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Fluoroscopic Stent Placement as a Bridge to Surgery for Malignant Colorectal Obstruction: Short- and Long-Term Outcomes

악성대장협착의 근치적 절제술을 위한 수술 전 투시장치하 스텐트 설치술: 단기 및 장기 결과

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Purpose To assess the outcomes of single-stage surgery following fluoroscopic stent placement for malignant colorectal obstruction.

Materials and Methods This retrospective study included 46 patients (28 male and 18 female; mean age, 67.2 years) who had undergone fluoroscopic stent placement followed by laparoscopic resection (*n* = 31) or open surgery (*n* = 15) for malignant colorectal obstruction. The surgical outcomes were analyzed and compared. After a mean follow-up of 38.9 months, the recurrence-free and overall survival were estimated, and prognostic factors were evaluated.

Results The mean interval between stent placement and surgery was 10.2 days. Primary anastomosis was possible in all patients. The mean postoperative length of hospitalization was 11.0 days. Bowel perforation was detected in six patients (13.0%). During the follow-up, ten patients (21.7%) developed recurrence; these included five of the six patients with bowel perforation. Bowel perforation had a significant effect on recurrence-free survival ($p = 0.010$).

Conclusion Single-stage surgery following fluoroscopic stent placement may be effective for treating malignant colorectal obstruction. Stent-related bowel perforation is a significant predictive factor for tumor recurrence.

Index terms Colorectal Neoplasms; Intestinal Obstruction; Laparoscopy; Self Expandable Metallic Stents

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INTRODUCTION

It has been reported that 7%–29% of patients with colorectal cancer present with bowel obstruction and require emergency surgery (1). Emergency colorectal surgery for acute obstruction results in a 15%–20% mortality rate and a 45%–50% morbidity rate, which are much higher than has been reported for elective surgery (2, 3). In addition, emergency surgery is associated with a high rate of a permanent colostomy, thereby compromising patient quality of life (4). Recently, placement of self-expandable metallic stent (SEMS) has been used effectively to decompress the obstructed colon as a palliative treatment or as a bridge to surgery (BTS) for potentially resectable colorectal cancer (5-7). Stent as a BTS allows optimization of patient condition while obviating the need for emergency surgery or colostomy, thereby enabling elective single-stage laparoscopic colon resection as well as open surgery (OS) (8-10). Many investigators have been reported the effective short-term outcomes of stent placement followed by single-stage surgery for colorectal obstruction (7-13). However, the potential long-term oncological consequences of preoperative stent placement have been debated. While several investigators have reported increased risk of oncological recurrence in patient with preoperative stent placement, mainly due to stent-related bowel perforation and tumor cell dissemination (14-17), others have reported favorable short-term and comparable long-term outcomes of stent placement as a BTS compared to emergency surgery (18-22).

Therefore, stent placement as a BTS could be a promising treatment strategy for malignant colorectal obstruction; however, controversy still exists regarding the long-term oncological outcomes of patients with a potentially curable cancer. The purpose of this study was to retrospectively evaluate the short-term and long-term outcomes of fluoroscopic stent placement as a BTS in patients with malignant colorectal obstruction.

MATERIALS AND METHODS

PATIENTS

This retrospective study was approved by the Institutional Review Board of our institution (IRB No. KUGHIRB 2018-10-003), and the requirement to obtain written informed consent was waived. Between January 2009 and January 2018, 162 patients underwent the placement of SEMS at our institution for a malignant colorectal obstruction. The inclusion criteria for our study were as follows: 1) documented colorectal cancer, 2) symptomatic colorectal obstruction, and 3) fluoroscopic stent placement as a BTS. One hundred fourteen of the 162 patients were excluded from the study for the following reasons: stent placement as a palliative treatment (n = 111), clinical evidence of peritonitis after stent placement necessitating emergency surgery (n = 1) and technical failure of stent placement (n = 2). The remaining 48 patients (29 male and 19 female; age range, 43–86 years; mean age, 62.4 years ± 11.4) were included in the study. All patients presented with clinical features of colonic obstruction, radiological presentation of a dilated colon, and an obstructive lesion on abdominal CT images. The diagnosis was established by means of colonoscopy with biopsy in all patients. The sites of obstruction included the rectum (n = 2), the rectosigmoid junction (n = 10), the sigmoid colon (n = 20), and the descending colon (n = 16).

