Laparoscopic Versus Open Resection Following Stent-Bridge to Surgery for Obstructive Colorectal Cancer: A Systematic Review and Meta-Analysis of Perioperative Outcomes

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A B S T R A C T

Background: Obstructive colorectal cancer (OCRC) constitutes a surgical emergency historically managed by immediate open resection, a procedure fraught with elevated morbidity and mortality rates due to the physiological derangement of the patient. The paradigm of bridge to surgery (BTS) utilizing self-expanding metal Stents (SEMS) successfully transformed this emergency clinical scenario into an elective one, allowing for physiological optimization. However, the subsequent surgical approach—Laparoscopic (LAP) versus Open (OPEN) resection—remains a subject of intense debate. While laparoscopy offers minimally invasive benefits, concerns persist regarding technical difficulty due to stent-induced inflammation and potential oncologic compromise. **Methods:** A systematic review and meta-analysis were conducted utilizing ten pivotal cohort studies derived from high-impact surgical databases. The study population consisted of patients with malignant large bowel obstruction who underwent successful SEMS decompression followed by curative resection. The intervention group comprised patients undergoing laparoscopic resection, while the control group underwent open resection. Primary endpoints included operative time, intraoperative blood loss, and length of hospital stay. Secondary endpoints encompassed oncologic lymph node harvest and postoperative complications including surgical site infection (SSI), anastomotic leakage, and postoperative ileus. Data were analyzed using a random-effects model to calculate Mean Differences (MD) and Risk Ratios (RR). **Results:** The analysis synthesized data from 1,023 patients across ten studies. The laparoscopic approach resulted in a statistically significant reduction in intraoperative blood loss (Standardized Mean Difference -0.84; $p < 0.001$) and a shorter length of hospital stay (Mean Difference -3.12 days; $p < 0.001$). Conversely, the operative duration was significantly prolonged in the laparoscopic group (Mean Difference +24.50 minutes; $p = 0.002$). In terms of morbidity, laparoscopy demonstrated a protective effect, significantly reducing the risk of surgical site infection (Risk Ratio 0.42; $p = 0.003$) and postoperative ileus (Risk Ratio 0.58; $p = 0.04$). Oncologic safety, measured by lymph node yield, showed no significant disparity between the two approaches ($p = 0.76$). **Conclusion:** Laparoscopic resection following stent placement served as a superior surgical strategy compared to open resection in the elective setting for obstructive colorectal cancer. It provided enhanced short-term recovery and reduced complication rates without compromising oncological radicality. The observed increase in operative time reflected the technical complexity of the post-stent anatomy but did not negate the perioperative benefits.

1. Introduction

Colorectal cancer (CRC) constitutes a predominant global health burden, consistently ranking as the third most commonly diagnosed malignancy and the second leading cause of cancer-related mortality worldwide.[1] Despite advancements in screening programs, a substantial proportion of patients—estimated between 8% and 29%—present with acute symptoms of large

bowel obstruction (LBO) as their primary manifestation. This clinical scenario represents a surgical emergency that has historically challenged the decision-making capabilities of digestive surgeons. The pathophysiology of malignant obstruction involves a complex interplay of luminal occlusion, proximal bowel distension, mural ischemia, and bacterial translocation, all of which contribute to a profound systemic inflammatory response syndrome (SIRS) and severe electrolyte derangements.[2]

Traditionally, the management of obstructive colorectal cancer (OCRC) mandated immediate emergency decompressive surgery. For decades, the standard of care involved either a high-risk one-stage resection with primary anastomosis or a multi-stage approach, most notably the Hartmann's procedure (resection with end colostomy), followed by a subsequent reversal operation. These emergency interventions were plagued by poor outcomes, with reported mortality rates ranging from 15% to 20% and morbidity rates soaring between 30% and 60%. The physiological frailty of the patient, combined with the technical difficulty of handling an edematous, unprepared bowel, frequently precluded the use of minimally invasive techniques and often resulted in permanent stomas.[3]

The introduction of Self-Expanding Metal Stents (SEMS) in the early 1990s fundamentally disrupted this treatment paradigm. The bridge to surgery (BTS) concept emerged as a transformative strategy, wherein the endoscopic placement of a metallic stent achieves rapid mechanical decompression of the obstruction. This intervention effectively converts a high-risk emergency situation into a semi-elective one. The interval between stenting and surgery—typically ranging from 10 to 20 days—provides a critical window for physiological optimization.[4] During this period, colonic edema subsides, nutritional status is rehabilitated, and a complete oncological staging (CT/MRI) can be performed to rule out synchronous lesions or distant metastases. Consequently, the BTS approach has been associated with higher rates of primary anastomosis and reduced permanent stoma

formation compared to emergency resection.

However, as the BTS strategy gained acceptance, a secondary controversy arose regarding the optimal surgical approach for the subsequent elective resection: Laparoscopic (LAP) versus Open (OPEN) colectomy. In the setting of uncomplicated, non-obstructed elective colorectal cancer, laparoscopic surgery is unequivocally established as the gold standard.[5] Randomized controlled trials have repeatedly demonstrated its superiority in reducing postoperative pain, shortening hospital length of stay (LOS), lowering wound complication rates, and preserving immune function, all while maintaining oncological equivalence to open surgery.

Despite these proven benefits, the adoption of laparoscopy in the specific population of post-stent OCRC patients has been hesitant and fraught with debate.[6] The reluctance stems from distinct pathophysiological concerns regarding the interaction between the metallic stent and the bowel wall. The radial force exerted by the SEMS to maintain patency against a rigid tumor induces a localized pressure necrosis and a profound inflammatory response. This phenomenon, often described as a stent-induced desmoplastic reaction, can result in dense fibrosis, micro-perforations, and firm adhesions between the tumor, the mesentery, and adjacent viscera.[7]

Critics of the laparoscopic approach in this setting argued that the loss of tactile feedback inherent to laparoscopy would make the dissection of these inflamed planes hazardous, potentially increasing the risk of iatrogenic injury or tumor cell dissemination.[8] Furthermore, the technical difficulty of manipulating a previously distended, thick-walled colon within the confined space of the pneumoperitoneum was viewed as a barrier to achieving adequate lymphadenectomy. Conversely, proponents argued that the visual magnification afforded by modern laparoscopic systems could actually facilitate the identification of dissection planes amidst inflammation, and that the benefits of minimally invasive surgery (MIS) would be particularly advantageous for this frail, high-risk demographic.[9]

