SYSTEMATIC REVIEW AND META-ANALYSIS

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Transforming outcomes: the pivotal role of self-expanding metal stents in right- and left-sided malignant colorectal obstructions-bridge to surgery: a comprehensive review and meta-analysis

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Transforming outcomes: the pivotal role of self-expanding metal stents in right- and left-sided malignant colorectal obstructions-bridge to surgery: a comprehensive review and meta-analysis

Aim

To compare surgical outcomes between self-expanding metallic stents (SEMS) as a bridge to surgery (BTS) and emergency surgery (ES) in patients with malignant colorectal obstruction

Methods

- A comprehensive database search until October 2023 to compare outcomes between SEMS as a BTS and ES
- 57 studies including 7,223 patients over a mean duration of 35.4 months

Results

- **Clinical success rate: 88.0%** (95% CI, 86.1%–90.1%)
- **Technical success rate: 91.6%** (95% CI, 89.7%–93.7%)
- **Reduced postoperative adverse events: OR 0.51** (95% CI, 0.41–0.63)
- **Reduced 30 day mortality: OR 0.52** (95% CI, 0.37–0.72)
- **Subgroup analysis**
  - Postoperative mortality: 5% and 1.5% for left- and right-sided malignancies
  - Adverse events: 15% and 33% for the left- and right colon

SEMS as a BTS demonstrated higher success rates, fewer postoperative adverse events, and a reduced 30-day mortality rate than ES, supporting its use as the preferred initial intervention for right- and left-sided obstructions.

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Background/Aims: Self-expanding metallic stents (SEMS) are an alternative to emergency surgery (ES) for malignant colorectal obstruction. This study aimed to compare surgical outcomes between SEMS as a bridge to surgery (BTS) and ES in patients with malignant colorectal obstruction.
Methods: A comprehensive database search was conducted until October 2023 to compare outcomes between SEMS as a BTS and ES. A subgroup analysis of results by malignancy site was performed.
Results: We analyzed 57 studies, including 7,223 patients over a mean duration of 35.4 months. SEMS as a BTS showed clinical and technical success rates of 88.0% (95% confidence interval [CI], 86.1%–90.1%; I^2=68%) and 91.6% (95% CI, 89.7%–93.7%; I^2=66%), respectively. SEMS as a BTS revealed reduced postoperative adverse events (odds ratio [OR], 0.51; 95% CI, 0.41–0.63; I^2=70%; p<0.001) and 30-day mortality (OR, 0.52; 95% CI, 0.37–0.72; I^2=10%; p<0.001) compared to ES. Subgroup analysis showed postoperative mortality of 5% and 1.5% for left- and right-sided malignancies, respectively. Adverse events were 15% and 33% for the right and left colon, respectively.
Conclusions: SEMS as a BTS demonstrated a higher success rate, fewer postoperative adverse events, and a reduced 30-day mortality rate than ES, supporting its use as the preferred initial intervention for right- and left-sided obstructions and indicating broader clinical adoption.

Keywords: Bridge to surgery; Colorectal neoplasm; Intestinal obstruction; Self-expanding metallic stents; Treatment outcomes

INTRODUCTION

Colon cancer is the fifth most common cancer responsible for malignancy-associated deaths.[1] Approximately 8% to 29% of individuals with colorectal cancer (CRC) are diagnosed after presenting with acute bowel obstruction.[2] Tumors located distal to the splenic flexure are usually implicated as a cause of acute obstruction, with the sigmoid colon being the most common location of obstruction.[3] Up until a few years ago, emergency resection was the primary treatment method for patients presenting with acute malignant colonic obstruction; however, in the recent past, self-expanding metallic stents (SEMS) as a bridge to surgery (BTS) have emerged as a safer alternative with lower postoperative mortality and morbidity.[4]

Many individual studies have been published since 1990, when SEMS were introduced as a BTS for the palliative treatment of incurable colonic malignancies.[5] For treatment with curative intent, stenting as a BTS is considered an alternative rather than the standard of care by both the European Society of Gastrointestinal Endoscopy and the American Society of Colon and Rectal Surgeons.[6]

Despite the recognized benefits of SEMS as a BTS over emergency surgery (ES), such as lower postoperative mortality, reduced permanent stoma rates, quicker recovery, and decreased need for maximally invasive surgery,[1,2,4,6,7] the literature has largely overlooked comparing the success rate of primary anastomosis when SEMS is used as a BTS versus ES across the entire colorectal tract. Previous studies often focused on specific obstruction sites without a comprehensive analysis or omitted to specify the location altogether, leaving a critical gap in understanding the broader efficacy of SEMS across different colorectal obstruction sites. This study aimed to fill this notable gap by evaluating the impact of obstruction sites on surgical outcomes and, particularly, the success rate of primary anastomosis, offering a more nuanced understanding of SEMS as a pre-surgical intervention for right- and left-sided malignant colorectal obstructions.

METHODS

This study adhered to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines.[8]

Search strategy

We conducted a comprehensive search of several databases and conference proceedings, including PubMed, Ovid, Cochrane, and CINHAL databases (from earliest inception to October 2023). An experienced medical librarian, using inputs from the study authors, helped with the literature search to identify studies reporting SEMS as a BTS in patients with malignant colorectal obstruction. The detailed literature search strategy is provided in Supplementary Material 1. Three authors (HK, AHS, and PY) independently reviewed the title and abstract of studies identified in the primary search and excluded studies that did not address the research question based on pre-specified exclusion and inclusion criteria. The full text of the remaining articles was reviewed to determine whether they contained relevant information. Any discrepancy in article selection was resolved by consensus or through discussion with a co-author (BPM). The bibliographic section of the selected articles, as well as the systematic and narrative articles on the topic, were manually searched for additional relevant articles.

Study selection

In this meta-analysis, we included studies that focused on the outcomes of SEMS as a BTS in patients with malignant colorectal obstruction. All the studies, irrespective of malignancy site, reporting technical and clinical success, postoperative adverse events, mortality, and anastomotic insufficiency rate were included. We considered studies from all geographic locations and in any publication status (abstract or manuscript) as long as they contributed necessary data for our analysis. Studies lacking adequate data for outcome estimation were excluded. Comparative analysis was conducted against ES, including procedures such as emergency resection. For cases of multiple reports from the same patient cohort, we included data from the most recent and comprehensive publication.