Study patients were treated with either laparoscopic colon resection (laparoscopic surgery [LS] group) or OS group. Two surgeons with 24 and 16 years of experience, respectively, performed the surgeries. The attending surgeon decided which of the two approaches to use, and the surgeons preferred different surgical approaches for such cases. Thirty-seven patients were treated with postoperative chemotherapy: 25 in the LS group and 12 in the OS group. No significant difference was observed in the age, sex, obstruction site, American Society of Anesthesiologists (ASA) score and body mass index between the two groups.

STENT PLACEMENT

The stent used in this study was a dual stent (S&G Biotech, Seongnam, Korea), which consists of an outer partially nylon covered stent and an inner bare nitinol stent (7). The stent was 24 mm in diameter when fully expanded. The stents were placed using an introducer system (S&G Biotech) consisting of a Teflon sheath with a 4.5-mm outer diameter, a pusher catheter, and a guiding olive tip. The outer and inner stents were loaded in their own Teflon sheaths. The stent placement technique has been previously described in detail (7). Briefly, with the patient in the left lateral decubitus position, a 5-F angled-tip vascular catheter (Cobra catheter; Cook, Bloomington, IN, USA) with a 0.035-inch hydrophilic guide wire (Radiofocus M; Terumo, Tokyo, Japan) was inserted through the anus into the rectum under the guidance of fluoroscopy with flat panel detector angiography system (AlluraClarity; Philips Healthcare, Best, the Netherlands). After injection of water-soluble iodinated contrast medium (Ultravist 300; Schering Korea; Ansung, Korea) to visualize the distal extension of the obstruction, the catheter was advanced across the obstruction to the proximal portion of the obstruction with help of the guide wire. Water-soluble contrast medium was injected to visualize the proximal extension of the obstruction, and the vascular catheter was replaced with a 5-F, graduated sizing catheter (Aurous Centimeter Sizing Catheter; Cook) to measure the length of the obstruction. The hydrophilic guide wire was then exchanged for a 260-cm-long, 0.035-inch super-stiff guide wire (Amplatz super-stiff; Boston Scientific, Marlborough, MA, USA), and the catheter was removed with the guide wire left in place. A dual stent was deployed over the guide wire under fluoroscopic guidance; the outer partially covered stent was placed first, and the inner bare stent is placed coaxially inside the indwelling partially covered stent with complete overlap. A stent approximately 50 mm longer than the obstruction was selected for placement so that its proximal and distal portion would extend sufficiently above and below the obstruction, respectively. An abdominal radiographic examination was performed daily after the procedure to assess the expansion of the stent and improvement of mechanical ileus.

DATA COLLECTION AND FOLLOW-UP

Demographic information, tumor site, time interval to operation, type of operation, perioperative details, postoperative complications within 30 days of surgery, pathological characteristics of the resected specimen, hospital stay, and survival were collected from patient medical records or the electronic patient information database. After surgery, all patients were followed up in the outpatient clinic. Serum carcinoembryonic antigen was measured at 3- to 6-months intervals in the first 2 years following surgery, and then every 6 months for a total 5 years. Chest and abdominal CT assessments were performed to screen for recurrence every 6

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to 12 months until 5 years after surgery. A surveillance colonoscopy was performed 1 year after surgery, 3 years after surgery, and then was repeated every 5 years thereafter.

STATISTICAL ANALYSIS

The short-term outcomes were evaluated and comparison between LS group and OS group was performed. To compare the baseline characteristics and surgical outcomes between patients in the LS group and the OS group, we used the Mann Whitney U-test for continuous variables and the chi-squared test or Fisher's exact test for categorical variables. To evaluate the long-term outcomes, overall survival rates, recurrence-free survival rates, and their associated predictive factors were analyzed. Overall survival and recurrence-free survival rates were estimated by using the Kaplan-Meier method and significant differences between groups were compared using the log-rank test.

Univariate and multivariate analyses were performed to determine parameters that significantly predicted recurrence-free survival and overall survival. A univariate Cox proportional hazard model was fitted to each variable. All variables with $p \leq 0.10$ at univariate analysis were assessed via the multivariate analysis by using the step-wise Cox proportional hazard regression model to evaluate their value as independent predictors of recurrence-free survival and overall survival. All statistical analyses were performed by using the SPSS software, version 25.0 (IBM Corp, Armonk, NY, USA). *p* values of less than 0.05 were considered statistically significant.