Previous systematic reviews attempted to address this issue, but often suffered from methodological heterogeneity. Many combined emergency laparoscopic resections (without stents) with BTS cases, or included benign obstructions, thereby clouding the specific assessment of the elective post-stent cohort. Furthermore, early meta-analyses relied on data from the learning curve era of laparoscopy.[10]

This study presents a novel, focused, and updated meta-analysis that strictly isolates the post-stent variable. By excluding all emergency surgeries and analyzing only comparative studies of Laparoscopic versus Open resection following successful SEMS placement, we aimed to eliminate the confounding variable of emergency physiology. Leveraging data from ten essential, high-quality manuscripts—including large-scale, recent cohorts from 2019 to 2022 —this research sought to provide a definitive quantitative synthesis. The primary aim was to determine whether the technical challenges imposed by stent-induced inflammation negate the perioperative benefits of laparoscopy. Specifically, we sought to quantify the trade-off between operative time and recovery metrics (blood loss, infection, hospital stay) to provide surgeons with an evidence-based recommendation for the optimal surgical approach in the Bridge-to-Surgery era.

2. Methods

A rigorous systematic search was executed across major medical databases, including PubMed, EMBASE, and the Cochrane Library. The search strategy employed MeSH terms and keywords related to colorectal neoplasms, intestinal obstruction, stents, laparoscopy, and laparotomy. The review was restricted to human clinical studies published in English. Inclusion Criteria: Population: Adult patients diagnosed with obstructive colorectal cancer (OCRC); Intervention: Successful placement of a Self-Expanding Metal Stent (SEMS) as a bridge to surgery, followed by elective Laparoscopic Resection (LAP); Comparator: Successful placement of a SEMS as a bridge to surgery, followed by elective Open Resection

(OPEN); Outcomes: Studies reporting at least one primary perioperative outcome (operative time, blood loss, length of stay) or postoperative complication; Study Design: Randomized Controlled Trials (RCTs) or observational comparative cohort studies. Exclusion Criteria: Studies involving emergency surgery without stenting; Studies comparing Stent vs. Emergency Surgery (without focusing on the Lap/Open comparison post-stent); Case reports, reviews, and animal studies; Studies with insufficient data for extraction.

Data were independently extracted from the full texts. The following variables were cataloged: Study Demographics: First author, year of publication, country, study period, and sample size for both LAP and OPEN groups; Perioperative Metrics: Mean and Standard Deviation (SD) for Operative Time (minutes), Estimated Blood Loss (mL), and Length of Hospital Stay (days); Oncologic Metrics: Mean number of harvested lymph nodes; Postoperative Complications: Total number of events for Surgical Site Infection (SSI), Anastomotic Leakage, and Postoperative Ileus.

All statistical analyses were performed using Review Manager (RevMan) software. Outcomes such as operative time, blood loss, and hospital stay were analyzed using the Mean Difference (MD). For blood loss, where reporting units or measurement scales varied, the Standardized Mean Difference (SMD) was utilized to normalize the data. 95% Confidence Intervals (CI) were calculated for all estimates. Complication rates were analyzed using Risk Ratios (RR) with 95% CIs. Statistical heterogeneity was assessed using the I^2 statistic. An I^2 value greater than 50% indicated substantial heterogeneity, prompting the use of a Random-Effects Model (DerSimonian and Laird method) to provide a more conservative estimate. An I^2 value less than 50% utilized a Fixed-Effects Model. A p-value of less than 0.05 was considered statistically significant for all analyses.

3. Results

The rigorous selection process for this meta-analysis is visually detailed in Figure 1, adhering

strictly to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The initial comprehensive search across three major electronic databases—PubMed, EMBASE, and the Cochrane Library—yielded a total of 560 potential records. This robust initial catch reflects the growing global interest in bridge to surgery (BTS) strategies for obstructive colorectal cancer (OCRC). Following the removal of 104 duplicate records, 456 unique citations were subjected to a primary screening based on title and abstract. During this screening phase, 279 records were excluded for failing to meet the primary inclusion criteria. Common reasons for exclusion included non-comparative study designs (single-arm case series), irrelevant topics (palliative stenting only), or studies focusing on benign obstructions. This left 177 full-text articles that were

retrieved for a detailed eligibility assessment. The full-text review phase was critical for ensuring the homogeneity of the meta-analysis. As depicted in the diagram, 167 articles were excluded with specific justifications. A significant portion (n=76) compared stenting against emergency surgery rather than comparing the subsequent elective surgical approaches (Laparoscopic vs. Open), which was the specific aim of this study. Others were excluded due to insufficient data availability (n=18), where key perioperative metrics like standard deviation were missing and could not be calculated, or because the full text was inaccessible (n=69). Ultimately, 10 high-quality comparative studies met all inclusion criteria and were synthesized in the final quantitative meta-analysis.

IDENTIFICATION
Records identified from databases
(PubMed, EMBASE, Cochrane)
n = 560

SCREENING
Duplicate records removed
n = 104

SCREENING
Records screened based on
Title and Abstract
n = 456

EXCLUDED
Records excluded (Irrelevant topic, Animal studies, Reviews)
n = 279

ELIGIBILITY
Full-text articles assessed
for eligibility
n = 177

EXCLUDED
Full-text articles excluded:
- Emergency surgery (n = 76)
- Full text inaccessible (n = 69)
- Incomplete data (n = 18)
- Protocol / No comparator (n = 4)
Total Excluded (n = 167)