Data abstraction and quality assessment

Data on study-related outcomes in the individual studies were abstracted independently into a standardized form by three authors (HK, AHS, and PY). The risk of bias was assessed in the included studies using the Newcastle Ottawa Scale for observational studies and the Jaded scale for randomized control trials (RCTs).

Outcomes assessed

The outcomes of interest were pooled rates of technical success, clinical success, postoperative adverse events, and 30-day mortality for SEMS as a BTS. Additionally, the pooled odds ratio (OR) of postoperative adverse events, 30-day mortality, and successful primary anastomosis with SEMS as a BTS versus ES were calculated. A subgroup analysis was planned based on the site of obstruction of the malignancy (right colon, left colon, unspecified).

Statistical analysis

We used meta-analysis techniques to calculate the pooled estimate in each case, following the methods suggested by DerSimonian and Laird[9] using the random effects model; our application can be considered to align with their general approach, where the effect is measured by risk probability. When the incidence of an outcome was zero in a study, a correction of 0.01 was added to the number of incident cases before statistical analysis.[10] We assessed heterogeneity between study-specific estimates using Cochran's Q and I^2 statistics.[11,12] In heterogeneity assessment, values of <30%, 30% to 60%, 61% to 75%, and >75% were suggestive of low, moderate, substantial, and considerable heterogeneity, respectively.[13] Additionally, we calculated the 95% prediction interval, which deals with the dispersion of the effects. Publication bias was ascertained qualitatively by visual inspection of the funnel plot and quantitatively by the Egger test.[14] All analyses were performed using the Comprehensive Meta-Analysis software ver. 4 (BioStat).

RESULTS

Search results and population characteristics

Of the 3,899 citations identified by our literature search, 1,935 titles were screened, and 351 full-length articles were assessed for eligibility. The final meta-analysis included 57 studies (47 observational and 10 RCTs). The schematic diagram of the study selection is illustrated in Supplementary Fig. 1.

Characteristics and quality of included studies

The meta-analysis included 57 studies, with a total of 7,223 patients, and 58% of them were female. Forty-seven studies were observational, and 10 were RCTs. Four, 31, and 22 studies assessed outcomes of SEMS as a BTS in patients with right, left, and right and left combined (unspecified site) malignant colorectal obstructions, respectively.

The mean follow-up duration for SEMS as a BTS was approximately 29.04 months, whereas it was 33.23 months for ES. Supplementary Table 1 describes the baseline characteristics of the included studies.[1-6,15-63] Supplementary Tables 2 and 3 provide a detailed quality assessment of the included studies.[1-6,15-27,29-52,54-63]

Meta-analysis outcomes

1) Cumulative pooled rates for SEMS as a BTS

The overall pooled clinical and technical success rates for SEMS as a BTS were 88.0% (95% confidence interval [CI], 86.1%–90.1%; I^2=68%) and 91.6% (95% CI, 89.7%–93.7%; I^2=66%), respectively (forest plot, Figs. 1, 2). Postoperative adverse events (i.e., surgical site infection, intra-abdominal abscess, sepsis, postoperative bleeding, postoperative ileus, urinary tract infection, thrombosis, intensive care unit admission, stent migration, stent occlusion, fistula formation, perforation, anastomotic de-

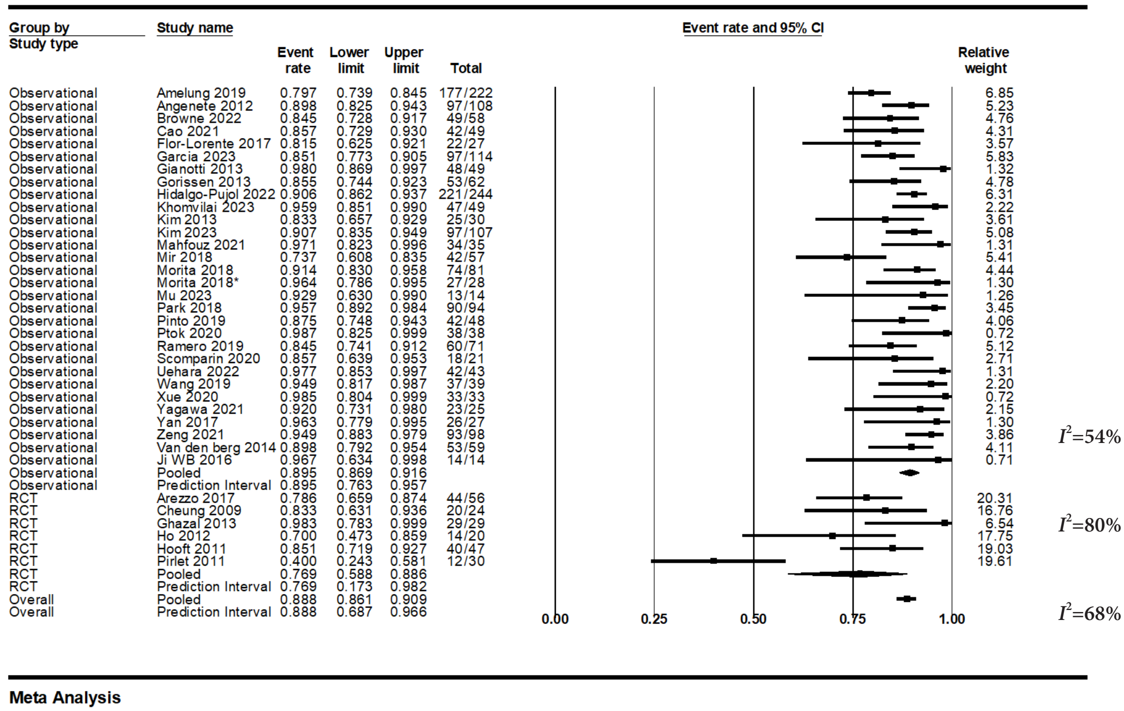


Fig. 1. Forest plot, pooled clinical success rate for self-expanding metallic stents as a bridge to surgery. CI, confidence interval.

