score, *BMI* body mass index, *PreCEA* preoperative carcinoembryonic antigen, *LN* lymph node, *LVI* lymphovascular invasion, *HR* hazard ratio, *CI* confidence interval, *WD* well-differentiated, *MD* moderately differentiated, *PD* poorly differentiated, *MCN* mucinous, *SRC* signet ring cell, *MIS* minimally invasive surgery, *CTx* chemotherapy

TABLE 3 The patterns and sites of recurrence after surgery

	ES (n = 71)	BTS (n = 182)	p Value
Overall recurrence	22 (31.0)	48 (26.4)	0.532
Locoregional recurrence	5 (22.7)	10 (20.8)	0.786
Systemic recurrence	17 (77.3)	38 (79.2)	0.512
Liver	8 (47.1)	20 (52.6)	
Peritoneum	4 (23.5)	10 (26.3)	
Lung	3 (17.6)	6 (15.8)	
Bone	1 (5.9)	0 (0.0)	
Brain	1 (5.9)	0 (0.0)	
Para-aortic lymph node	0 (0.0)	2 (5.3)	

Data are expressed as n (%)

ES emergency surgery, *BTS* bridge to surgery

risk factors for perforation after SEMS insertion were the degree of occlusion and endoscopic technique.[21] A completely occluded MCO may result in friable, microperforated tissue, in addition to presenting a severely tight stricture that makes SEMS deployment technically challenging. The complication risk was also influenced by the endoscopist's technique, and most colonic injuries are attributable to the insertion process.[21,22] The favorable stenting results in our study may be associated with the high technical (93.9%) and clinical (92.9%) success rates and low perforation rate (4.4%) related to stent placement, compared with those in a previous meta-analysis (70.0%, 69.0%, and 6.9%, respectively).[23] Although the results of this study may not support the association between stent-related microperforation and dissemination of tumor cells, our findings emphasize that SEMS as a BTS may be safely performed in a high-volume center with experienced endoscopists. However, caution should be taken in centers where this procedure is not routinely performed.

In this study, the primary anastomosis rate (77.5 vs. 91.2%, $p = 0.004$) was higher and the stoma creation rate was lower in the BTS group, whereas the permanent stoma rate (18.3 vs. 2.7%, $p < 0.001$) was higher in the ES group, in line with the results of previous meta-analyses.[25,26] The median time interval from stent placement to surgery was 8 days. An optimal time interval of 5–10 days between SEMS placement and surgery was suggested to allow full decompression, subsidence of tissue edema, and recovery of the patients' physical and nutritional status.[25] Accordingly, primary anastomosis can be considered safe without the need for stoma creation. This finding may be attributable to a general preference for primary anastomosis without a diverting stoma among surgeons at our institution, as well as the low permanent stoma rate related to the high experience level of our surgical team.

MIS is preferred over open surgery due to its early recovery and more favorable short-term outcomes.[24,25] However, colonic obstruction has been considered a major reason for conversion to open surgery. Moreover, SEMS placement makes MIS more difficult if colonic decompression is insufficient.[26] Although some studies have suggested that using SEMS as a BTS with a well-trained minimally invasive colorectal surgeon after preoperative decompression and bowel preparation in an elective setting increases the possibility of laparoscopic resection, they are limited by their low numbers of patients.[7,27–33] The present study showed that SEMS placement as a BTS resulted in a higher minimally invasive resection rate with a lower conversion rate. A total of 105 patients (57.6%) with SEMS insertion successfully underwent MIS, with only three patients (2.9%) requiring open conversion from laparoscopic surgery. The conversion rate in this study is comparable with that in a previous randomized controlled study[7] and is consistent with the outcomes of laparoscopic colonic resection at our institution.[34] Patients who underwent MIS after SEMS insertion showed more favorable short-term outcomes than patients who underwent open surgery. The shorter times to flatus passage and soft diet resumption suggest an earlier recovery of bowel function in the MIS group and, subsequently, shorter hospital stays after SEMS insertion or surgery. The overall postoperative complication rate was lower in the MIS group (44.2 vs. 18.1%, $p < 0.001$), although the anastomotic leakage rate was not significantly different between open surgery and MIS. This result is consistent with previous studies in which MIS had better short-term outcomes in colon cancer patients.[13–15] Moreover, operation type (open vs. MIS) was not a significant prognostic factor for DFS and OS in patients with acute MCO. Interestingly, the current study found no significant differences in operation time between the two groups. This may be related to the greater number of patients and larger tumor sizes in the open surgery group than in the MIS group (7.0 vs. 6.0 cm, $p = 0.001$).

