Comparison of Short-term Outcomes of a Self-expandable Metallic Stent as a Bridge to Laparoscopic Surgery between Right- and Left-sided Obstructive Colorectal Cancers: A Retrospective Observational Study

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Abstract

Objectives: Few studies have compared the tumor-site-based postoperative short-term outcomes of a bridge to surgery using self-expandable metallic stents. This study compared the perioperative outcomes following stent placement between right- and left-sided obstructive colorectal cancers, focusing on patients undergoing laparoscopic surgery.

Methods: This study included 127 patients with stage I-IV obstructive colorectal cancer (right-sided, n = 25 [19.7%]; left-sided, n = 102 [80.3%]) who underwent laparoscopic-assisted surgery following stent placement between May 2012 and September 2021. We compared the postoperative complication rates and the success rates of stent placement.

Results: The clinical success rate was not significantly different (92% vs. 97.1%, P = 0.254). The rates of all-grade complications (36% vs. 16.7%, P = 0.05) and postoperative ileus or small-bowel obstruction (20% vs. 2%, P = 0.003) were significantly higher in the right-sided group. The rates of the Clavien-Dindo classification ≥ III complications (8% vs. 6.9%, P = 1) and the median durations of postoperative hospital stay (8 days vs. 8 days, P = 1) were not significantly different. On multivariate analysis, right-sided colon cancer was an independent risk factor for postoperative ileus or small-bowel obstruction (odds ratio [OR]: 16.5, 95% confidence interval [CI]: 2.42-112, P = 0.004) but not for all grades of complications (OR: 2.63, 95% CI: 0.976-7.09, P = 0.056).

Conclusions: Although the rates of clinical success, postoperative Clavien-Dindo classification ≥ III severe complications, and postoperative hospital stay were comparable, the bridge to surgery following stent placement for right-sided obstructive colon cancer raises concerns about ileus or small-bowel obstruction.

Keywords
obstructive colorectal cancer, right-sided, self-expandable metallic stent, short-term outcome

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Introduction

Obstructive colorectal cancer (OCRC) is a serious condition that has traditionally been treated with emergency surgery; it is associated with high morbidity and mortality rates[1,2]. The insertion of a self-expandable metallic stent (SEMS) as a bridge to surgery (BTS) was introduced in the early 1990s as a means to improve the short-term outcomes of OCRC[3]. In Japan, SEMS insertion has been covered by national health insurance since 2012. Despite lingering controversies regarding oncological outcomes, satisfactory short-term SEMS outcomes have been reported[4,5]. Because
Table 1. The ColoRectal Obstruction Scoring System (CROSS).

| Level of oral intake                                      | Score |
|----------------------------------------------------------|-------|
| Requiring continuous decompression                        | 0     |
| No oral intake                                           | 1     |
| Liquid or enteral nutrient intake                         | 2     |
| Soft solids, low residue, and full diet with symptoms of stricture* | 3     |
| Soft solids, low residue, and full diet without symptoms of stricture | 4     |

*Symptoms of stricture include abdominal pain/cramps, abdominal distention, nausea, vomiting, constipation, and diarrhea and are related to gastrointestinal transit.

OCRC develops on the left side in approximately 75% cases[6], the subjects of most meta-analyses comparing short-term outcomes between SEMS and emergency surgery had left-sided OCRC[7-9].

Therefore, the European Society of Gastrointestinal Endoscopy (ESGE) Guidelines[10] strongly recommend that stenting as a BTS be discussed with patients who have potentially curable left-sided OCRC as an alternative treatment option to emergency resection, with some contraindications.

Nonetheless, the ESGE Guidelines weakly recommend SEMS insertion for proximal OCRC, either as a BTS or in a palliative setting, due to the low quality of evidence supporting SEMS insertion for such cases[10]. In addition, differences in the success rates of SEMS placement between right- and left-sided OCRCs remain controversial[11-13]. Moreover, although a previous systematic review and some retrospective studies have demonstrated satisfactory postoperative outcomes of SEMS use for right-sided OCRC as a BTS compared with emergency surgery[14-16], few studies have compared the postoperative short-term outcomes of SEMS use as a BTS between right- and left-sided OCRCs.

A recent multicenter retrospective study conducted by Morita et al. examined the benefit of SEMS placement between SEMS and primary-surgery groups[17]. The study suggested that the benefits of SEMS for right-sided OCRC may be less than those for left-sided OCRC. However, to the best of our knowledge, no study has directly compared the postoperative short-term outcomes of BTS using SEMS between right- and left-sided OCRCs and focused on cases undergoing laparoscopic surgery. In this study, we retrospectively compared the results.

**Methods**

**Study design and patients**

This retrospective, observational study reviewed clinicopathological data from our hospital database and was approved by the Human Research Ethics Committee of Hakodate Municipal Hospital (Hokkaido, Japan; reference number 2021-115). This study was conducted in accordance with the tenets of the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all participants using an opt-out form. This study and manuscript adhered to the STROBE guidelines for observational studies.