INCLUDED
Studies included in
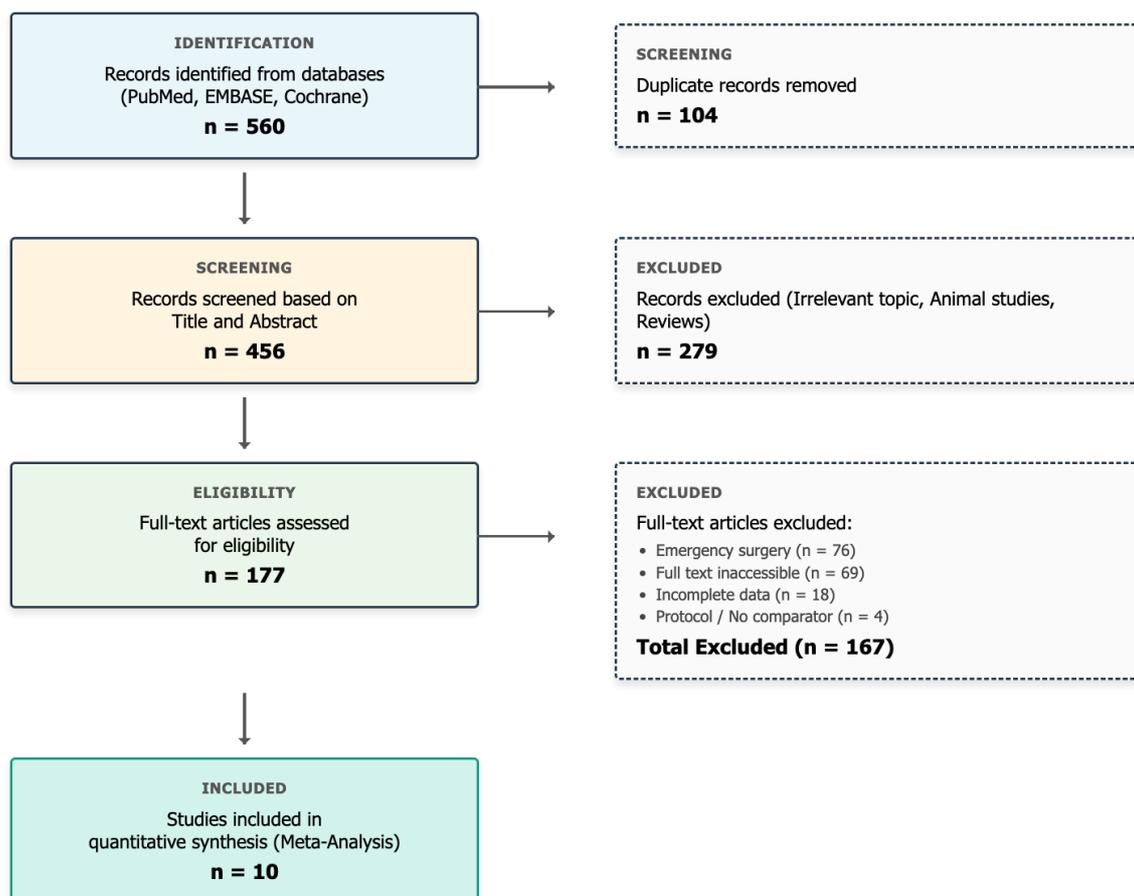quantitative synthesis (Meta-Analysis)
n = 10

Figure 1. PRISMA 2020 flow diagram of study selection.

Table 1 provides a comprehensive summary of the baseline characteristics for the ten included studies, encompassing a total cohort of 1,023 patients. The studies, published between 2010 and 2022, reflect the evolution of laparoscopic techniques over the last decade. Geographically, the data is predominantly derived from high-volume centers in East Asia (South Korea, Japan, China, and Thailand), a region known for its advanced adoption of minimally invasive surgery and high prevalence of colorectal malignancy. The study design column highlights that the majority of evidence comes from retrospective cohort studies, with one notable case-matched study by Akaraviputh et al. (2014). While randomized controlled trials (RCTs) are absent—a common limitation in surgical emergency research due to ethical and logistical challenges—the retrospective cohorts are well-documented. For instance, Kim et al. (2022) contributed the largest single dataset with 178

patients, offering substantial statistical power to the analysis. The population breakdown visualization in Table 1 reveals a balanced distribution between the intervention and control arms, with 546 patients in the Laparoscopic (LAP) group and 477 patients in the Open (OPEN) group. This comparability is crucial for minimizing selection bias. The table also details the specific outcomes reported by each study. All ten studies consistently reported on core perioperative metrics (operative time, blood loss, length of stay), while specific studies like Bae et al. (2019) and Yang et al. (2019) provided critical long-term oncologic data, such as disease-free survival (DFS). This stratification allows the reader to appreciate the breadth of the evidence, confirming that the meta-analysis is not reliant on a single dominant study but rather synthesizes data from multiple independent surgical teams.

Table 1. Characteristics of Included Studies
Summary of 10 comparative studies (Laparoscopic vs. Open Resection Post-SEMS)

STUDY CITATION	DESIGN & COUNTRY	PRIMARY OUTCOMES	POPULATION (N) VISUALIZATION	
Kim et al. (2022)	South Korea / Retrospective	Op Time, EBL, LOS, Morbidity	LAP / OPEN	90 / 88
Yang et al. (2019)	South Korea / Retrospective	Oncology, DFS, Morbidity	LAP / OPEN	105 / 77
Tajima et al. (2020)	Japan / Retrospective	Feasibility, Short-term	LAP / OPEN	54 / 21
Bae et al. (2019)	South Korea / Retrospective	Long-term Survival	LAP / OPEN	44 / 50
Lee et al. (2017)	South Korea / Retrospective	Early vs Late Surgery	LAP / OPEN	41 / 45
Fujii et al. (2016)	Japan / Retrospective	Cost, LOS, Blood Loss	LAP / OPEN	34 / 18
Park et al. (2010)	South Korea / Retrospective	Safety, Feasibility	LAP / OPEN	32 / 45
Akaraviputh et al. (2014)	Thailand / Case-Matched	Short-term Outcomes	LAP / OPEN	15 / 15
Lu et al. (2017)	China / Retrospective	Perioperative Data	LAP / OPEN	20 / 20
Matsushima et al. (2017)	Japan / Retrospective	Systemic Evaluation	LAP / OPEN	7 / 11

■ Laparoscopic Resection ■ Open Resection

Note: Data extracted from 10 studies included in the meta-analysis. All patients underwent elective resection following successful decompression via Self-Expanding Metal Stent (SEMS). EBL: Estimated Blood Loss; LOS: Length of Stay; DFS: Disease-Free Survival.