In summary, based on the oncologic safety of SEMS insertion as BTS in patients with MCO, we observed that MIS was associated with more favorable short-term outcomes than open surgery. However, this study was limited by its non-randomized retrospective design and small number of patients. Furthermore, differences in the surgeons' preferred management protocols and difficulty standardizing the patient selection process might have influenced our results.

In addition, certain confounding variables, such as low BMI, may have been associated with the favorable short-term outcomes in both the MIS and open surgery groups. Nevertheless, to our knowledge, the present study

TABLE 4 Baseline clinicopathologic characteristics and surgical outcomes of patients who underwent SEMS placement as a BTS

Characteristics	Open surgery (n = 77)	MIS (n = 105)	p Value
Patient demographics			
Age, years (mean ± SD)	63.4 ± 12.4	66.5 ± 12.3	0.098
Sex			0.448
Male	48 (62.3)	59 (56.2)	
Female	29 (37.7)	46 (43.8)	
ASA			0.515
I–II	56 (72.7)	71 (67.6)	
III–IV	21 (27.3)	34 (32.4)	
BMI, kg/m^2 (mean ± SD)	21.8 ± 3.3	23.2 ± 9.90	0.544
Previous abdominal operation	12 (15.6)	21 (20.0)	0.560
PreCEA, ng/mL (IQR)	3.35 (1.74–12.90)	3.55 (2.14–7.20)	0.329
Tumor location			0.484
Right	21 (27.3)	23 (21.9)	
Left	56 (72.7)	82 (78.1)	
Time to surgery, days (IQR)[a]	8.0 (6.0–14.0)	8.0 (6.0–12.0)	0.420
Operation time, min (IQR)	232 (180–287)	217 (170–264)	0.057
Blood loss, mL (IQR)	75 (0–360)	50 (0–150)	0.078
Pathologic results			
TNM stage			> 0.999
I	0 (0.0)	0 (0.0)	
II	36 (46.8)	50 (47.6)	
III	41 (53.2)	55 (52.4)	
T classification			0.587
pT1, T2	0 (0.0)	0 (0.0)	
pT3	62 (80.5)	80 (76.2)	
pT4	15 (19.5)	25 (23.8)	
N classification			0.680
pN0	36 (46.8)	50 (47.6)	
pN1	24 (31.2)	37 (35.2)	
pN2	17 (22.1)	18 (17.1)	
Tumor differentiation grade			0.292
WD/MD	68 (88.3)	98 (93.3)	
PD/MCN/SRC	9 (11.7)	7 (6.7)	
LN retrieval < 12	1 (1.3)	4 (3.8)	0.398
Resection margin involvement	0 (0.0)	0 (0.0)	> 0.999
Lymphovascular invasion	24 (31.2)	40 (38.1)	0.350
Tumor size, cm (IQR)	7.0 (6.0–8.0)	6.0 (5.2–7.0)	0.004
Postoperative outcomes			
Primary anastomosis without stoma	9 (11.7)	7 (6.7)	0.292
Permanent stoma	4 (50.2)	1 (1.0)	0.164
Postoperative complications	34 (44.2)	19 (18.1)	< 0.001
Wound infection	6 (17.6)	4 (21.1)	0.516
Wound dehiscence	2 (5.9)	0 (0.0)	0.407
Urinary complication	4 (11.8)	1 (5.3)	0.404
Intra-abdominal fluid collection	8 (23.5)	3 (15.8)	0.385
Ileus/obstruction	11 (32.4)	7 (36.8)	0.770
Anastomosis leakage	3 (8.8)	2 (10.5)	0.596
Postoperative pneumonia	0 (0.0)	2 (10.5)	0.124

TABLE 4 continued

Characteristics	Open surgery (n = 77)	MIS (n = 105)	p Value
Major complication (G ≥ 3)	14 (18.2)	6 (5.7)	0.009
Postoperative mortality	0 (0.0)	1 (1.0)	> 0.999
Time to first flatus, days (IQR)	4 (3–5)	3 (3–4)	< 0.001
Time to soft diet, days (IQR)	6 (5–7)	5 (4–5)	< 0.001
LOS, days (IQR)	13 (9–16)	8 (6–9)	< 0.001
Adjuvant chemotherapy	62 (80.5)	80 (76.2)	0.587

Data are expressed as n (%) unless otherwise specified

SEMS self-expandable metal stents, *BTS* bridge to surgery, *MIS* minimally invasive surgery, *SD* standard deviation, *ASA* American Society of Anesthesiologists physical status score, *BMI* body mass index, *IQR* interquartile range, *PreCEA* preoperative carcinoembryonic antigen, *TNM* American Joint Committee on Cancer pathologic staging 8th edition, *LN* lymph node, *LOS* length of hospital stay after operation, *WD* well-differentiated, *MD* moderately differentiated, *PD* poorly differentiated, *MCN* mucinous, *SRC* signet ring cell

[a]Time to surgery after stent insertion

represents the largest series to date and provides meaningful data about MIS after SEMS insertion in patients with MCO.