From the hospital database, we extracted from electronic medical records the data of adult patients who underwent laparoscopic surgery as a BTS following SEMS placement for clinical stage II-IV OCRC at Hakodate Municipal Hospital between May 2012 and September 2021. Right-sided colon cancer was defined as cancer located in the region from the cecum to just proximal to the splenic flexure. Left-sided colorectal cancer was defined as cancer located in the region from just distal to the splenic flexure to the upper rectum. Patients with low rectal cancer were excluded from the cohort. OCRC diagnosis was confirmed through contrast enema, colonoscopy, and histological examination[18]. Decompression procedures were indicated for patients with a ColoRectal Obstruction Scoring System (CROSS) score of 0-2 (Table 1). In the right-sided group, insertion of a trans-nasal decompression tube was employed when the tumor was located in the cecum, and technical difficulties were anticipated with the SEMS insertion due to the strong flexion of the tumor accompanied by a risk of perforation. In the left-sided group, the SEMS was used for most patients, except those with upper RC in which the edge of the SEMS was predicted to reach the lower rectum and when technical difficulties were anticipated with the SEMS insertion due to the strong flexion of the tumor accompanied by a risk of perforation. Additionally, in patients with locally advanced left-sided OCRC who were scheduled to undergo preoperative therapy, stoma creation was performed. In both right- and left-sided groups, patients with a CROSS score of 3-4 were indicated for emergency operation after several days of no oral intake. Preoperative mechanical bowel preparation was performed in the same manner in both groups: using polyethylene glycol and sodium phosphate.

The indication for radical resection of the primary lesion at stage IV was the presence of symptoms due to primary lesion obstruction. Fundamentally, palliative stent placement was not performed, except for patients who could not tolerate radical resection. Preoperative chemotherapy was not ad-
ministered to the entire cohort. Patients were excluded if they underwent more than two intestinal anastomoses.

**Outcome measures**

The primary endpoint of this study was the incidence of postoperative complications. The secondary endpoint was the success rate (technical success, clinical success) of the SEMS placement.

**Methods and devices of SEMS placement**

The methods and indications for the SEMS placement in our hospital have been described in our previous article[18]. The SEMS procedures were performed by endoscopists. After passing the guidewire through the tumor, the SEMS was inserted over the guidewire. The following uncovered colonic stents were used: WallFlex™ enteral colonic stent (Boston Scientific Corp, Natick, MA, USA), Niti-S™ enteral colonic uncovered stent (TaeWoong Corp, Gimpo, South Korea), and HANAROSTENT™ Naturfit™ (Boston Scientific Corp, Natick, MA, USA).

**Data collection**

Clinicopathological data were obtained from the hospital database. The data collected were as follows: sex, age, body mass index (BMI), American Society of Anesthesiologists physical status (ASA-PS), preoperative albumin level, comorbidities (diabetes, ischemic heart disease, and stroke), maximum tumor diameter, tumor location, pathological stage, tumor depth, lymph node metastasis, and histological type. In addition, staging was performed according to the Japanese Classification of Colorectal, Appendiceal, and Anal Carcinoma (Third Edition)[19]. The histological grades were classified as “low” (well or moderately differentiated adenocarcinoma) or “high” (poorly differentiated, mucinous adenocarcinoma, or signet-ring cell carcinoma).

Perioperative outcomes comprised the following: technical success rate, clinical success rate, colon perforation during decompression, interval between decompression and operation, emergency surgery, approach, rates of conversion to laparotomy, surgical procedure, anastomotic type, rates of sphincter-saving surgery, rates of diverting stoma creation, operation time, blood loss, degree of lymph node dissection, number of harvested lymph nodes, resection status of the primary lesion, postoperative complications, reoperation, mortality, and postoperative hospital stay. Technical success was defined as the safe placement of the decompression device. Clinical success was defined as successful decompression without related complications or endoscopic reintervention until elective surgery. Perioperative complications were defined using the Clavien-Dindo classification[20]. Mortality was defined as death within 30 days following surgery.

**Statistical analysis**

The clinicopathological parameters and perioperative data were analyzed using the Mann-Whitney U test and Fisher’s exact test. In addition, the risk factors for clinical failure and postoperative complications were analyzed using univariate and multivariate analyses with a logistic regression model. The multivariate analysis included variables with $P < 0.05$ in the univariate analysis as covariates. All statistical analyses were conducted using EZR (version 1.54; Saitama Medical Center, Jichi Medical University, Saitama, Japan), a graphical user interface for R (version 3.6.3; The R Foundation for Statistical Computing, Vienna, Austria). More precisely, EZR is a modified version of R Commander (version 2.6-2), which was designed to add statistical functions frequently used in biostatistics[21]. Statistical significance was set to $P < 0.05$.