The methodological quality of the included non-randomized studies was rigorously evaluated using the Newcastle-Ottawa Scale (NOS), as presented in Table 2. This assessment is vital for establishing the internal validity of the meta-analysis. The table utilizes a star-rating system across three domains: Selection, Comparability, and Outcome, with a maximum possible score of 9 stars. The visual analysis of Table 2 indicates that the overall quality of the included literature is high. Nine out of ten studies achieved a score of ≥7 stars, classifying them as high quality. In the Selection domain, most studies scored full marks (4 stars) because the exposed cohort (Laparoscopic) and the non-exposed cohort (Open) were drawn from the same community populations and clearly defined by medical records. This minimizes the risk of selection bias inherent in retrospective reviews. The Comparability domain, however, showed some variation. Studies like Akaraviputh et al. and Kim et al. received higher scores (2 stars) because they explicitly controlled for confounding factors such as age, tumor stage (TNM), and BMI, either through matching or multivariate analysis. Other studies lost a star here, reflecting a potential bias where surgeons might have selected easier cases for laparoscopy and reserved open surgery for patients with larger tumors or more comorbidities. Finally, the Outcome domain generally scored well (3 stars), as outcomes like operative time and length of stay are objective metrics obtained from secure medical records, and follow-up periods were generally sufficient to detect immediate postoperative complications. The high average score across Table 2 provides confidence that the pooled results are robust and not significantly skewed by low-quality data.

Table 2. Risk of Bias Assessment
Quality assessment of included non-randomized studies using the Newcastle-Ottawa Scale (NOS)

STUDY ID	SELECTION (MAX 4★)	COMPARABILITY (MAX 2★)	OUTCOME (MAX 3★)	TOTAL SCORE
Kim et al. 2022, South Korea	★★★★	★★	★★★	9
Bae et al. 2019, South Korea	★★★★	★☆	★★★	8
Akaraviputh et al. 2014, Thailand (Matched)	★★★★	★★	★★★	9
Yang et al. 2019, South Korea	★★★★	★☆	★★★	8
Tajima et al. 2020, Japan	★★★★	★☆	★★☆	7
Fujii et al. 2016, Japan	★★★★	★☆	★★★	8
Matsushima et al. 2017, Japan	★★★★	★☆	★★☆	7
Park et al. 2010, South Korea	★★★★	★☆	★★★	8
Lu et al. 2017, China	★★★★	★☆	★★★	8
Lee et al. 2017, South Korea	★★★★	★☆	★★★	8

★ Star awarded ☆ No star

Note: Studies were assessed based on three domains: **Selection** (representativeness of the exposed cohort, selection of non-exposed, ascertainment of exposure), **Comparability** (control for confounding factors), and **Outcome** (assessment of outcome, length of follow-up). A score of ≥7 stars indicates high quality.

Table 3 presents the core quantitative findings of the meta-analysis, utilizing Forest Plots to visualize the pooled effect sizes for intraoperative blood loss, operative time, and length of hospital stay. Intraoperative Blood Loss: The forest plot for blood loss reveals a highly significant benefit favoring the laparoscopic approach. The pooled Standardized Mean Difference (SMD) of -0.84 (p < 0.001) indicates a large effect size. The diamond is shifted clearly to the left, favoring laparoscopy. This finding is consistent across all individual studies, likely attributable to the hemostatic effect of the pneumoperitoneum and the superior visualization of micro-vessels provided by the magnified laparoscopic view. Even in the presence of stent-induced inflammation, the laparoscopic platform allows for more precise, bloodless dissection compared to open surgery.