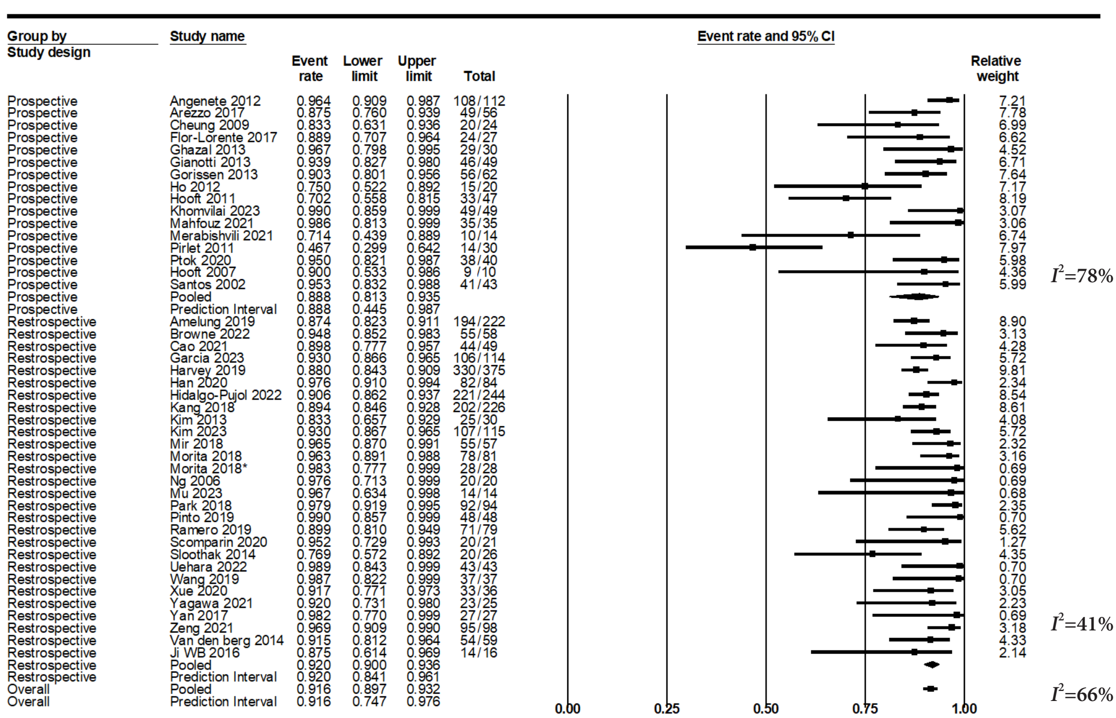


Fig. 2. Forest plot, pooled technical success rate for self-expanding metallic stents as a bridge to surgery. CI, confidence interval.

hiscence, anastomotic leakage, anastomotic stenosis, incisional hernia, cardiopulmonary complications [e.g., pneumonia and cardiac arrhythmia], tenesmus, abdominal-rectal pain, and stoma prolapse) and mortality rates for SEMS as a BTS were 21.6% (95% CI, 18.7%–24.9%; I^2=89%) and 4.6% (95% CI, 3.7%–5.9%; I^2=33%), respectively (forest plot, Figs. 3, 4). The anastomotic insufficiency rate (calculated from a number of non-successful anastomoses following SEMS/total number of anastomoses performed following SEMS) was 4.9% (95% CI, 3.9%–6.2%; I^2=29%) for SEMS as a BTS (forest plot, Fig. 5).

2) Cumulative pooled OR

The pooled OR of postoperative adverse events favored SEMS as a BTS (OR, 0.51; 95% CI, 0.41–0.63; I^2=70%; p<0.001) (forest plot, Fig. 6). Similarly, the OR for 30-day mortality was 0.52 (95% CI, 0.37–0.72; I^2=10%; p<0.001) (forest plot, Fig. 7), and successful primary anastomosis favored stent placement as a BTS (OR, 3.31; 95% CI, 2.09–5.25; I^2=67%; p<0.001) (forest plot, Fig. 8).

3) Subgroup analysis based on the site of obstruction

Subgroup analysis demonstrated high technical and clinical success pooled rates for SEMS as a BTS regardless of the site of obstruction. The pooled clinical success rate for SEMS as a BTS for right colon obstruction was 95.2% (95% CI, 90.3%–97.8%; I^2=0%) compared to 89.0% (95% CI, 80.9%–89.9%; I^2=73%) for left-sided colon obstruction. The technical success rate for SEMS as a BTS for the right- and left-sided colon obstruction was 95.2% (95% CI, 86.1%–98.4%; I^2=35%) and 89.9% (95% CI, 85.8%–92.9%; I^2=73%), respectively (Forest plot, Figs. 1, 2). Postoperative mortality rates for SEMS as a BTS were 5% (95% CI, 3%–6%; I^2=34%) and 1.5% (95% CI, 0.4%–5%; I^2=0%) for left- and right-sided malignancy, respectively (forest plot, Fig. 4). Postoperative adverse events for SEMS as a BTS were 15% (95% CI, 10%–21%; I^2=0%) for the right colon and 33% (95% CI, 30%–35%; I^2=91%) for the left colon (forest plot, Fig. 3). Comparing postoperative adverse events between SEMS as a BTS and ES, OR favored SEMS across all subgroups with OR, 0.28 (95% CI, 0.14–0.55; I^2=0%; p<0.001) for right-sided vs. OR, 0.55 (95% CI, 0.41–0.74; I^2=65%; p<0.001) for left-sided obstruction (forest plot, Fig. 6).