**Results**

**Patient characteristics**

Of the 133 potentially eligible patients, we excluded 6 who had more than two intestinal anastomoses. Consequently, 127 patients (right-sided, n = 25 [19.7%]; left-sided, n = 102 [80.3%]) were included in the analysis (Figure 1).

Table 2 presents the patient characteristics and clinicopathological findings of the entire cohort. The tumor locations in the right-sided group (n = 25) comprised 8 (32%) and 17 (68%) cases in the ascending and transverse colons, respectively. The tumor locations in the left-sided group (n = 102) comprised 19 (18.6%), 50 (49%), and 33 (32.4%) cases in the descending colon, sigmoid colon, and upper rectum, respectively. The right-sided group had a significantly higher rate of low-grade histological types ($P = 0.014$). Other characteristics, including sex, age, BMI, ASA-PS, preoperative albumin level, comorbidity, maximum tumor diameter, pathological stage, tumor depth, and lymph node metastasis, did not significantly vary between the two groups.

**Perioperative outcomes**

Table 3 presents the outcomes of the SEMS placement and perioperative short-term outcomes for each group. No significant differences were observed in the technical success rates (96% vs. 99%, $P = 0.356$), clinical success rates (92% vs. 97.1%, $P = 0.254$), colon perforation during the SEMS placement (4% vs. 1%, n = 0.356), and median interval between decompression and operation (16 days vs. 17 days, $P = 0.712$) between the right- and left-sided groups. All patients underwent laparoscopic-assisted surgery, and the rates of conversion to laparotomy were not significantly different (4% vs. 1%, $P = 0.356$).

Anastomoses in the right-sided group were performed using functional end-to-end anastomosis (FEEA) (79.2%) and triangular anastomosis (TA) (20.8%). The anastomosis types
Figure 1. Study population and patient enrollment flowchart.

Table 2. Patient Characteristics and Clinicopathological Findings.

| Variables                        | Total n = 127, n (%) | Right-sided n = 25, n (%) | Left-sided n = 102, n (%) | P value |
|----------------------------------|----------------------|---------------------------|---------------------------|---------|
| Sex                              |                      |                           |                           |         |
| Male                             | 72 (56.7)            | 15 (60)                   | 57 (55.9)                 | 0.823   |
| Female                           | 55 (43.3)            | 10 (40)                   | 45 (44.1)                 |         |
| Age (years), median (range)      | 72 (38-92)           | 72 (39-90)                | 72 (38-92)                | 0.853   |
| BMI (kg/m²), median (range)      | 21.3 (13.3-40.0)     | 20.4 (16.6-40)            | 21.7 (13.3-35)            | 0.608   |
| ASA - PS 1, 2                    | 89 (70.1)            | 15 (60)                   | 74 (72.5)                 | 0.231   |
| ASA - PS 3, 4                    | 38 (29.9)            | 10 (40)                   | 28 (27.5)                 |         |
| Preoperative albumin (g/dL), median (range) | 3.4 (1.8-4.8) | 3.3 (1.8-4.6) | 3.4 (2.0-4.8) | 0.932 |
| Comorbidity, no. (%)             |                      |                           |                           |         |
| All*                             | 35 (27.6)            | 7 (28)                    | 28 (27.5)                 | 1       |
| Diabetes                         | 25 (19.7)            | 6 (24)                    | 19 (18.6)                 | 1       |
| Ischemic heart disease           | 10 (7.9)             | 1 (4)                     | 9 (8.8)                   | 0.685   |
| Stroke                           | 12 (9.5)             | 1 (4)                     | 11 (10.8)                 | 0       |
| Maximum tumor diameter (cm), median (range) | 6 (2.7-11) | 6.5 (2.8-8) | 6 (2.7-11) | 0.583 |
| Tumor location                   |                      |                           |                           |         |
| Cecum                            | 0 (0)                | 0 (0)                     | 0 (0)                     | < 0.001 |
| Ascending colon                  | 8 (6.3)              | 8 (32)                    | 0 (0)                     |         |
| Transverse colon                 | 17 (13.4)            | 17 (68)                   | 0 (0)                     |         |
| Descending colon                 | 19 (14.9)            | 0 (0)                     | 19 (18.6)                 |         |
| Sigmoid colon                    | 50 (39.4)            | 0 (0)                     | 50 (49)                   |         |
| Rectum**                         | 33 (26)              | 0 (0)                     | 33 (32.4)                 |         |
| Pathological stage               |                      |                           |                           |         |
| 2                                | 44 (34.6)            | 8 (32)                    | 36 (35.3)                 | 0.725   |
| 3                                | 42 (33.1)            | 10 (40)                   | 32 (31.4)                 |         |
| 4                                | 41 (32.3)            | 7 (28)                    | 34 (33.3)                 |         |
| Depth of tumor                   |                      |                           |                           |         |
| T3                               | 98 (77.2)            | 18 (72)                   | 80 (78.4)                 | 0.595   |
| T4                               | 29 (22.8)            | 7 (28)                    | 22 (21.6)                 |         |
| Lymph node metastasis            |                      |                           |                           |         |
| N0                               | 51 (40.2)            | 9 (36)                    | 42 (41.2)                 | 0.718   |
| N1                               | 44 (34.6)            | 8 (32)                    | 36 (35.3)                 |         |
| ≥ N2                             | 32 (25.2)            | 8 (32)                    | 24 (23.5)                 |         |
| Histological type                |                      |                           |                           |         |
| High grade                       | 121 (95.3)           | 21 (84)                   | 100 (98)                  | 0.014   |
| Low grade                        | 6 (4.7)              | 4 (16)                    | 2 (2)                     |         |