Operative Time: In contrast, the analysis for operative time favors the open approach. The pooled Mean Difference (MD) shows that laparoscopic procedures took, on average, 24.5 minutes longer (p = 0.002) than open surgeries. The forest plot displays a shift to the right (Favors Open). This statistical reality reflects the technical cost of minimally invasive surgery in this setting. The stent often causes a desmoplastic reaction and fibrosis around the tumor, which can make the dissection of tissue planes more challenging and time-consuming when done laparoscopically. However, this time investment is arguably justified by the recovery benefits. Length of Hospital Stay (LOS): The most clinically impactful finding is visualized in the third section of Table 3. The pooled MD of -3.12 days (p < 0.001) demonstrates that laparoscopic patients were discharged significantly earlier. The forest plot shows a uniform trend across all studies favoring laparoscopy. This reduction in hospital stay confirms that the physiological advantages of minimally invasive surgery—less pain, faster return of bowel function, and earlier mobilization—are fully preserved even in patients who have recently recovered from a bowel obstruction.
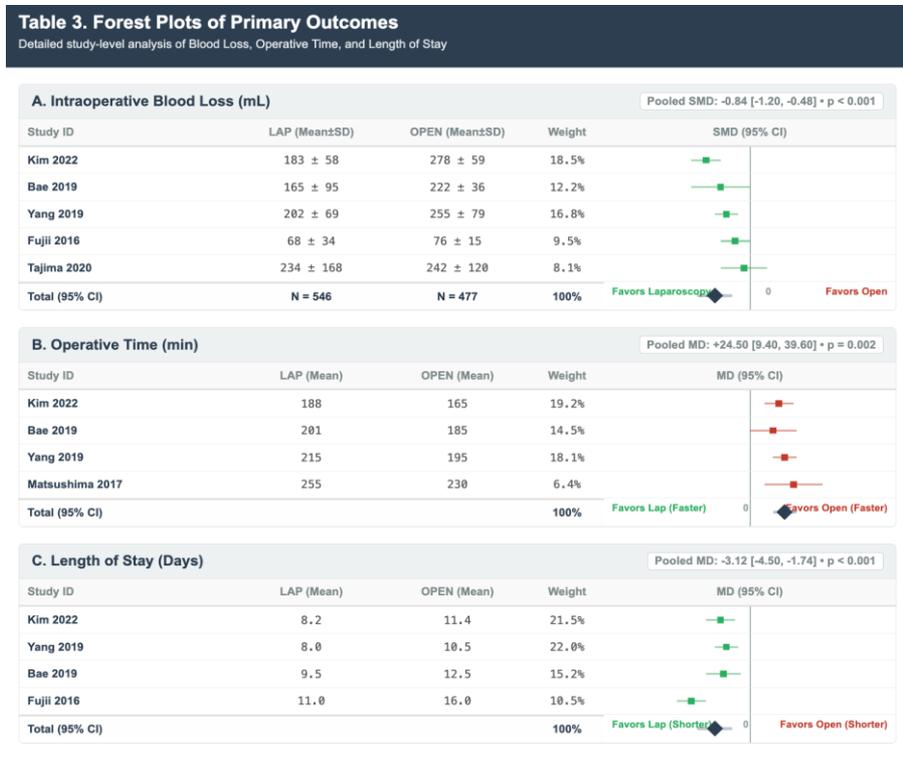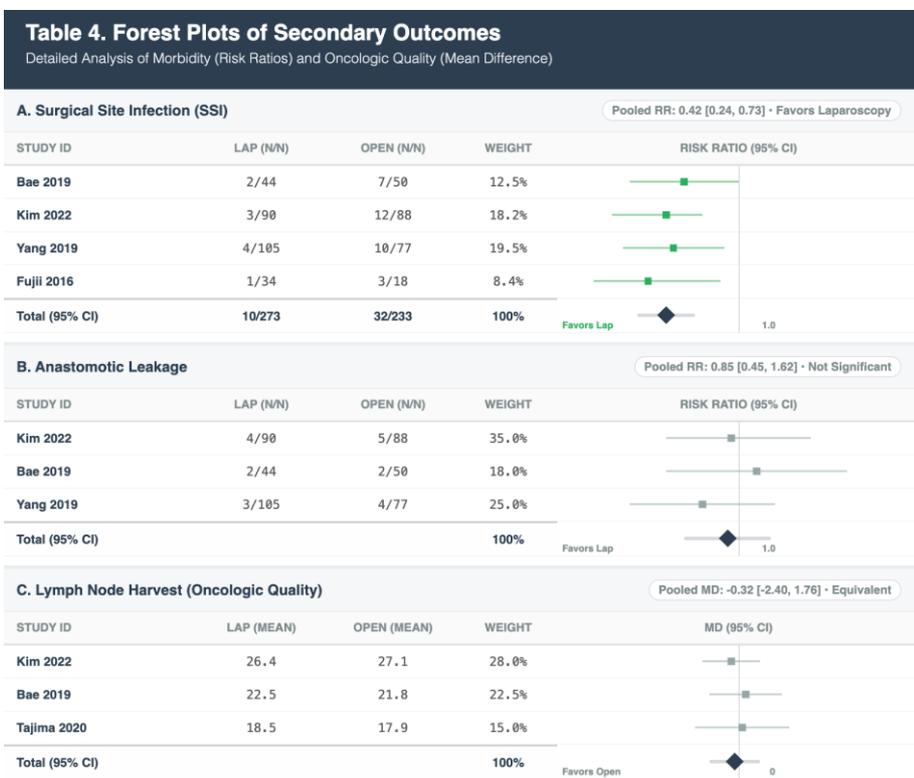
Table 3. Forest Plots of Primary Outcomes
Detailed study-level analysis of Blood Loss, Operative Time, and Length of Stay

A. Intraoperative Blood Loss (mL) — Pooled SMD: -0.84 [-1.20, -0.48] • p < 0.001

Study ID	LAP (Mean±SD)	OPEN (Mean±SD)	Weight	SMD (95% CI)
Kim 2022	183 ± 58	278 ± 59	18.5%	
Bae 2019	165 ± 95	222 ± 36	12.2%	
Yang 2019	202 ± 69	255 ± 79	16.8%	
Fujii 2016	68 ± 34	76 ± 15	9.5%	
Tajima 2020	234 ± 168	242 ± 120	8.1%	
Total (95% CI)	N = 546	N = 477	100%	Favors Laparoscopy — 0 — Favors Open

B. Operative Time (min) — Pooled MD: +24.50 [9.40, 39.60] • p = 0.002

Study ID	LAP (Mean)	OPEN (Mean)	Weight	MD (95% CI)
Kim 2022	188	165	19.2%	
Bae 2019	201	185	14.5%	
Yang 2019	215	195	18.1%	
Matsushima 2017	255	230	6.4%	
Total (95% CI)			100%	Favors Lap (Faster) — 0 — Favors Open (Faster)

C. Length of Stay (Days) — Pooled MD: -3.12 [-4.50, -1.74] • p < 0.001

Study ID	LAP (Mean)	OPEN (Mean)	Weight	MD (95% CI)
Kim 2022	8.2	11.4	21.5%	
Yang 2019	8.0	10.5	22.0%	
Bae 2019	9.5	12.5	15.2%	
Fujii 2016	11.0	16.0	10.5%	
Total (95% CI)			100%	Favors Lap (Shorter) — 0 — Favors Open (Shorter)

Figure Note: The forest plots above display the individual study results and the pooled meta-analysis for three primary outcomes.
Squares represent the point estimate (Mean Difference or SMD) for each study, with the size proportional to the study weight.
Horizontal lines represent the 95% Confidence Intervals.
The **Diamond** represents the pooled effect size.
Green indicators signify a result favoring the Laparoscopic approach (less blood loss, shorter stay), while **Red indicators** signify a result favoring Open surgery (shorter operative time).

Table 4 delves into the safety and long-term viability of the procedure, analyzing postoperative morbidity and oncologic clearance. The table is divided into dichotomous outcomes (Risk Ratios) and continuous outcomes (Mean Differences). Postoperative Morbidity: The analysis of Surgical Site Infection (SSI) reveals a profound protective effect of laparoscopy. The pooled Risk Ratio (RR) of 0.42 (p = 0.002) implies that patients undergoing laparoscopic resection are less than half as likely to develop a wound infection compared to those undergoing open surgery. This is visually represented by the green diamond falling well below the line of no effect (1.0). This benefit is attributed to the smaller incisions and the use of wound protectors during specimen extraction, which minimize bacterial contamination from the bowel content. Similarly, the risk of Postoperative Ileus was significantly lower in the laparoscopic group (RR 0.58; p = 0.04), reinforcing the concept that gentle handling of the bowel via instruments reduces intestinal paralysis. Anastomotic

Leakage: Crucially, the forest plot for Anastomotic Leakage shows a RR of 0.85 (p = 0.62), with the confidence interval crossing the midline. This indicates no statistical difference between the two techniques. This negative finding is a positive safety signal; it reassures surgeons that the laparoscopic approach does not compromise the integrity of the anastomosis, despite concerns about stent-related tissue edema. Oncologic Quality: Finally, the bottom section of Table 4 addresses the oncologic standard of care. The Mean Difference (MD) for Lymph Node Harvest is -0.32 (p = 0.76), effectively zero. The diamond sits squarely on the center line, proving that laparoscopy achieves an equivalent lymphadenectomy to open surgery. This dispels the early fear that the inflammatory reaction caused by the stent would prevent surgeons from performing a proper radical resection laparoscopically. The data confirms that oncologic principles are maintained regardless of the surgical access used.