DEFINITION

Overall survival was defined as the length of time between surgery and death or the last follow-up visit to the outpatient clinic. Recurrence-free survival was defined as the length of time between surgery and the diagnosis of disease recurrence, death, or the last follow-up visit. Disease recurrence was either locoregional or distant. Locoregional recurrence was defined as recurrence limited to the intestines, regional lymph nodes, or peritoneum. The last date of data collection was October 30, 2018, and patients for whom no event had occurred or who were lost to follow-up were censored from our study.

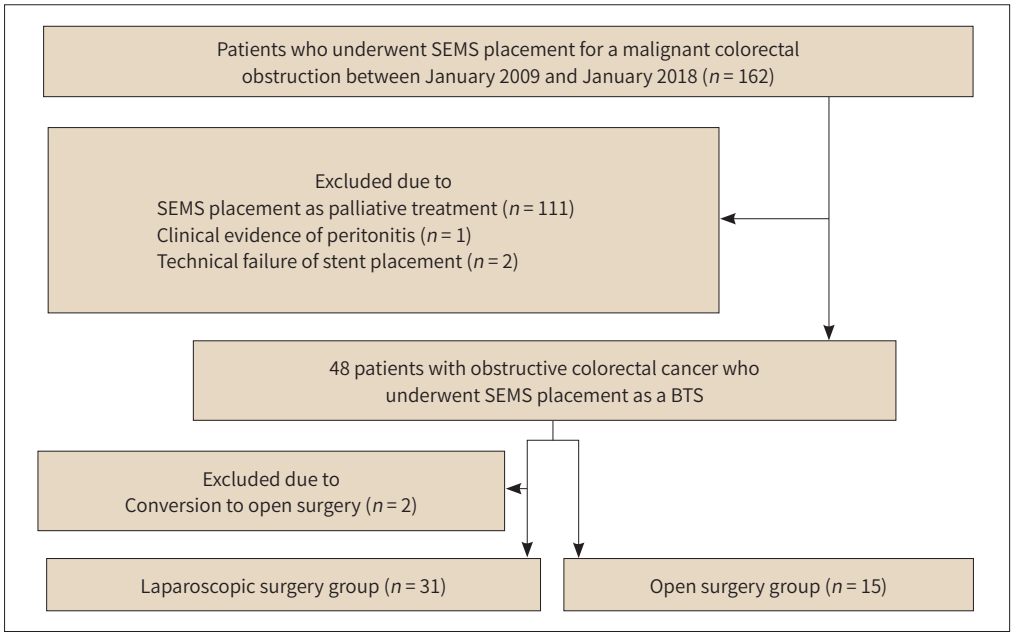
RESULTS

PATIENT CHARACTERISTICS AND SURGICAL OUTCOMES

A total of 48 patients with stent placement as a BTS were included in this study. In all patients, complete expansion of the stent occurred and the bowel obstruction resolved within 2 days after stent placement. The mean interval between stent placement and surgery was 10.2 ± 5.5 days (range, 1–25 days). LS was performed in thirty-three patients. Two of them required conversion to OS because of local intestinal adhesion (n = 1) or extensive tissue invasion (n = 1), which were unrelated to stenting. These two patients were excluded from the analyzed data. Finally, 31 patients were included in the LS group and 15 patients were included in the OS group (Fig. 1). Primary anastomosis was possible in all patients. Types of operations performed are shown in Table 1.

Comparisons of the surgical outcomes between the LS group and the OS group are shown

Fig. 1. Flow diagram of the study population.