Validation of meta-analysis results

1) Heterogeneity and sensitivity analysis

To assess the possible dominant effect of individual studies on the meta-analysis, we excluded one study at a time and ana-

Group by Location	Study name	Statistics for each study: Event rate	Lower limit	Upper limit	Total	Relative weight	
Asia	Alkhayal 2020	0.417	0.241	0.617	10/24	4.26	
Asia	Cao 2021	0.224	0.129	0.362	11/49	5.33	
Asia	Cheung 2009	0.020	0.001	0.251	0/24	0.54	
Asia	Ghazal 2013	0.138	0.053	0.315	4/29	2.95	
Asia	Han 2020	0.167	0.101	0.262	14/84	6.25	
Asia	Ho 2012	0.350	0.177	0.574	7/20	3.61	
Asia	Katsuki 2021	0.233	0.198	0.272	116/498	10.55	
Asia	Khomvilai 2023	0.286	0.177	0.426	14/49	5.80	
Asia	Kim 2023	0.200	0.137	0.283	23/115	7.55	
Asia	Li 2020	0.114	0.044	0.268	4/35	3.02	
Asia	Mahfouz 2021	0.200	0.098	0.364	7/35	4.15	
Asia	Morita 2018	0.198	0.125	0.298	16/81	6.53	
Asia	Morita 2018*	0.107	0.035	0.284	3/28	2.43	
Asia	Ng 2006	0.300	0.141	0.527	6/20	3.41	
Asia	Mu 2023	0.077	0.011	0.391	1/13	0.97	
Asia	Park 2018	0.021	0.005	0.081	2/94	1.88	
Asia	Uehara 2022	0.256	0.148	0.405	11/43	5.21	
Asia	Wang 2019	0.162	0.075	0.317	6/37	3.86	
Asia	Wang 2020	0.222	0.124	0.366	10/45	5.07	
Asia	Xue 2020	0.273	0.148	0.447	9/33	4.58	
Asia	Yagawa 2021	0.240	0.112	0.442	6/25	3.61	
Asia	Yan 2017	0.018	0.001	0.230	0/27	0.54	
Asia	Zeng 2021	0.184	0.119	0.273	18/98	6.92	I^2=45%
Asia	Ji WB 2016	0.071	0.010	0.370	1/14	0.97	
Asia	Pooled	0.203	0.171	0.239			
Asia	Prediction Interval	0.203	0.114	0.335			
Europe	Alca ´ntaray 2011	0.133	0.034	0.405	2/15	3.30	
Europe	Arnarson 2022	0.469	0.388	0.550	67/143	5.49	
Europe	Amelung 2019	0.779	0.720	0.829	173/222	5.50	
Europe	Angenete 2012	0.223	0.156	0.310	25/112	5.34	
Europe	Arezzo 2017	0.518	0.389	0.645	29/56	5.22	
Europe	Fiori 2012	0.091	0.013	0.439	1/11	2.39	
Europe	Flor-Lorente 2017	0.370	0.212	0.562	10/27	4.74	
Europe	Garcia 2023	0.360	0.277	0.452	41/114	5.42	
Europe	Gianotti 2013	0.245	0.145	0.383	12/49	4.99	
Europe	Gorissen 2013	0.081	0.034	0.180	5/62	4.47	
Europe	Harvey 2019	0.136	0.105	0.175	51/375	5.52	
Europe	Hidalgo-Pujol 2022	0.451	0.389	0.514	110/244	5.57	
Europe	Hooft 2011	0.532	0.391	0.668	25/47	5.13	
Europe	Mir 2018	0.298	0.194	0.428	17/57	5.14	
Europe	Pinto 2019	0.146	0.071	0.276	7/48	4.70	
Europe	Pirlet 2011	0.267	0.139	0.450	8/30	4.68	
Europe	Ramero 2019	0.155	0.088	0.259	11/71	5.01	
Europe	Tanis 2015	0.313	0.252	0.381	61/195	5.52	
Europe	Hooft 2007	0.958	0.575	0.997	11/11	1.58	I^2=93%
Europe	Santos 2002	0.395	0.262	0.546	17/43	5.07	
Europe	Van den berg 2014	0.390	0.275	0.519	23/59	5.22	
Europe	Pooled	0.322	0.238	0.419			
Europe	Prediction Interval	0.322	0.065	0.765			
United States	Browne 2022	0.086	0.036	0.191	5/58	30.92	
United States	Dolan 2021	0.101	0.061	0.163	14/139	45.25	
United States	Merabishvili 2021	0.286	0.111	0.561	4/14	23.83	I^2=54%
United States	Pooled	0.126	0.065	0.229			
United States	Prediction Interval	0.126	0.000	0.997			
Overall	Pooled	0.216	0.187	0.249			I^2=89%
Overall	Prediction Interval	0.216	0.049	0.595			

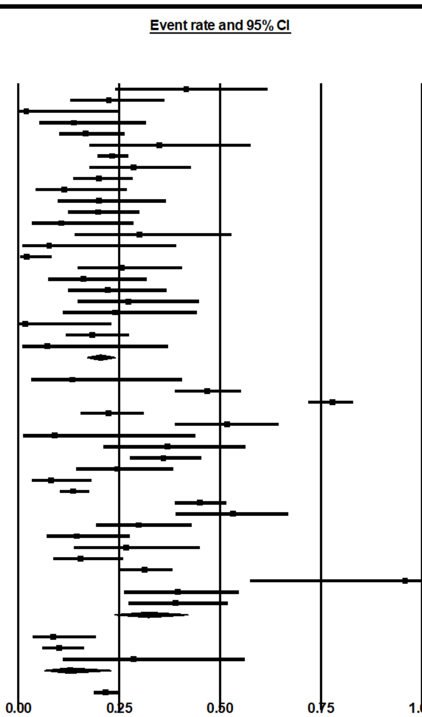
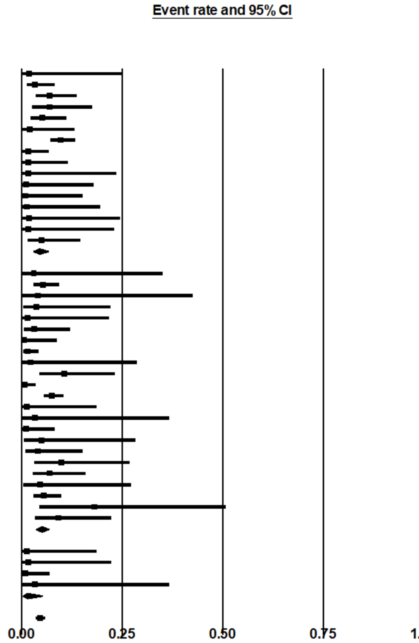


Fig. 3. Forest plot, pooled postoperative adverse events rate for self-expanding metallic stents as a bridge to surgery. CI, confidence interval.