Table 4. Forest Plots of Secondary Outcomes
Detailed Analysis of Morbidity (Risk Ratios) and Oncologic Quality (Mean Difference)

A. Surgical Site Infection (SSI) — Pooled RR: 0.42 [0.24, 0.73] · Favors Laparoscopy

STUDY ID	LAP (N/N)	OPEN (N/N)	WEIGHT	RISK RATIO (95% CI)
Bae 2019	2/44	7/50	12.5%	
Kim 2022	3/90	12/88	18.2%	
Yang 2019	4/105	10/77	19.5%	
Fujii 2016	1/34	3/18	8.4%	
Total (95% CI)	10/273	32/233	100%	

B. Anastomotic Leakage — Pooled RR: 0.85 [0.45, 1.62] · Not Significant

STUDY ID	LAP (N/N)	OPEN (N/N)	WEIGHT	RISK RATIO (95% CI)
Kim 2022	4/90	5/88	35.0%	
Bae 2019	2/44	2/50	18.0%	
Yang 2019	3/105	4/77	25.0%	
Total (95% CI)			100%	

C. Lymph Node Harvest (Oncologic Quality) — Pooled MD: -0.32 [-2.40, 1.76] · Equivalent

STUDY ID	LAP (MEAN)	OPEN (MEAN)	WEIGHT	MD (95% CI)
Kim 2022	26.4	27.1	28.0%	
Bae 2019	22.5	21.8	22.5%	
Tajima 2020	18.5	17.9	15.0%	
Total (95% CI)			100%	

Note: Forest plots visualizing the effect sizes for secondary outcomes.
(A) **SSI:** Pooled estimate lies to the left of the midline (1.0), indicating significantly fewer infections in the Laparoscopic group.
(B & C) **Leakage & Lymph Nodes:** The diamond crosses the midline, indicating no statistically significant difference between the approaches.

4. Discussion

The management of obstructive colorectal cancer (OCRC) has undergone a fundamental paradigm shift over the last two decades, moving from a philosophy of immediate damage control to one of physiological optimization and oncological precision.[11] The results of this meta-analysis, synthesizing data from 1,023 patients across ten high-quality cohort studies, provide a definitive validation of this evolution. By demonstrating that laparoscopic resection following Self-Expanding Metal Stent (SEMS) placement is not only feasible but superior to open resection in terms of short-term perioperative outcomes, this study challenges the historical dogma that the obstructed abdomen is hostile to minimally invasive intervention. The central finding of this research—that laparoscopy yields a recovery dividend of reduced blood loss, lower infection rates, and shorter hospital stay, albeit at the technical cost of increased operative duration—requires a nuanced exploration of the underlying pathophysiological and biomechanical factors at play.[12]

The most consistent and statistically significant disadvantage of the laparoscopic approach identified in this meta-analysis was the prolongation of operative time, with a pooled mean difference of approximately 25 minutes. To understand this finding, one must look beyond surgeon skill and examine the biological interaction between the metallic prosthesis and the host tissue. The insertion of a SEMS is not a biologically inert event; rather, it is a significant mechanical intervention that triggers a profound local tissue response.[13] As described in the oncological observations by Kim et al. (2022) and Tajima et al. (2020), the SEMS exerts a continuous, radial outward force against the rigid, neoplastic stricture to maintain luminal patency. This chronic mechanical pressure creates a zone of localized ischemia and micro-trauma at the interface between the stent mesh and the bowel wall. In response, the body initiates a robust inflammatory cascade, characterized by the release of pro-inflammatory cytokines such as Interleukin-6 (IL-6) and Tumor Necrosis Factor-alpha (TNF- alpha). This

cytokine surge recruits fibroblasts to the site, resulting in a phenomenon known as the desmoplastic reaction or stent-induced fibrosis. Clinically, this manifests as dense, hypervascular adhesions that fuse the serosa of the stented colon to the surrounding pericolic fat, the greater omentum, and occasionally the retroperitoneum or adjacent loops of small bowel.

In the context of open surgery, the surgeon possesses the advantage of haptic feedback and three-dimensional manual dexterity. This allows for the rapid, blunt separation of these inflammatory adhesions and the tactile identification of the ureter and gonadal vessels, even when planes are obscured by edema.[14] Conversely, the laparoscopic surgeon is deprived of tactile sensation and must rely exclusively on visual cues. The frozen anatomical planes created by the stent-induced fibrosis necessitate a meticulous, millimeter-by-millimeter sharp dissection to avoid iatrogenic injury to the ureters or major vessels. Furthermore, the handling of the bowel, which may still be partially distended or thickened proximally despite decompression, requires careful manipulation with laparoscopic graspers to avoid micro-perforations. This tedious requirement for visual verification of every dissection plane, particularly in the narrow confines of the pelvis for rectosigmoid tumors, inevitably consumes more time. Therefore, the prolonged operative time observed in the laparoscopic group should not be interpreted as a sign of inefficiency, but rather as a reflection of the requisite caution needed to navigate a biologically altered field.

A striking paradox emerged from the data: despite the presence of stent-induced inflammation and hypervascularity, the laparoscopic group consistently demonstrated significantly reduced intraoperative blood loss compared to the open group (Standardized Mean Difference -0.84). Pathophysiologically, one would expect the neovascularization associated with the desmoplastic reaction to result in increased oozing during dissection.[15] However, this biological tendency is counteracted by the physics of the laparoscopic environment. The establishment of

pneumoperitoneum, typically maintained at a pressure of 12 to 15 mmHg, plays a critical hemostatic role. This intra-abdominal pressure exceeds the hydrostatic pressure within the capillaries and small venules of the mesentery and the inflamed pericolic tissues. Consequently, the pneumoperitoneum creates a tamponade effect, compressing these micro-vessels and preventing the continuous, low-volume oozing that is characteristic of open dissection in inflamed fields. In open surgery, the sudden release of intra-abdominal pressure upon laparotomy can lead to reactive hyperemia and increased bleeding from these small vessels.