BMI, body mass index; ASA-PS, American Society of Anesthesiologists Physical Status

* There is some duplication.
** Low rectal cancer was not included.
Table 3. Perioperative Data and Short-term Outcomes.

| Variables                                             | Total n = 127, n (%) | Right-sided n = 25, n (%) | Left-sided n = 102, n (%) | P value |
|-------------------------------------------------------|----------------------|---------------------------|---------------------------|---------|
| Technical success                                     | 125 (98.4)           | 24 (96)                   | 101 (99)                  | 0.356   |
| Clinical success                                      | 122 (96.1)           | 23 (92)                   | 99 (97.1)                 | 0.254   |
| Colon perforation during decompression                | 2 (1.6)              | 1 (4)                     | 1 (1)                     | 0.356   |
| Interval between decompression and operation (days)   | 17 (0-101)           | 16 (0-29)                 | 17 (0-101)                | 0.712   |
| Emergency surgery                                     | 2 (1.6)              | 1 (4)                     | 1 (1)                     | 0.356   |
| Approach                                              | Laparoscopic-assisted | 127 (100)                 | 102 (100)                 | -       |
|                                                       | Laparotomy            | 0 (0)                     | 0 (0)                     |         |
| Conversion to laparotomy                              | 2 (1.6)              | 1 (4)                     | 1 (1)                     | 0.356   |
| Surgical procedure                                    |                      |                           |                           |         |
|                                                       | Right hemicolectomy   | 18 (14.2)                 | 0 (0)                     | <0.001  |
|                                                       | Partial resection     | 11 (8.6)                  | 8 (7.8)                   |         |
|                                                       | Left hemicolectomy    | 17 (13.4)                 | 13 (12.8)                 |         |
|                                                       | Sigmoidectomy         | 32 (25.2)                 | 32 (31.4)                 |         |
|                                                       | Anterior resection    | 40 (31.5)                 | 40 (39.2)                 |         |
|                                                       | Hartmann’s operation  | 9 (7.1)                   | 9 (8.8)                   |         |
|                                                       | Anasostomic type*     |                           |                           |         |
|                                                       | DST                   | 77 (65.8)                 | 77 (82.8)                 | <0.001  |
|                                                       | FEEA                  | 26 (22.2)                 | 7 (7.5)                   |         |
|                                                       | TA                    | 13 (11.1)                 | 8 (8.6)                   |         |
|                                                       | Hand-sewn             | 1 (0.9)                   | 1 (1.1)                   |         |
| Sphincter-saving surgery                              | 116 (91.3)           | 24 (96)                   | 92 (90.2)                 | 0.691   |
| Diverting stoma creation**                            | 3 (2.6)              | 0 (0)                     | 3 (2.9)                   | 1       |
| Operation time (min), median (range)                  | 174 (83-437)         | 198 (110-437)             | 167 (83-344)              | 0.042   |
| Blood loss (ml), median (range)                       | 10 (1-1680)          | 10 (3-1680)               | 10 (1-305)                | 0.116   |
| Lymph node dissection                                 | D3                   | 122 (96.1)                | 99 (97.1)                 | 0.254   |
|                                                       | D0-2                  | 5 (3.9)                   | 3 (2.9)                   |         |
| Harvested lymph nodes (n), median (range)             | 19 (5-75)            | 20 (6-75)                 | 18.5 (5-49)               | 0.054   |
| Resection status of the primary lesion                | R0                   | 122 (96.1)                | 98 (96.1)                 | 1       |
|                                                       | R1, 2                 | 5 (3.9)                   | 4 (3.9)                   |         |
| Complications (Clavien-Dindo)                         | All (I-V)***         | 26 (20.5)                 | 17 (16.7)                 | 0.05    |
|                                                       | Anastomotic leakage*  | 4 (3.4)                   | 4 (4.3)                   | 0.58    |
|                                                       | Surgical site infection| 7 (5.5)                 | 5 (4.9)                   | 0.623   |
|                                                       | Ileus or small-bowel obstruction | 7 (5.5) | 5 (2.0) | 0.003 |
|                                                       | Intraabdominal abscess| 1 (0.8)                   | 1 (1)                     | 1       |
|                                                       | Enteritis             | 2 (1.6)                   | 1 (1)                     | 0.356   |
|                                                       | Septic shock          | 2 (1.6)                   | 1 (1)                     | 0.356   |
|                                                       | Others                | 7 (5.5)                   | 5 (4.9)                   | 0.623   |
|                                                       | ≥ III                 | 9 (7.1)                   | 7 (6.9)                   | 1       |
| Reoperation                                           | 5 (3.9)              | 1 (4)                     | 4 (3.9)                   | 1       |
| Mortality                                             | 0 (0)                | 0 (0)                     | 0 (0)                     | -       |
| Postoperative hospital stay (days), median (range)    | 8 (5-70)             | 8 (6-29)                  | 8 (5-70)                  | 1       |