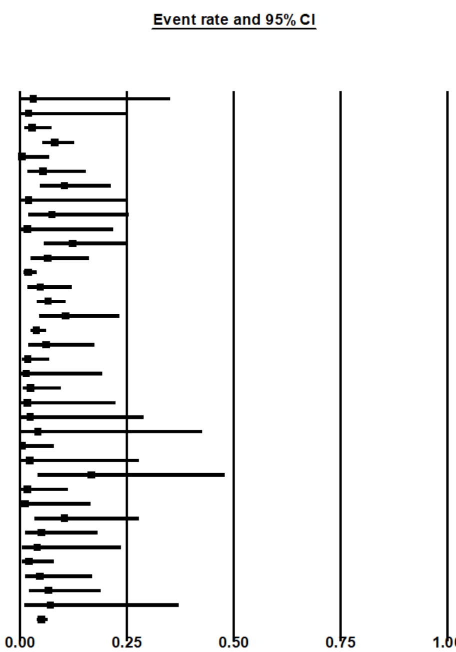
Group by Site	Study name	Event rate	Lower limit	Upper limit	Total	Relative weight	
Both/unspecified location	Alkhayal 2020	0.020	0.001	0.251	0/24	1.95	
Both/unspecified location	Arnarson 2022	0.035	0.015	0.081	5/143	10.88	
Both/unspecified location	Angenete 2012	0.071	0.036	0.136	8/112	13.30	
Both/unspecified location	Arezzo 2017	0.071	0.027	0.175	4/56	9.42	
Both/unspecified location	Garcia 2023	0.053	0.024	0.112	6/114	11.80	
Both/unspecified location	Gianotti 2013	0.020	0.003	0.131	1/49	3.58	
Both/unspecified location	Harvey 2019	0.099	0.072	0.133	37/375	19.55	
Both/unspecified location	Kim 2023	0.017	0.004	0.067	2/115	6.20	
Both/unspecified location	Mir 2018	0.018	0.002	0.114	1/57	3.59	
Both/unspecified location	Sloothak 2014	0.019	0.001	0.236	0/26	1.95	
Both/unspecified location	Wang 2019	0.013	0.001	0.178	0/37	1.96	
Both/unspecified location	Wang 2020	0.011	0.001	0.151	0/45	1.96	
Both/unspecified location	Xue 2020	0.015	0.001	0.196	0/33	1.96	
Both/unspecified location	Yagawa 2021	0.019	0.001	0.244	0/25	1.95	
Both/unspecified location	Yan 2017	0.018	0.001	0.230	0/27	1.95	
Both/unspecified location	Van den berg 2014	0.051	0.016	0.146	3/59	8.00	I^2=37%
Both/unspecified location	Pooled	0.045	0.031	0.067			
Both/unspecified location	Prediction Interval	0.045	0.016	0.119			
Left-sided	Alca ´ntarav 2011	0.031	0.002	0.350	0/15	1.18	
Left-sided	Amelung 2019	0.054	0.031	0.093	12/222	10.93	
Left-sided	Fiori 2012	0.042	0.003	0.425	0/11	1.17	
Left-sided	Flor-Lorente 2017	0.037	0.005	0.221	1/27	2.19	
Left-sided	Ghazal 2013	0.017	0.001	0.217	0/29	1.19	
Left-sided	Gorissen 2013	0.032	0.008	0.120	2/62	3.91	
Left-sided	Han 2020	0.006	0.000	0.087	0/84	1.21	
Left-sided	Hidalgo-Pujol 2022	0.016	0.006	0.043	4/244	6.44	
Left-sided	Ho 2012	0.024	0.001	0.287	0/20	1.19	
Left-sided	Hooft 2011	0.106	0.045	0.231	5/47	6.97	
Left-sided	Kang 2018	0.009	0.002	0.035	2/226	3.98	
Left-sided	Katsuki 2021	0.076	0.056	0.103	38/498	14.56	
Left-sided	Mahfouz 2021	0.014	0.001	0.187	0/35	1.20	
Left-sided	Merabishvili 2021	0.033	0.002	0.366	0/14	1.18	
Left-sided	Morita 2018	0.012	0.002	0.082	1/81	2.24	
Left-sided	Ng 2006	0.050	0.007	0.282	1/20	2.17	
Left-sided	Pinto 2019	0.042	0.010	0.152	2/48	3.88	
Left-sided	Pirlet 2011	0.100	0.033	0.268	3/30	5.01	
Left-sided	Ramero 2019	0.070	0.030	0.158	5/71	7.13	
Left-sided	Scomparin 2020	0.048	0.007	0.271	1/21	2.17	
Left-sided	Tanis 2015	0.056	0.032	0.099	11/195	10.56	
Left-sided	Hooft 2007	0.182	0.046	0.507	2/11	3.43	I^2=34%
Left-sided	Santos 2002	0.093	0.035	0.223	4/43	6.12	
Left-sided	Pooled	0.050	0.037	0.068			
Left-sided	Prediction Interval	0.050	0.022	0.113			
Right sided	Li 2020	0.014	0.001	0.187	0/35	20.06	
Right sided	Morita 2018*	0.017	0.001	0.223	0/28	19.99	
Right sided	Zeng 2021	0.010	0.001	0.069	1/98	40.28	
Right sided	Ji WB 2016	0.033	0.002	0.366	0/14	19.67	I^2=0%
Right sided	Pooled	0.015	0.004	0.051			
Right sided	Prediction Interval						
Overall	Pooled	0.046	0.037	0.059			I^2=33%
Overall	Prediction Interval	0.046	0.021	0.100			



Meta Analysis

Fig. 4. Forest plot, pooled 30-day postoperative mortality rate for self-expanding metallic stents as a bridge to surgery. CI, confidence interval.