BTS = bridge to surgery, SEMS = self-expandable metallic stent

Table 1. Surgical and Pathological Data of the Study Patients

Characteristic	Total (*n* = 46)	LS Group (*n* = 31)	OS Group (*n* = 15)	*p*-Value
Interval to operation, days	10.2 ± 5.5	9.4 ± 3.6	14.2 ± 10.2	0.107
Type of operation				
Anterior resection	29 (63.0)	21 (67.7)	8 (53.3)	
Left hemicolectomy	15 (32.6)	10 (32.3)	5 (33.3)	
Hartmann's operation	2 (4.4)	-	2 (13.4)	
Operation time, min	163.4 ± 50.7	149.5 ± 39.2	192.0 ± 60.7	0.014
Estimated blood loss, mL	160.7 ± 156.1	121.6 ± 136.7	241.3 ± 167.3	0.009
Tumor size, cm	6.5 × 4.4 × 1.7	6.3 × 4.3 × 1.6	6.6 × 4.5 ×1.7	0.815
Pathologic stage				0.479
II	22 (47.8)	16 (51.6)	6 (40.0)	
III	16 (34.8)	11 (35.5)	5 (33.3)	
IV	8 (17.4)	4 (12.9)	4 (26.7)	
Histologic grade				0.372
WD	10 (21.7)	8 (25.8)	2 (13.3)	
MD	32 (69.6)	22 (71.0)	10 (66.7)	
PD/M	4 (8.7)	1 (3.2)	3 (20.0)	
No. of harvested lymph node	22.4 ± 10.0	21.8 ± 11.2	23.5 ± 7.1	0.351
No. of positive lymph node	2.1 ± 3.2	1.2 ± 1.8	3.8 ± 4.7	0.441
Morbidity	1	-	1	
Postoperative hospital stay, days	11.0 ± 4.6	9.7 ± 4.1	13.7 ± 4.4	0.001

Data are presented as the means ± standard deviations or no. of patients (%). *p* values of less than 0.05 were considered statistically significant.
LS = laparoscopic surgery, M = mucinous, MD = moderately differentiated, OS = open surgery, PD = poorly differentiated, WD = well differentiated

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in Table 1. The mean postoperative hospital stay was 11.0 ± 4.6 days (range, 6–23 days). No intraoperative morbidity was observed in either group. One patient in the OS group presented with a postoperative complication, hematochezia due to bleeding ulceration at the anastomotic site 9 days after surgery.

Colon perforation was detected in six patients (13.0%) during surgery (n = 5) or during pathologic examination (n = 1) (five patients in the LS group and one in the OS group). The perforation site was either in the tumor bed (n = 2) or in the normal colon at the proximal end of the stent (n = 4). All of these patients were asymptomatic before surgery. Baseline characteristics and surgical outcomes of the patients with and without stent-related perforation are shown in Table 2. Tumor size was significantly bigger in patients without perforation than in patients with perforation (p = 0.021). Other parameters were not significantly different between the two groups.

LONG-TERM OUTCOMES

During the mean follow-up period of 38.9 months ± 31.2, ten patients (21.7%) developed a

Table 2. Comparison of Patients with and without Stent-Related Perforation

Characteristic	Perforation (+)	Perforation (-)	*p*-Value
No. of patients	6	40	
Age, years			
Mean	63.2 ± 7.7	67.8 ± 10.6	0.203
Range	50–70	43–86	
Sex ratio (M:F)	3:3	25:15	0.666
ASA score	2.0 ± 0.0	2.1 ± 0.7	0.787
I	-	7	
II	6	23	
III	-	10	
Body mass index	20.9 ± 3.8	21.5 ± 3.3	0.644
Tumor size, cm	5.8 × 3.4 × 0.9	6.5 × 4.5 × 1.7	0.021
Pathologic stage			0.289
II	5	17	
III	1	15	
IV	-	8	
Histologic grade			1.000
WD	1	9	
MD	5	27	
PD/M	-	4	
No. of harvested lymph node	23.2 ± 17.6	22.2 ± 8.6	0.832
No. of positive lymph node	0.2 ± 0.4	2.4 ± 3.4	0.782
Adjuvant chemotherapy	6 (100)	31 (77.5)	0.327
Mean follow-up, month	25.5 ± 15.1	40.9 ± 32.6	0.473

Data are presented as the means ± standard deviations or no. of patients (%). p values of less than 0.05 were considered statistically significant.
ASA = American Society of Anesthesiologists, M = mucinous, MD = moderately differentiated, PD = poorly differentiated, WD = well differentiated

recurrence (4 locoregional metastasis, 6 distant metastasis): five of the six patients (83.3%) with stent-related perforation developed a recurrence (3 locoregional metastasis, 2 distant metastases; 1 lung, 1 ovary), and five of the 40 patients (12.5%) without stent-related perforation developed a recurrence (1 locoregional metastasis, 4 distant metastases; 2 liver, 1 lung, 1 adrenal gland). The estimated 1- and 3-year recurrence-free survival rates after surgery were 77.4% and 54.0%, respectively. The prognostic factors affecting recurrence-free survival are summarized in Table 3. At a multivariate analysis with the Cox proportional hazard model, stent-related perforation ($p = 0.010$) and pathologic stage IV categorization ($p = 0.001$) were significant predictive factors that affected recurrence-free survival. The estimated 1- and 3-year recur-