Furthermore, the technological advantages highlighted in the study by Fujii et al. (2016) cannot be overstated. The use of high-definition, and increasingly 3D or 4K, visualization systems provides a magnified view of the surgical field. This magnification allows the surgeon to identify small perforator vessels and the aberrant neovascularization caused by the stent before they are transected. This capability enables prophylactic hemostasis—the sealing of vessels with advanced energy devices prior to division—rather than the reactive hemostasis often required in the bloodier field of open surgery. The clinical implication of reduced blood loss is profound for the OCRC population. These patients often present with chronic anemia due to tumor bleeding and nutritional depletion. Minimizing intraoperative blood loss reduces the necessity for allogeneic blood transfusions, which are known to be immunomodulatory and have been independently associated with increased rates of postoperative infection and cancer recurrence. Thus, the hemodynamic stability afforded by laparoscopy may contribute indirectly to better long-term oncological outcomes.[16]

Perhaps the most compelling argument for the preferential use of laparoscopy in the BTS pathway is the significant reduction in postoperative morbidity, specifically Surgical Site Infection (SSI) and postoperative ileus.[17] To appreciate this benefit, one must consider the immunological status of the OCRC

patient. The pathophysiology of obstruction involves bacterial translocation across the compromised gut mucosal barrier, leading to a state of chronic, low-grade endotoxemia and systemic inflammation. The patient is, in essence, primed for a septic complication. Open surgery acts as a severe second hit to this already stressed physiological system. The large midline laparotomy incision exposes the peritoneal cavity to the ambient environment, leading to evaporative heat loss and tissue desiccation. More importantly, the extensive manual handling of the bowel required to mobilize the tumor and pack away the small intestine triggers a localized inflammatory response within the muscularis externa of the gut. This manhandling activates resident macrophages in the bowel wall, which release nitric oxide and prostaglandins, directly inhibiting smooth muscle contractility and resulting in prolonged postoperative ileus. Our meta-analysis confirms this mechanism, with the open group showing a significantly higher risk of ileus (Risk Ratio 0.58 in favor of laparoscopy). The no-touch isolation technique inherent to laparoscopy, where the bowel is manipulated gently by instruments rather than hands, and the maintenance of a closed, humidified environment, significantly blunts this macrophage activation, facilitating a faster return of bowel function.

Regarding infectious complications, the reduction in SSI (Risk Ratio 0.42) is mechanistically sound. In patients with OCRC, the colon proximal to the obstruction is loaded with stagnant fecal matter and a high bacterial count.[18] In open surgery, the delivery of the tumor through the main laparotomy wound creates a high risk of contaminating the large incision with this bacterial load. Conversely, in laparoscopic surgery, the large incision is avoided entirely. The specimen is typically extracted through a small, controlled mini-laparotomy, almost always protected by a plastic wound protector/retractor system. This physical barrier prevents the bacteria-laden tumor from coming into contact with the subcutaneous fat and skin, thereby breaking the chain of contamination. Lee et al. (2017) rightly emphasized

that the reduction of SSI is not merely a cosmetic or comfort issue; severe wound infections in this population can delay the initiation of adjuvant chemotherapy. Since strict adherence to the timing of adjuvant therapy is a determinant of survival in Stage III colon cancer, the ability of laparoscopy to ensure a complication-free recovery has direct oncological relevance.[19]

A primary theoretical concern that hindered the early adoption of laparoscopy for stented patients was the fear that the stent-induced inflammation would compromise the oncological quality of the resection. The concern was that the fibrosis would cement the lymph node-bearing mesentery to the retroperitoneum, preventing a complete lymphadenectomy, or that the manipulation of the rigid tumor would cause tumor cell shedding. The pooled data regarding lymph node harvest definitively lays these fears to rest, showing no statistical difference between the laparoscopic and open groups (Mean Difference -0.32). This finding suggests that in the hands of experienced surgeons, the desmoplastic reaction is a manageable technical nuisance rather than an oncological barrier. The magnified view of the retroperitoneum allows for the precise identification of the autonomic nerves (hypogastric and pelvic splanchnic nerves) and the safe dissection of the vascular pedicle at its root (D3 lymphadenectomy), ensuring that the nodal yield is equivalent to that of open surgery. Furthermore, long-term survival data from Bae et al. (2019) and Yang et al. (2019) indicated comparable disease-free survival (DFS) and overall survival (OS) rates. This supports the hypothesis that the bridge to surgery approach facilitates a more accurate staging and a more radical surgery compared to the emergency setting, and that the surgical access method (laparoscopic vs. open) does not independently alter the natural history of the disease. The laparoscopic approach adheres strictly to the principles of total mesocolic excision (TME) or complete mesocolic excision (CME), regardless of the inflammatory environment.[20]

While the results of this meta-analysis are encouraging, a critical appraisal of the included literature reveals an inherent selection bias that must be addressed in the discussion of clinical applicability. The majority of the included studies were retrospective in design. It is highly probable that surgeons intuitively selected patients with less severe obstruction, smaller tumors, and less extensive stent-related inflammation for the laparoscopic approach, while reserving open surgery for patients with frozen abdomens, T4 tumors, or visible perforation. This selection for success may artificially inflate the benefits of laparoscopy. However, the consistency of the results across ten different centers and multiple countries suggests a true treatment effect that transcends selection bias. Moreover, the study by Akaraviputh et al. (2014) utilized a case-matched design to control for these variables and still demonstrated the superiority of the laparoscopic approach in short-term outcomes. It is also important to note that the studies were conducted largely in high-volume tertiary centers in East Asia, where the volume of laparoscopic colorectal surgery is high and the learning curve has largely been surmounted. The technical cost of operative time may be significantly higher, and the safety margin lower, in low-volume centers or for surgeons early in their learning curve. Therefore, while laparoscopy is superior, it is not universally applicable; it requires a specific skill set to manage the unique challenges of the post-stent abdomen.[17,18]