Study name	Statistics for each study: Event rate	Lower limit	Upper limit	Total	Relative weight
Alca ´ntarav 2011	0.031	0.002	0.350	0/15	0.73
Alkhayal 2020	0.020	0.001	0.251	0/24	0.74
Arnarson 2022	0.028	0.011	0.072	4/143	4.10
Amelung 2019	0.081	0.052	0.125	18/222	8.28
Angenete 2012	0.004	0.000	0.067	0/112	0.75
Arezzo 2017	0.054	0.017	0.153	3/56	3.30
Browne 2022	0.103	0.047	0.212	6/58	5.02
Cheung 2009	0.020	0.001	0.251	0/24	0.74
Flor-Lorente 2017	0.074	0.019	0.252	2/27	2.38
Ghazal 2013	0.017	0.001	0.217	0/29	0.74
Gianotti 2013	0.122	0.056	0.247	6/49	4.96
Gorissen 2013	0.065	0.024	0.160	4/62	4.00
Harvey 2019	0.019	0.009	0.039	7/375	5.75
Han 2020	0.048	0.018	0.120	4/84	4.05
Hidalgo-Pujol 2022	0.066	0.041	0.104	16/244	8.02
Hooft 2011	0.106	0.045	0.231	5/47	4.49
Katsuki 2021	0.038	0.024	0.059	19/498	8.54
Khomvilai 2023	0.061	0.020	0.173	3/49	3.28
Kim 2023	0.017	0.004	0.067	2/115	2.49
Li 2020	0.014	0.001	0.191	0/34	0.74
Morita 2018	0.025	0.006	0.093	2/81	2.48
Morita 2018*	0.017	0.001	0.223	0/28	0.74
Ng 2006	0.024	0.001	0.287	0/20	0.73
Mu 2023	0.042	0.003	0.425	0/11	0.72
Park 2018	0.005	0.000	0.079	0/94	0.75
Pinto 2019	0.023	0.001	0.277	0/21	0.73
Pirlet 2011	0.167	0.042	0.477	2/12	2.18
Ramero 2019	0.017	0.002	0.111	1/59	1.39
Uehara 2022	0.012	0.001	0.164	0/41	0.74
Wang 2019	0.103	0.034	0.276	3/29	3.17
Wang 2020	0.050	0.013	0.179	2/40	2.43
Yagawa 2021	0.040	0.006	0.235	1/25	1.36
Zeng 2021	0.020	0.005	0.078	2/98	2.49
Santos 2002	0.047	0.012	0.168	2/43	2.43
Van den berg 2014	0.067	0.022	0.187	3/45	3.27
Ji WB 2016	0.071	0.010	0.370	1/14	1.32
Pooled	0.049	0.039	0.062		
Prediction Interval	0.049	0.023	0.102		



I^2=29%

Meta Analysis

Fig. 5. Forest plot, pooled anastomotic insufficiency rate for self-expanding metallic stents as a bridge to surgery. CI, confidence interval.

Study name	Odds ratio	Lower limit	Upper limit	p-Value	Group-A	Group-B	Relative weight
Alca ´ntarav 2011	0.132	0.021	0.835	0.031	2/15	7/13	1.00
Alkhayal 2020	1.726	0.602	4.953	0.310	10/24	12/41	1.98
Arnarson 2022	1.576	1.114	2.231	0.010	67/143	467/1302	3.44
Amelung 2019	1.038	0.749	1.437	0.824	95/222	186/444	3.47
Angenete 2012	0.575	0.286	1.154	0.119	25/112	20/60	2.70
Arezzo 2017	0.790	0.378	1.648	0.530	29/56	34/59	2.62
Browne 2022	1.113	0.305	4.060	0.871	5/58	5/64	1.59
Cao 2021	1.287	0.480	3.450	0.617	11/49	9/49	2.10
Cheung 2009	0.040	0.002	0.734	0.030	0/24	8/24	0.47
Dolan 2021	0.861	0.403	1.840	0.699	14/139	16/139	2.56
Fiori 2012	0.450	0.035	5.843	0.542	1/11	2/11	0.59
Flor-Lorente 2017	0.952	0.368	2.467	0.920	10/27	21/55	2.17
Garcia 2023	0.337	0.186	0.610	0.000	41/114	50/80	2.93
Ghazal 2013	0.160	0.045	0.573	0.005	4/29	15/30	1.62
Gianotti 2013	0.593	0.248	1.417	0.240	12/48	18/50	2.33
Gorissen 2013	0.331	0.103	1.071	0.065	5/62	9/43	1.78
Harvey 2019	0.351	0.243	0.508	0.000	51/375	116/375	3.40
Han 2020	0.227	0.121	0.428	0.000	14/84	102/218	2.84
Hidalgo-Pujol 2022	0.368	0.260	0.520	0.000	110/244	221/320	3.44
Ho 2012	0.392	0.107	1.428	0.156	7/20	11/19	1.59
Hooft 2011	1.383	0.625	3.064	0.424	25/47	23/51	2.49
Katsuki 2021	1.110	0.824	1.495	0.494	116/498	107/498	3.52
Khomvilai 2023	0.506	0.235	1.088	0.081	14/49	34/77	2.55
Kim 2023	0.563	0.267	1.185	0.130	23/115	16/52	2.59
Li 2020	0.313	0.098	0.998	0.050	4/35	21/72	1.80
Mahfouz 2021	0.958	0.282	3.252	0.946	7/35	6/29	1.70
Merabishvili 2021	0.400	0.088	1.826	0.237	4/14	8/16	1.31
Mir 2018	0.425	0.150	1.207	0.108	17/57	10/20	1.99
Morita 2018	0.554	0.248	1.237	0.150	16/81	16/52	2.47
Morita 2018*	0.257	0.065	1.021	0.054	3/38	10/40	1.48
Ng 2006	0.125	0.013	1.160	0.067	1/13	8/20	0.75
Mu 2023	0.348	0.030	4.065	0.400	2/94	1/17	0.63
Park 2018	0.535	0.228	1.256	0.151	14/48	20/46	2.37
Pinto 2019	0.727	0.240	2.206	0.574	8/30	10/30	1.88
Ptok 2020	0.234	0.104	0.524	0.000	11/71	29/66	2.46
Sloothak 2014	0.610	0.443	0.839	0.002	61/195	631/1476	3.48
Tung 2012	0.898	0.374	2.152	0.809	11/43	18/65	2.32
Uehara 2022	145.667	5.298	4004.906	0.003	11/11	1/10	0.38
Hooft 2007	0.528	0.173	1.608	0.261	6/37	11/41	1.87
Wang 2019	0.354	0.143	0.877	0.025	10/45	21/47	2.25
Wang 2020	0.061	0.020	0.185	0.000	9/33	43/50	1.88
Xue 2020	0.192	0.062	0.597	0.004	6/25	23/37	1.84
Yagawa 2021	0.297	0.056	1.570	0.153	2/27	7/33	1.16
Yan 2017	0.486	0.269	0.880	0.017	18/98	62/196	2.93
Zeng 2021	0.351	0.112	1.098	0.072	6/20	22/40	1.83
Santos 2002	0.400	0.152	1.052	0.063	17/43	18/29	2.14
Van den berg 2014	0.412	0.191	0.888	0.024	23/59	31/51	2.55
Ji WB 2016	0.115	0.013	1.027	0.053	1/14	10/25	0.77
Pooled	0.512	0.413	0.635	0.000			
Prediction Interval	0.512	0.161	1.628				