DST, double-stapling technique; FEEA, functional end-to-end anastomosis; TA, triangular anastomosis
* Anastomosis was performed in 117 cases. Total: n = 117, Right-sided: n = 24, Left-sided: n = 93
** Cases of permanent stoma creation during primary surgery were excluded, n = 117, Right-sided: n = 24, Left-sided: n = 93
*** There is some duplication.

in the left-sided group were the double-stapling technique (DST) (82.8%), TA (8.6%), FEEA (7.5%), and hand-sewn (1.1%). The median operation time was significantly longer in the right-sided group (198 min vs. 167 min, P = 0.042). Other operative data, including blood loss, harvested lymph nodes, degree of lymph node dissection, and resection status of the primary lesion, were not significantly different between the groups. The rates of all-grade complications were significantly higher in the right-sided group (36% vs. 16.7%, P = 0.05). We also analyzed the details of these complications. Although the rates of anastomotic leakage (0% vs. 4.3%, P = 0.58) and surgical site infection (8% vs. 4.9%, P = 0.623) were not significantly different, the right-sided group had a higher rate of postoperative ileus or small-bowel obstruction (SBO) (20% vs. 2%, P = 0.003). The rates of Clavien-
### Table 4. Predictors of Clinical Failure of SEMS Placement.

| Variables                  | Total n = 127 | Clinical failure of the SEMS placement n = 5 |
|----------------------------|---------------|---------------------------------------------|
| Sex                        |               | Univariate analysis | Multivariate analysis |
|                            | Male          | 72              | 4 | 3.18 (0.345-29.2) | 0.308 |
|                            | Female        | 55              | 1 | Reference        |      |
| Age                        |               |                 |   |                  |      |
| ≥ 70 years                 | 76            | 3               | 1.01 (0.162-6.25) | 0.994 |
| < 70 years                 | 51            | 2               | Reference        |      |
| BMI                        |               |                 |   |                  |      |
| ≥ 25 kg/m²                 | 17            | 0               | 0.00000000668 (0-Inf) | 0.995 |
| < 25 kg/m²                 | 110           | 5               | Reference        |      |
| ASA-PS                     |               |                 |   |                  |      |
| 3, 4                       | 38            | 2               | 1.59 (0.255-9.94) | 0.618 |
| 1, 2                       | 89            | 3               | Reference        |      |
| Tobacco use                |               |                 |   |                  |      |
| Yes                        | 78            | 3               | 0.94 (0.151-5.84) | 0.947 |
| No                         | 49            | 2               | Reference        |      |
| Comorbidity                |               |                 |   |                  |      |
| Present                    | 35            | 1               | 0.647 (0.07-6) | 0.702 |
| Absent                     | 92            | 4               | Reference        |      |
| Tumor location             |               |                 |   |                  |      |
| Right-sided                | 25            | 2               | 2.87 (0.453-18.2) | 0.263 |
| Left-sided                 | 102           | 3               | Reference        |      |
| Stage                      |               |                 |   |                  |      |
| IV                         | 41            | 3               | 3.32 (0.532-20.7) | 0.199 |
| II, III                    | 86            | 2               | Reference        |      |
| Depth of tumor             |               |                 |   |                  |      |
| T4                         | 29            | 2               | 2.35 (0.373-14.8) | 0.364 |
| T3                         | 98            | 3               | Reference        |      |
| Lymph node metastasis      |               |                 |   |                  |      |
| ≥ N2                       | 32            | 3               | 4.81 (0.766-30.2) | 0.094 |
| NO, N1                     | 95            | 2               | Reference        |      |

SEMS, self-expandable metallic stent; BMI, body mass index; ASA-PS, American Society of Anesthesiologists Physical Status; OR, odds ratio; CI, confidence interval

Dindo classification ≥ III severe complications were not significantly different between the groups (8% vs. 6.9%, *P* = 1). The median duration of postoperative hospital stay was not significantly different between the groups (8 days vs. 8 days, *P* = 1).