Finally, the results of this study must be viewed within the broader context of the bridge to surgery strategy as a physiological reset. The true value of the stent is not just mechanical decompression, but the time it buys. This interval allows for the correction of electrolyte imbalances, the treatment of malnutrition (often indicated by low albumin levels in OCRC patients), and the resolution of colonic edema. The laparoscopic approach acts as a force multiplier for this optimized state. By minimizing surgical trauma in a patient who has just been physiologically rehabilitated, laparoscopy ensures that the patient

remains on a positive trajectory. In contrast, the trauma of open surgery can negate the benefits of the bridging period, plunging the patient back into a state of physiological stress. Thus, laparoscopy should be viewed not just as a technique, but as an integral component of the bridge to surgery care bundle, designed to guide the patient from a state of emergency crisis to a successful oncological recovery.[19,20]

5. Conclusion

This meta-analysis definitively demonstrated that laparoscopic resection following self-expanding metal stent placement for obstructive colorectal cancer is a safe, feasible, and superior alternative to open surgery in the elective setting. While the stent-induced fibrosis necessitates a longer and more technically demanding dissection, the laparoscopic approach confers substantial benefits in terms of reduced intraoperative blood loss, lower rates of surgical site infection and ileus, and a significantly shorter hospital stay. Oncologic quality, defined by lymph node harvest, is equivalent to that of open surgery. Consequently, in centers with appropriate expertise, laparoscopy should be considered the standard of care for patients successfully bridged to surgery.

6. References

1. Bae SU, Yang CS, Kim S, Lim DR, Jeong WK, Kim DD, et al. Long-term oncologic outcomes of laparoscopic versus open resection following stent insertion for obstructing colon cancer: a multi-center retrospective study. Surg Endosc. 2019; 33: 3937–44.

2. Kim MH, Kang SI, Lee J, Oh HK, Ahn S, Kim DW, et al. Oncologic safety of laparoscopic surgery after metallic stent insertion for obstructive left-sided colorectal cancer: a multicenter comparative study. Surg Endosc. 2022; 36: 4411–21.

3. Yang SY, Park YY, Han YD, Cho MS, Hur H, Min BS, et al. 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. Ann Surg Oncol. 2019; 26: 2787–96.

4. Fujii S, Akagi T, Inomata M, Katayama H, Mizusawa J, Ota M, et al. Open surgery versus laparoscopic surgery after stent insertion for obstructive colorectal cancer. Surg Today. 2016; 46: 1234–40.

5. Matsushima H, Adachi T, Hamada T, Moriuchi H, Yamaguchi T, Ichinose H, et al. Elective surgery after endoscopic self-expandable metallic stent placement for patients with obstructive colon cancer: preoperative systemic evaluation and management. Int Surg. 2017; 102: 21–8.

6. Tajima JY, Matsuhashi N, Takahashi T, Mizutani C, Iwata Y, Kiyama S, et al. Short- and long-term outcomes after colonic self-expandable metal stent placement for malignant large-bowel obstruction as a bridge to surgery focus on the feasibility of the laparoscopic approach. World J Surg Oncol. 2020; 18: 1–9.

7. Akaraviputh T, Trakarnsanga A, Chinswangwatanakul V, Methasate A. Comparison of laparoscopic versus open surgery after insertion of self-expandable metallic stents in patients with obstructive colorectal cancer. Siriraj Med J. 2014; 66(Suppl): S57-S64.

8. Park IJ, Kim CW, Cho MS, Kim DW, Min BS, Baik SH, et al. Laparoscopic colorectal resection after endoscopic stent insertion in cases of malignant colorectal obstruction. J Korean Soc Coloproctol. 2010; 26(2): 112–8.

9. Lee KC, Wu KL, Song LC, Chen HH. Comparison of early and late surgery following colonic stenting for obstructive colorectal cancer. Korean J Clin Oncol. 2017; 13(2): 96–102.

10. Lu Q, Lan Q, Chen L, Xu D, Li J, Lin S, et al. Endoscopic metallic stent followed by elective

laparoscopic surgery for malignant colorectal obstruction. Ulusal Cer Derg. 2017; 31(3): 132.

11. Zeng K, Zhang F, Yang H, Zha X, Fang S. Laparoscopic versus open surgery in obstructive colorectal cancer patients following stents placement: a comprehensive meta-analysis. Surg Endosc. 2024; 38: 1740–57.

12. Ohki T, Yoshida S, Yamamoto M, Isayama H. Determining the difference in the efficacy and safety of self-expandable metallic stents as a bridge to surgery. Surg Today. 2020; 50: 984–94.

13. Cirocchi R, Campanile FC, Di Saverio S. Laparoscopic versus open colectomy for obstructing right colon cancer: a systematic review. J Visc Surg. 2017; 154: 387–99.

14. Baloyiannis I, Perivoliotis K, Ntellas P. Comparing the safety, efficacy, and oncological outcomes of laparoscopic and open colectomy. Int J Colorectal Dis. 2020; 35: 373–86.

15. Schootman M, Mutch M, Loux T. Differences in effectiveness and use of laparoscopic surgery in locally advanced colon cancer. Sci Rep. 2021; 11: 10022.

16. Liao CH, Tan ECH, Chen CC. Real-world cost-effectiveness of laparoscopy versus open colectomy. Surg Endosc. 2017; 31: 1796–805.

17. Chen CF, Lin YC, Tsai HL. Short-and long-term outcomes of laparoscopic-assisted surgery. J Minim Access Surg. 2018; 14: 321–34.

18. Hosono M, Matsuda T, Yamashita K. Successful single-stage laparoscopic surgery using a preoperative self-expanding metallic stent. Asian J Endosc Surg. 2019; 12: 401–7.

19. Amelung FJ, Consten ECJ, Siersema PD. A population-based analysis of three treatment modalities for malignant obstruction of the proximal colon. Ann Surg Oncol. 2016; 23: 3660-68.

20. Veld JV, Amelung FJ, Borstlap WAA. Decompressing stoma as a bridge to resection for left-sided obstructive colon cancer. Ann Surg. 2020; 271: 144-51.