CONCLUSIONS

This study suggests that elective surgery after stent insertion is oncologically safe and effective for the management of acute MCO, and that MIS combined with stent insertion for MCO is also safe and feasible, with faster postoperative recovery than open surgery.

AUTHOR CONTRIBUTIONS SYY: Data collection and analysis, manuscript writing. YYP: Data collection, critical review. YDH: Data collection, critical review. MSC: Data collection, critical review. HH: Data collection, critical review. BSM: Data collection, critical review. KYL: Data collection, critical review. NKK: Study idea, design, data collection and analysis, manuscript writing

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HUMAN RIGHTS STATEMENT All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions. This retrospective study was approved by the Institutional Review Board (IRB) of Severance Hospital, Yonsei University College of Medicine (4-2018-0191).

INFORMED CONSENT Owing to the retrospective nature of the study, signed patient informed consent was waived as per the IRB approval.

DISCLOSURES Seung Yoon Yang, Youn Young Park, Yoon Dae Han, Min Soo Cho, Hyuk Hur, Byung Soh Min, Kang Young Lee, and Nam Kyu Kim have no disclosures to declare.

CONFLICT OF INTEREST All authors have completed the disclosure declaration, and none of the authors or their immediate family members report any conflicting financial interest.

REFERENCES

1. McArdle CS, McMillan DC, Hole DJ. The impact of blood loss, obstruction and perforation on survival in patients undergoing curative resection for colon cancer. *Br J Surg.* 2006;93:483–88.
2. Cheynel N, Cortet M, Lepage C, Benoit L, Faivre J, Bouvier AM. Trends in frequency and management of obstructing colorectal cancers in a well-defined population. *Dis Colon Rectum.* 2007;50:1568–75.
3. Saida Y, Sumiyama Y, Nagao J, Uramatsu M. Long-term prognosis of preoperative "bridge to surgery" expandable metallic stent insertion for obstructive colorectal cancer: comparison with emergency operation. *Dis Colon Rectum.* 2003;46:S44–9.
4. Small AJ, Baron TH. Comparison of Wallstent and Ultraflex stents for palliation of malignant left-sided colon obstruction: a retrospective, case-matched analysis. *Gastrointest Endosc.* 2008;67:478–88.
5. Harris GJ, Senagore AJ, Lavery IC, Fazio VW. The management of neoplastic colorectal obstruction with colonic endolumenal stenting devices. *Am J Surg.* 2001;181:499–06.
6. Sebastian S, Johnston S, Geoghegan T, Torreggiani W, Buckley M. Pooled analysis of the efficacy and safety of self-expanding metal stenting in malignant colorectal obstruction. *Am J Gastroenterol.* 2004;99:2051–057.
7. Cheung HY, Chung CC, Tsang WW, Wong JC, Yau KK, Li MK. Endolaparoscopic approach vs conventional open surgery in the treatment of obstructing left-sided colon cancer: a randomized controlled trial. *Arch Surg.* 2009;144:1127–132.
8. Maruthachalam K, Lash GE, Shenton BK, Horgan AF. Tumour cell dissemination following endoscopic stent insertion. *Br J Surg.* 2007;94:1151–154.
9. Alcantara M, Serra-Aracil X, Falco J, Mora L, Bombardo J, Navarro S. Prospective, controlled, randomized study of intraoperative colonic lavage versus stent placement in obstructive left-sided colonic cancer. *World J Surg.* 2011;35:1904–910.
10. Arezzo A, Balague C, Targarona E, et al. Colonic stenting as a bridge to surgery versus emergency surgery for malignant colonic obstruction: results of a multicentre randomised controlled trial (ESCO trial). *Surg Endosc.* 2017;31(8):3297–305.
11. van Hooft JE, Bemelman WA, Oldenburg B, et al. Colonic stenting versus emergency surgery for acute left-sided malignant colonic obstruction: a multicentre randomised trial. *Lancet Oncol.* 2011;12:344–52.