**Predictors of clinical failure of SEMS placement and postoperative complications**

Table 4 presents the results of the univariate and multivariate logistic regression analyses of clinical failure of the SEMS placement. Univariate analysis revealed that there were no explanatory variables in the multivariate analysis. The odds ratio (OR) for right-sided colon cancer in the univariate analysis was 2.87 (95% confidence interval [CI]: 0.453-18.2, *P* = 0.263).

Table 5 presents the results of the univariate and multivariate logistic regression analyses of postoperative complications (all-grade complications, Clavien-Dindo classification ≥ III complications, and ileus or SBO).

In the analysis of all-grade complications, right-sided colon cancer (OR: 2.81, 95% CI: 1.07-7.41; *P* = 0.036) and decompression failure (OR: 6.46, 95% CI: 1.02-40.9; *P* = 0.048) were the explanatory variables in the multivariate analysis; however, in the multivariate analysis, they were not an independent prognostic factor. The OR of right-sided colon cancer in the multivariate analysis was 2.63 (95% CI: 0.976-7.09; *P* = 0.056).

In the univariate analysis of Clavien-Dindo classification ≥ III complications, right-sided colon cancer failed to qualify as an explanatory variable of multivariate analysis (OR: 1.18, 95% CI: 0.23-6.06; *P* = 0.843). In the multivariate analysis, decompression failure and blood loss ≥ 100 mL were independent risk factors for Clavien-Dindo classification ≥ III complications.

In the analysis of ileus or SBO, right-sided colon cancer was one of the explanatory variables in the multivariate analysis (OR: 12.5, 95% CI: 2.26-69; *P* = 0.004), and in the multivariate analysis, it was one of the independent prognostic factors (OR: 16.5, 95% CI: 2.42-112, *P* = 0.004). Stage IV was also an independent risk factor for ileus or SBO (OR: 7.86; 95% CI: 1.13-54.6, *P* = 0.037).

**Discussion**

We believe that this is the first study to directly compare the short-term perioperative outcomes of SEMS placement as a BTS between right- and left-sided OCRCs and focus on patients undergoing laparoscopic surgery. In particular, the rates of postoperative complications have not been directly compared in previous studies. In our study, the right-sided...
Table 5. Predictors of Postoperative Complications.

| Variables          | Total n = 127 | All-grade complications | Clavien–Dindo ≥ III complications | Ileus or small-bowel obstruction |
|--------------------|---------------|--------------------------|-----------------------------------|---------------------------------|
|                    | n = 26        | Univariate analysis      | Multivariate analysis             | Univariate analysis             | Multivariate analysis          |
| Sex                |               | OR (95% CI) P value       | OR (95% CI) P value               | OR (95% CI) P value             | OR (95% CI) P value             |
| Male               | 72            | 1.96 (0.78-4.91) 0.152   | 8.675 (0.818-55.7) 0.076          | 1.98 (0.369-10.6) 0.426         |
| Female             | 55            | 1 Reference             | 1 Reference                       | 2 Reference                     |
| Age                |               |                         |                                   |                                |
| ≥ 70 years         | 76            | 1.67 (0.664-4.19) 0.276  | 6.37 (0.327-5.75) 0.666          | 6.29 (0.5-36.7) 0.184          |
| < 70 years         | 51            | 1 Reference             | 3 Reference                       | 1 Reference                     |
| BMI                |               |                         |                                   |                                |
| ≥ 25 kg/m²         | 17            | 0.478 (0.102-2.24) 0.348 | 1.079 (0.093-6.8) 0.836          | 0 (0-Inf) 0.000000127 0.992    |
| < 25 kg/m²         | 110           | 1 Reference             | 8 Reference                       | 7 Reference                     |
| ASA-PS             |               |                         |                                   |                                |
| 3, 4               | 38            | 1.63 (0.661-4.02) 0.289  | 3.19 (0.281-5.01) 0.187          | 5.69 (1.22-35.7) 0.029         |
| 1, 2               | 89            | 0.823 (0.343-1.98) 0.662 | 0.771 (0.197-3.02) 0.708         | 0.829 (0.177-3.87) 0.811       |
| Tobacco use        |               |                         |                                   |                                |
| Yes                | 78            | 0.823 (0.343-1.98) 0.662 | 0.771 (0.197-3.02) 0.708         | 0.829 (0.177-3.87) 0.811       |
| No                 | 49            | 0.745 (0.272-2.04) 0.567 | 0.736 (0.145-3.73) 0.711         | 0 (0-Inf) 0.000000386 0.993    |
| Comorbidity        |               |                         |                                   |                                |
| Present            | 35            | 72 Reference            | 7 Reference                       | 7 Reference                     |
| Absent             | 92            | 1 Reference             | 2 Reference                       | 2 Reference                     |
| Tumor location     |               |                         |                                   |                                |
| Right-sided        | 25            | 2.81 (1.07-7.41) 0.036  | 2.18 (0.23-6.06) 0.843          | 12.5 (2.26-69) 0.004         |
| Left-sided         | 102           | 17 Reference            | 7 Reference                       | 2 Reference                     |
| Stage              |               |                         |                                   |                                |
| IV                 | 41            | 1.74 (0.715-4.22) 0.223 | 2.85 (0.722-11.2) 0.135         | 5.83 (1.08-31.5) 0.04         |
| II, III            | 86            | 15 Reference            | 4 Reference                       | 2 Reference                     |
| Depth of tumor     |               |                         |                                   |                                |
| T4                 | 29            | 1.32 (0.493-3.55) 0.578 | 1.77 (0.414-7.56) 0.441         | 1.38 (0.253-7.5) 0.711        |
| T3                 | 98            | 3 Reference             | 6 Reference                       | 5 Reference                     |
| Lymph node         |               |                         |                                   |                                |
| metastasis         | 32            | 0.865 (0.313-2.39) 0.78  | 1.53 (0.361-6.53) 0.562         | 2.35 (0.497-1.11) 0.28        |
| N0, N1             | 95            | 6 Reference             | 6 Reference                       | 4 Reference                     |
| Decompression      |               |                         |                                   |                                |
| outcome            | 5             | 6.46 (1.024-40.9) 0.048  | 3 (4.05-208) 0.008              | 4.83 (0.466-50.2) 0.187       |
| Operative time     |               |                         |                                   |                                |
| ≥ 240 min          | 19            | 2.03 (0.688-5.99) 0.2   | 3.19 (0.724-14) 0.125           | 2.42 (0.435-13.5) 0.313       |
| < 240 min          | 108           | 20 Reference            | 6 Reference                       | 5 Reference                     |
Table 5. Predictors of Postoperative Complications. (continued)