Table 3. Cox Analysis of the Predictors of Recurrence-Free Survival

Characteristic	Univariate Analysis			Multivariate Analysis		
	HR	95% CI	*p*-Value	HR	95% CI	*p*-Value
Age	1.02	0.98–1.06	0.363			
Sex, male	0.72	0.31–1.68	0.451			
ASA score	1.71	0.86–3.40	0.127			
Body mass index	1.00	0.88–1.13	0.971			
Stent-related perforation	2.77	0.99–7.73	0.052	4.67	1.45–15.04	0.010
Tumor size, cm^3	1.00	0.99–1.01	0.988			
Pathologic stage (II)						
III	0.31	0.09–1.10	0.070	0.35	0.10–1.24	0.104
IV	5.96	1.63–12.31	0.004	7.13	2.29–22.17	0.001
Histologic grade	1.62	0.72–3.62	0.245			
No. of harvested LN	0.99	0.94–1.04	0.598			
No. of positive LN	1.05	0.90–1.24	0.521			
Adjuvant chemotherapy	0.98	0.36–2.64	0.962			

p values of less than 0.05 were considered statistically significant.
ASA = American Society of Anesthesiologists, CI = confidence interval, HR = hazard ratio, LN = lymph node

Fig. 2. Cumulative recurrence-free and overall survival rates estimated by the Kaplan–Meier method.
A. Graph depicting the Kaplan–Meier estimates of recurrence-free survival for the six patients with stent-related bowel perforation and the 40 without perforation ($p = 0.043$).
B. Graph depicting the Kaplan–Meier estimates of overall survival for the six patients with stent-related bowel perforation and the 40 without perforation ($p = 0.997$).

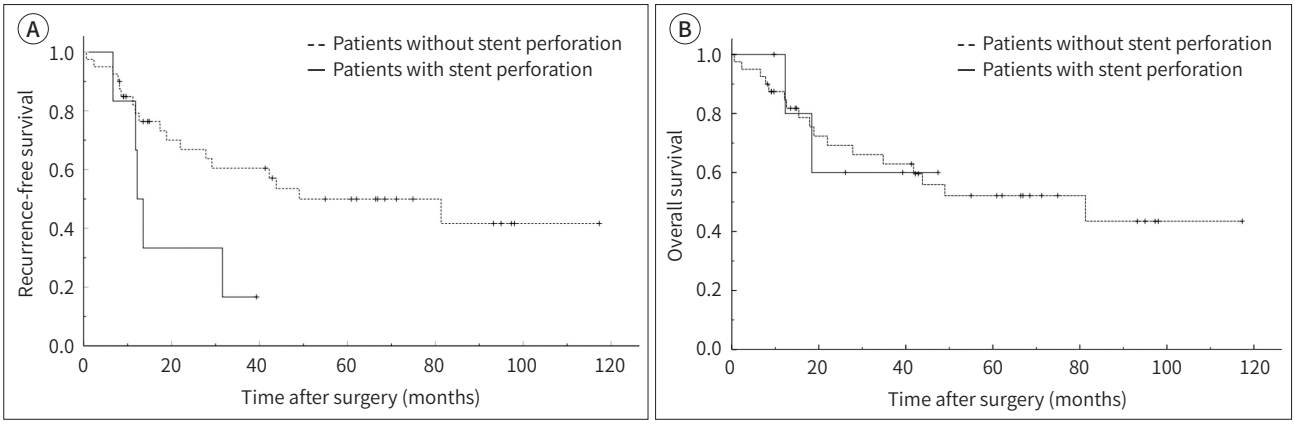

Table 4. Cox Analyses of the Predictors of Overall Survival

Characteristic	Univariate Analysis			Multivariate Analysis		
	HR	95% CI	*p*-Value	HR	95% CI	*p*-Value
Age	1.03	0.98–1.08	0.237			
Sex, male	0.61	0.24–1.53	0.289			
ASA score	1.83	0.88–3.83	0.107			
Body mass index	0.98	0.85–1.12	0.710			
Stent-related perforation	1.11	0.25–4.90	0.893			
Tumor size, cm^3	1.00	0.99-1.01	0.879			
Pathologic stage (II)						
III	0.41	0.11–1.49	0.175	0.42	0.11–1.57	0.198
IV	5.94	2.03–17.33	0.001	5.71	1.94–16.80	0.002
Histologic grade	1.55	0.66–3.69	0.318			
No. of harvested LN	0.96	0.91–1.02	0.176			
No. of positive LN	1.09	0.93–1.28	0.274			
Adjuvant chemotherapy	0.83	0.30–2.29	0.717			