12. Jacobs M, Verdeja JC, Goldstein HS. Minimally invasive colon resection (laparoscopic colectomy). *Surg Laparosc Endosc.* 1991;1:144–50.
13. Jayne DG, Guillou PJ, Thorpe H, et al. Randomized trial of laparoscopic-assisted resection of colorectal carcinoma: 3-year results of the UK MRC CLASICC Trial Group. *J Clin Oncol.* 2007;25:3061–068.
14. COLOR Study Group. COLOR: a randomized clinical trial comparing laparoscopic and open resection for colon cancer. *Dig Surg.* 2000;17:617–22.
15. 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;246:655–62 (**discussion 62-4**).
16. Baron TH, Rey JF, Spinelli P. Expandable metal stent placement for malignant colorectal obstruction. *Endoscopy.* 2002;34:823–30.
17. van Hooft JE, van Halsema EE, Vanbiervliet G, et al. Self-expandable metal stents for obstructing colonic and extracolonic cancer: European Society of Gastrointestinal Endoscopy (ESGE) Clinical Guideline. *Endoscopy.* 2014;46:990–1053.
18. Arezzo A, Balague C, Targarona E, et al. Colonic stenting as a bridge to surgery versus emergency surgery for malignant colonic obstruction: results of a multicentre randomised controlled trial (ESCO trial). *Surg Endosc.* 2017;31:3297–305.
19. Sabbagh C, Browet F, Diouf M, et al. Is stenting as "a bridge to surgery" an oncologically safe strategy for the management of acute, left-sided, malignant, colonic obstruction? A comparative study with a propensity score analysis. *Ann Surg.* 2013;258:107–15.
20. Tung KL, Cheung HY, Ng LW, Chung CC, Li MK. Endo-laparoscopic approach versus conventional open surgery in the treatment of obstructing left-sided colon cancer: long-term follow-up of a randomized trial. *Asian J Endosc Surg.* 2013;6:78–81.
21. Small AJ, Coelho-Prabhu N, Baron TH. Endoscopic placement of self-expandable metal stents for malignant colonic obstruction: long-term outcomes and complication factors. *Gastrointest Endosc.* 2010;71:560–72.
22. Kim SJ, Kim HW, Park SB, et al. Colonic perforation either during or after stent insertion as a bridge to surgery for malignant colorectal obstruction increases the risk of peritoneal seeding. *Surg Endosc.* 2015;29:3499–506.
23. Tan CJ, Dasari BV, Gardiner K. Systematic review and meta-analysis of randomized clinical trials of self-expanding metallic stents as a bridge to surgery versus emergency surgery for malignant left-sided large bowel obstruction. *Br J Surg.* 2012;99:469–76.
24. Lacy AM, Garcia-Valdecasas JC, Delgado S, et al. Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: a randomised trial. *Lancet.* 2002;359:2224–229.
25. Kim CW, Kim CH, Baik SH. Outcomes of robotic-assisted colorectal surgery compared with laparoscopic and open surgery: a systematic review. *J Gastrointest Surg.* 2014;18:816–30.
26. Yang C, Wexner SD, Safar B, et al. Conversion in laparoscopic surgery: does intraoperative complication influence outcome? *Surg Endosc.* 2009;23:2454–458.
27. Morino M, Bertello A, Garbarini A, Rozzio G, Repici A. Malignant colonic obstruction managed by endoscopic stent decompression followed by laparoscopic resections. *Surg Endosc.* 2002;16:1483–487.
28. Olmi S, Scaini A, Cesana G, Dinelli M, Lomazzi A, Croce E. Acute colonic obstruction: endoscopic stenting and laparoscopic resection. *Surg Endosc.* 2007;21:2100–1004.
29. Stipa F, Pigazzi A, Bascone B, et al. Management of obstructive colorectal cancer with endoscopic stenting followed by single-stage surgery: open or laparoscopic resection? *Surg Endosc.* 2008;22:1477–481.
30. Rho SY, Bae SU, Baek SJ, et al. Feasibility and safety of laparoscopic resection following stent insertion for obstructing left-sided colon cancer. *J Korean Surg Soc.* 2013;85:290–95.
31. Chung TS, Lim SB, Sohn DK, et al. Feasibility of single-stage laparoscopic resection after placement of a self-expandable metallic stent for obstructive left colorectal cancer. *World J Surg.* 2008;32:2275–280.
32. Law WL, Poon JT, Fan JK, Lo OS. Colorectal resection after stent insertion for obstructing cancer: comparison between open and laparoscopic approaches. *Surg Laparosc Endosc Percutan Tech.* 2013;23:29–32.
33. Park IJ, Choi GS, Kang BM, et al. Comparison of one-stage managements of obstructing left-sided colon and rectal cancer: stent-laparoscopic approach vs. intraoperative colonic lavage. *J Gastrointest Surg.* 2009;13:960–65.
34. Cho JH, Lim DR, Hur H, et al. Oncologic outcomes of a laparoscopic right hemicolectomy for colon cancer: results of a 3-year follow-up. *J Korean Soc Coloproctol.* 2012;28:42–8.