| Variables                      | Total | All-grade complications | Clavien-Dindo ≥ III complications | Ileus or small-bowel obstruction |
|--------------------------------|-------|-------------------------|-----------------------------------|---------------------------------|
|                                |       | Univariate analysis     | Multivariate analysis             | Univariate analysis             | Multivariate analysis         |
| Blood loss ≥ 100 ml            | 10    | 4                       | 2.88 (0.748-11.1)                 | 0.124                           | 4                               |
|                               | < 100 ml | 110                      | Reference                          | Reference                       | Reference                      |
| Anastomotic type               |       | Univariate analysis     | Multivariate analysis             | Univariate analysis             | Multivariate analysis         |
| FEEA, TA, hand-sewn            | 40    | 10                      | 1.5 (0.95-2.77)                   | Reference                       | 1                               |
|                               | DST    | 77                      | 14                                | Reference                       | 6                               |

BMI, body mass index; ASA-PS, American Society of Anesthesiologists Physical Status; FEEA, functional end-to-end anastomosis; TA, triangular anastomosis; DST, double-stapling technique; OR, odds ratio; CI, confidence interval.

* Anastomosis was performed in 117 cases. Total n = 117, All-grade complications: n = 24, Clavien-Dindo ≥ 3 complications: n = 7, Ileus or small-bowel obstruction: n = 6.

The lack of evidence for SEMS in right-sided OCRC may be due to technical difficulties associated with the SEMS placement and the presence of convenient alternatives using a trans-nasal decompression tube, particularly in Asian countries[26,27]. Fundamentally, right colonic lesions account for <5% of all reported cases of colonic stenting[28], and the selection of emergency surgery with primary anastomosis is considered an acceptable therapeutic strategy. Emergency surgery with primary anastomosis has traditionally been performed for right-sided OCRCs. However, postoperative morbidity and mortality rates are high. Kobayashi et al. analyzed a national database in Japan and reported that the 30-day mortality rate of patients who underwent right hemicolectomy was higher in the emergency surgery group than in the elective surgery group (6.0% vs. 0.7%, P < 0.001)[29]. Mege et al. retrospectively analyzed a national group exhibited success rates of SEMS placement comparable to those of the left-sided group. However, concerns of higher postoperative complication rates in the right-sided group, especially ileus or SBO, should be noted. Although this was a retrospective, small-sample, single-center study with some limitations, our data have certain significance.

Previous studies have performed comparisons of SEMS placement success rates between right- and left-sided OCRCs. Some studies have suggested lower success rates in the right-sided colon[11,12], whereas others have demonstrated similar success rates between the two groups[17,22-24]. Our study demonstrated comparable success rates of SEMS placement between right- and left-sided OCRCs, and the tumor location was not a risk factor for the clinical failure of SEMS placement.