p values of less than 0.05 were considered statistically significant.
ASA = American Society of Anesthesiologists, CI = confidence interval, HR = hazard ratio, LN = lymph node

rence-free survival rates were 79.2% and 60.5%, respectively, in the 40 patients without stent-related perforation, compared to 66.7% and 16.7%, respectively, in the six patients with stent-related perforation. This difference was statistically significant ($p = 0.043$) (Fig. 2A).

During follow-up, 19 of the 46 patients (41.3%) died due to progression of colon cancer. Twenty-seven patients remained alive until the end of the study period on October 30, 2018. The estimated 1- and 3-year overall survival rates after surgery were 89.1% and 62.4%, respectively. The prognostic factors affecting overall survival are summarized in Table 4. At a multivariate analysis with the Cox proportional hazard model, pathologic stage IV categorization ($p = 0.002$) was the only significant predictive factor for overall survival. The estimated 1- and 3-year overall survival rates were 87.4% and 62.9%, respectively, in the 40 patients without stent-related perforation, compared to 100% and 60.0%, respectively, in the six patients with stent-related perforation. This difference was not statistically significant ($p = 0.997$) (Fig. 2B).

DISCUSSION

In this study, fluoroscopic stent placement seems to provide a feasible bridge to subsequent elective surgery for malignant colorectal obstruction. However, preoperative stent placement may increase the risk of recurrence, due mainly to bowel perforation. In our study, the bowel perforation after stent placement was a significant predictive factor for reduced recurrence-free survival. The estimated 1- and 3-year recurrence-free survival rates in the six patients with stent-related bowel perforation were significantly lower than those in the 40 patients without bowel perforation.

Since first reported in 1991 (23), laparoscopic colectomy has been increasingly performed worldwide for the treatment of colorectal cancer (24). However, 7%–29% of patients with colorectal cancer present with bowel obstruction (1), which is considered a contraindication

to LS due to poor view of the surgical field and the potential risk of injury to the distended bowel. Preoperative stent placement for malignant colorectal obstruction can improve the surgical view to allow for LS. Morino et al. (25) first reported four patients with malignant colorectal obstruction who were treated with a stent-laparoscopic approach in 2002, and many researchers have reported the use of LS after stent placement (8-10, 13). While several studies have reported increased technical difficulties and surgical time when using the laparoscopic procedure to remove the rigid colonic segment containing the stent and tumor (25), others reported that laparoscopic mobilization was not particularly difficult (26). In our study, 31 of the 33 patients with malignant colorectal obstruction underwent successful laparoscopic resection after bowel decompression by stent placement. Laparoscopic excision and removal of the stented tumors were not associated with increased technical difficulties, intraoperative morbidities, estimated blood loss or surgical time compared to OS after stent placement. Laparoscopic retrieval of lymph nodes was not significantly different from OS. Two patients required conversion to OS, but the causes of conversion were unrelated to stenting (local intestinal adhesion or extensive tissue invasion).

Despite the favorable short-term outcomes of the stent placement as a BTS, the long-term oncological outcomes of surgery after stent placement have been debated. Several studies have reported no significant difference in survival between elective surgery after stent placement and emergency surgery (18-22), whereas others have reported worse recurrence-free or overall survival in patients with preoperative stent placement (14-17). Therefore, the new European Society of Gastrointestinal Endoscopy (ESGE) guidelines do not strongly recommend preoperative stent placement as a standard treatment for symptomatic left-sided malignant colonic obstruction due to this oncological uncertainty (27). Maruthachalam et al. (14) reported significantly increased levels of cytokeratin 20 mRNA in the peripheral circulation after colonic stent insertion, and they suggested that stent insertion may induce dissemination of cancer cells into the circulation. It has been also reported that stent-related bowel perforation could potentially cause tumor spread and was associated with a high risk of recurrence (15-17). The results of our study further support the findings of these previous studies. Of the six patients with stent-related perforation in our study, five (83.3%) developed a recurrence. However, only five of the 40 patients (12.5%) without stent-related perforation developed a recurrence. Characteristics and surgical outcomes of the patients with and without stent-related perforation were comparable. Multivariate logistic analysis demonstrated that stent-related perforation was a significant predictive factor for recurrence-free survival (hazard ratio, 4.67; 95% confidence interval, 1.45–15.04).