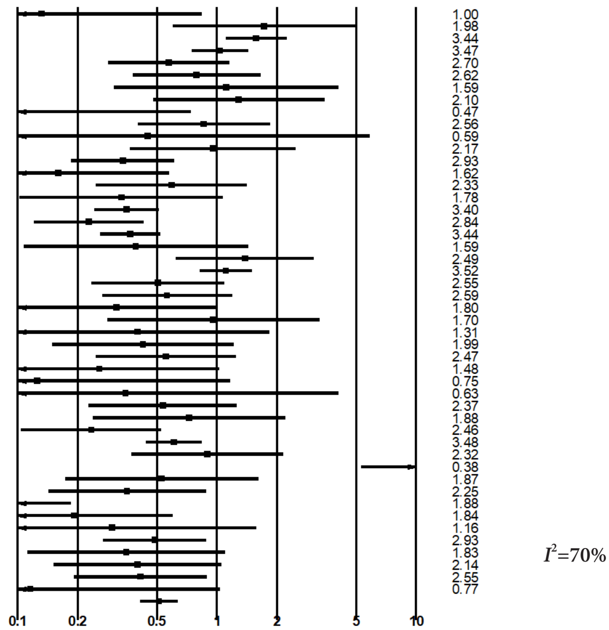


Fig. 6. Forest plot, pooled odd ratio for postoperative adverse events. CI, confidence interval.

Study name	Odds ratio	Lower limit	Upper limit	p-Value	Group-A	Group-B	Relative weight
Arnarson 2022	0.089	0.012	0.647	0.017	1/143	95/1302	2.62
Angenete 2012	0.308	0.118	0.802	0.016	8/112	12/60	9.14
Browne 2022	0.736	0.157	3.446	0.698	3/58	4/58	4.12
Cao 2021	1.000	0.061	16.453	1.000	1/49	1/49	1.35
Garcia 2023	0.833	0.245	2.831	0.770	6/114	5/80	6.18
Harvey 2019	0.197	0.086	0.452	0.000	7/375	33/375	11.31
Hooft 2011	1.095	0.296	4.052	0.892	5/47	5/51	5.51
Kang 2018	4.054	0.450	36.556	0.212	4/226	1/226	2.15
Kim 2023	0.289	0.047	1.785	0.181	2/115	3/52	3.06
Li 2020	0.671	0.027	16.901	0.809	0/35	1/72	1.03
Merabishvili 2021	0.356	0.013	9.467	0.537	0/14	1/16	1.00
Mir 2018	0.071	0.007	0.685	0.022	1/57	4/20	2.04
Morita 2018	0.313	0.028	3.537	0.347	1/81	2/52	1.78
Morita 2018*	0.462	0.018	11.757	0.640	0/28	1/40	1.02
Park 2018	0.623	0.099	3.912	0.614	2/48	3/46	3.01
Pinto 2019	3.222	0.316	32.889	0.324	3/30	1/30	1.94
Ptok 2020	0.924	0.255	3.349	0.905	5/71	5/66	5.66
Ramero 2019	9.878	0.387	251.857	0.166	1/21	0/67	1.02
Sloothak 2014	0.805	0.424	1.528	0.508	11/195	102/1476	15.80
Uehara 2022	5.526	0.234	130.343	0.289	2/11	0/10	1.07
Hooft 2007	0.211	0.010	4.534	0.320	0/37	2/41	1.13
Wang 2019	0.200	0.009	4.283	0.303	0/45	2/47	1.14
Wang 2020	0.154	0.008	2.962	0.215	0/33	4/50	1.22
Xue 2020	0.477	0.019	12.187	0.654	0/25	1/37	1.02
Yagawa 2021	0.394	0.015	10.065	0.573	0/27	1/33	1.02
Yan 2017	0.495	0.055	4.488	0.532	1/98	4/196	2.14
Zeng 2021	0.368	0.040	3.387	0.378	1/20	5/40	2.11
Santos 2002	0.322	0.085	1.225	0.096	4/43	7/29	5.32
Van den berg 2014	0.629	0.134	2.955	0.557	3/59	4/51	4.11
Pooled	0.518	0.372	0.722	0.000			
Prediction Interval	0.518	0.268	1.000				