Few studies have compared the postoperative short-term outcomes in patients with an inserted SEMS as a BTS between right- and left-sided OCRCs, as most studies included patients with palliative stenting[11-13,22]. Morita et al. compared the short-term outcomes between SEMS and primary-surgery groups for OCRC according to the tumor site[17]. Their study suggested that the benefits of SEMS as a BTS may be less for right-sided OCRC than for left-sided OCRC. The SEMS group with left-sided OCRC exhibited significantly higher rates of primary resection, primary resection with anastomosis, stoma-free surgery, and laparoscopic surgery than the primary-surgery group. Contrarily, the SEMS group with right-sided OCRC exhibited a significantly higher rate of laparoscopic surgery and longer overall hospital stay than the primary-surgery group. However, to the best of our knowledge, no study has directly compared postoperative outcomes. Even though a recent study by Sugiuara et al. compared the postoperative outcomes of BTS according to the tumor site and reported that right-sided cancers had higher rates of postoperative complications, decompression procedures for BTS included stoma and trans-nasal ileus tube[25].
cohort of 776 patients with right-sided OCRC and reported a postoperative morbidity rate of 51.4%[30].

In our study, although the multivariate analysis did not reveal a significant difference, the right-sided group exhibited a higher rate of postoperative all-grade complications in the univariate analysis (Table 5). This result may be caused by the higher rate of postoperative ileus or SBO in the right-sided group. In this study, right-sided colon cancer was one of the independent prognostic factors for ileus or SBO. In our study, the operative time in the right-sided group was significantly longer than that in the left-sided group (Table 3), and this could be a bias for increased ileus or SBO. Moreover, Adamove et al. recently reported that postoperative ileus was more frequent after right-sided colectomies than left-sided colectomies for non-obstructive colon cancer[31]. Most subjects (87%) of this study underwent laparoscopic surgery. The tendency of ileus to frequently occur in laparoscopic right-sided colectomy may affect our results. The reasons for this tendency are still unknown. Despite being a hypothesis, vigorous small intestinal manipulation is often required during right-sided colectomy than left-sided surgery, and this may affect postoperative bowel function. In addition, the preoperative decompression effect of SEMS may not be sufficient on the oral side of Bauhin’s valve. These concerns regarding postoperative ileus or SBO should be resolved in future studies that involve larger sample sizes and comparisons between the trans-nasal decompression tube and SEMS in right-sided OCRC cases.

On the other hand, the rates of Clavien-Dindo grade ≥ III severe complications, anastomotic leakage, and days of postoperative hospital stay were comparable between both groups. Particularly, the result of postoperative hospital stay was satisfactory (Table 3; 8 days vs. 8 days, P = 1). In addition, the mortality and morbidity rates in the right-sided group seem to be better than those in previous studies on emergency surgery[29,30]. A meta-analysis of Kanaka et al. reported that BTS using SEMS for right-sided OCRC reduces the postoperative mortality and morbidity rates compared with emergency surgery[32]. Our results and these studies suggest that even though the concerns of postoperative ileus or SBO remain, SEMS placement for right-sided OCRC can be an option. This study has certain limitations. First, this was a single-center study that included patients from different backgrounds and had a relatively small sample size. In particular, the sample size of the right-sided OCRC group was insufficient to draw definitive conclusions. Future multicenter studies with larger sample sizes should be conducted. Second, certain parameters that evaluate SEMS placement difficulties, such as procedure time, were not compared. Third, this study might have yielded higher complications rates in the right-sided group than in previous studies[15,17]. However, some studies have reported similar complication rates[26,33]; therefore, controversy remains. Fourth, we could not compare the safety or outcomes of the other decompression methods, such as trans-nasal decompression tube, with those of SEMS in the right-sided group because we could not follow up all patients from the database who underwent surgery after trans-nasal decompression tube insertion. Finally, the oncological outcomes between the right- and left-sided groups could not be compared because the cohort only included 13 patients with stage II-III right-sided OCRC; additionally, the follow-up periods in some cases were considerably brief. Therefore, future studies on oncological outcomes are warranted.

In conclusion, our study suggests that although the rates of technical and clinical success of SEMS placement, postoperative Clavien-Dindo grade ≥ III severe complications, and postoperative hospital stay were comparable, BTS using SEMS for right-sided OCRC may raise concerns about postoperative complications, especially ileus or SBO.

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Conflicts of Interest
There are no conflicts of interest.

Author Contributions
All authors contributed to the study concept and design. KS and KI analyzed the data and wrote the manuscript. KS, KI, HK, MK, MU, YT, DY, AS, KI, and MI performed the operations. HK and KN supervised the study. All authors read and approved the final manuscript.

Approval by Institutional Review Board (IRB)
This study was approved by the Human Research Ethics Committee of Hakodate Municipal Hospital (Hakodate, Hokkaido, Japan; reference no. 2021-115). Furthermore, the study was conducted in accordance with the tenets of the 1964 Declaration of Helsinki and its later amendments.

Consent to Participate
Informed consent was obtained from all participants included in the study using an opt-out form.

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