Overall perforation rates of 1.4%–23.1% have been reported in studies (5-7, 15-17) that have included between 26 and 145 patients receiving stent placement for malignant colorectal obstruction. Stent-related bowel perforation may occur due to excessive manipulation of the guide wire during cannulation of the obstruction, injury to friable tumor tissue by stent wires, or erosion of the colonic wall by the end of the stent (5, 6). It has also been reported that the severity of the obstruction, stent design, and operator's expertise are important factors influencing the occurrence of bowel perforation (7). Given that stent-related perforation is associated with short-term mortality and long-term negative oncological consequences in patients with malignant colorectal obstruction, there remains a need for a better-designed stent as a

BTS, and placement should be performed with caution by an experienced interventionist. In addition, patients suffering from bowel perforation may need modifications to the follow-up protocol to include more meticulous and careful follow-up to allow for early detection of possible recurrence.

Our study has several limitations. First, our study was limited by its retrospective design, and selection bias could have influenced some of the results. Second, the small number of patients and low number of events (perforation) in our study may cause low precision of estimates. Third, our study did not compare preoperative stent treatment with emergency surgery for malignant colorectal obstruction. In addition, the increased risk of recurrence in patients with stent-related perforation did not translate into a worse overall survival rate. Therefore, long-term oncological results in our study need to be interpreted with caution. Well-designed, prospective trials with a larger number of patients are warranted in order to fully assess the long-term outcomes of stent placement.

In conclusion, fluoroscopic stent placement seems to provide a feasible bridge to subsequent elective single stage surgery for malignant colorectal obstruction. However, stent-related bowel perforation is associated with an increased risk of recurrence following surgery. Therefore, it will be important to develop improved stent designs and that the procedure be performed by experienced interventionists in order to minimize bowel perforation during stent placement.

Author Contributions

Conceptualization, J.G.; data curation, all authors; formal analysis, all authors; investigation, all authors; methodology, all authors; project administration, all authors; resources, all authors; software, all authors; supervision, J.G.; validation, J.G.; visualization, J.G.; writing—original draft, all authors; and writing—review & editing, J.G.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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악성대장협착의 근치적 절제술을 위한 수술 전 투시장치 하 스텐트 설치술: 단기 및 장기 결과

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목적 악성대장협착에서 스텐트 설치 후 시행한 단단계 수술의 결과를 평가하고자 하였다.

대상과 방법 2009년 1월부터 2018년 1월까지, 악성대장협착으로 투시장치 하 스텐트를 설치하여 장세척을 한 후 수술을 시행한 46명의 환자(남:여 = 28:18, 평균 67.2세)를 대상으로 하였다. 그중 31명은 복강경수술, 15명은 개복수술을 시행하였으며, 수술 결과를 후향적으로 분석하였다. 평균 38.9개월의 추적관찰 기간 동안, 무재발생존율과 전체생존율을 구하였고, 예후인자를 알아보았다.

결과 스텐트 설치 후 평균 10.2일 후에 수술을 시행하였으며, 전례에서 성공적으로 스텐트를 포함한 종양 절제 후 문합이 가능하였다. 수술 후 평균 입원기간은 11일이었다. 6명의 환자(13%)에서 수술 중 혹은 수술 후 병리 소견에서 장천공이 관찰되었다. 추적 기간 동안 10명의 환자(21.7%)에서 종양이 재발하였으며, 장천공이 관찰되었던 6명의 환자 중 5명에서 재발이 발생하였다. 장천공은 무재발생존율에 유의미한 영향을 미쳤다($p = 0.010$).

결론 악성대장협착에서 스텐트 설치 후 시행한 단단계 수술은 효과적인 치료 방법으로 생각된다. 스텐트와 연관된 장천공이 재발의 위험인자였다.

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