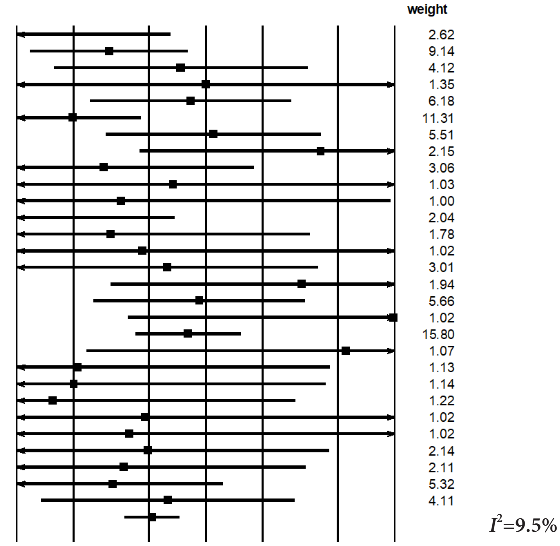
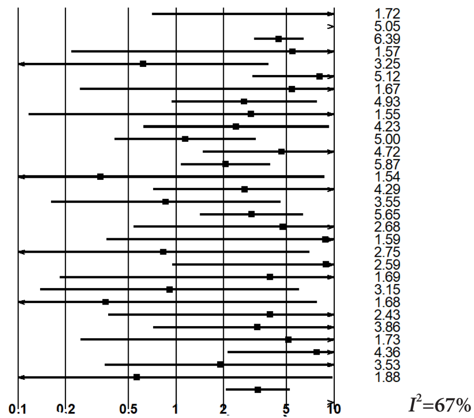


Fig. 7. Forest plot, pooled odd ratio for 30-day mortality. CI, confidence interval.

Study name	Odds ratio	Lower limit	Upper limit	p-Value	Group-A	Group-B	Relative weight
	Statistics for each study				Events / Total		
Alca ´ntarav 2011	14.684	0.709	304.318	0.082	15/15	9/13	1.72
Arnarson 2022	165.447	60.605	451.658	0.000	139/143	226/1302	5.05
Amelung 2019	4.492	3.145	6.415	0.000	165/222	174/444	6.39
Angenete 2012	5.471	0.219	136.397	0.300	108/108	59/60	1.57
Arezzo 2017	0.620	0.100	3.856	0.608	53/56	57/59	3.25
Browne 2022	8.141	3.065	21.627	0.000	52/58	33/64	5.12
Cheung 2009	5.444	0.248	119.632	0.282	24/24	22/24	1.67
Flor-Lorente 2017	2.710	0.946	7.760	0.063	21/27	31/55	4.93
Ghazal 2013	3.000	0.117	76.681	0.506	29/29	29/30	1.55
Gorissen 2013	2.411	0.625	9.301	0.202	45/49	28/34	4.23
Harvey 2019	1.146	0.411	3.193	0.794	368/375	367/375	5.00
Han 2020	4.661	1.487	14.608	0.008	68/72	62/79	4.72
Hidalgo-Pujol 2022	2.070	1.082	3.959	0.028	194/210	164/192	5.87
Ho 2012	0.333	0.013	8.697	0.509	19/20	19/19	1.54
Hooft 2011	2.727	0.724	10.269	0.138	15/20	11/21	4.29
Khomvilai 2023	0.865	0.163	4.589	0.865	32/35	37/40	3.55
Morita 2018	3.021	1.430	6.386	0.004	62/81	27/52	5.65
Morita 2018*	4.765	0.541	42.001	0.160	27/28	34/40	2.68
Ng 2006	8.846	0.366	213.798	0.180	11/11	6/8	1.59
Pinto 2019	0.833	0.099	7.027	0.867	10/12	12/14	2.75
Ptok 2020	8.923	0.950	83.784	0.055	58/59	26/30	2.59
Tung 2012	3.952	0.185	84.593	0.379	41/41	52/54	1.69
Hooft 2007	0.912	0.139	6.005	0.924	26/29	19/21	3.15
Wang 2019	0.358	0.016	7.807	0.514	38/40	21/21	1.68
Xue 2020	3.938	0.374	41.485	0.254	21/22	16/19	2.43
Yan 2017	3.295	0.722	15.030	0.124	95/97	173/185	3.86
Zeng 2021	5.151	0.251	105.585	0.287	19/19	26/29	1.73
Santos 2002	7.792	2.131	28.492	0.002	22/26	12/29	4.36
Van den berg 2014	1.909	0.355	10.258	0.451	42/45	22/25	3.53
Ji WB 2016	0.565	0.033	9.811	0.695	13/14	23/24	1.88
Pooled	3.308	2.086	5.248	0.000			
Prediction Interval	3.308	0.479	22.855				



Meta Analysis

Fig. 8. Forest plot, pooled odd ratio for successful primary anastomosis. CI, confidence interval.

lyzed the resulting effect on the main summary estimate. No single study significantly affected the outcomes of interest or the heterogeneity. Table 1 shows the I^2% values for all the studied pooled outcomes alongside the pooled rates. Subgroup sensitivity analyses based on the study design and geography are summarized in Tables 2 and 3.

2) Publication bias

Egger's regression output, with an intercept of -1.08405 and a two-tailed p=0.04, signifies the presence of publication bias in our meta-analysis, suggesting an under-representation of smaller or negative studies. The results are summarized in Table 4 and illustrated in Figure 9.

DISCUSSION

Our systematic review and meta-analysis evaluated the efficacy of SEMS as a BTS for malignant colorectal obstruction. The pooled results demonstrated excellent clinical (89%) and technical success (91.6%) rates and reduced the likelihood of postoperative adverse events and 30-day mortality, regardless of the site of colonic obstruction. The successful primary anastomosis was significantly greater when a colonic stent was deployed preoperatively.

Addressing the paramount concern of postoperative adverse events, our meta-analysis showed a pooled OR of 0.51, favoring SEMS as a BTS over ES. This convincing result aligns with the conclusions of previous studies[1,2,16] and emphasizes that patients who underwent SEMS placement experienced significantly fewer complications compared to those who underwent traditional surgery. For instance, a meta-analysis conducted by Arezzo et al.[17] demonstrated lower short-term overall morbidity and reduced rates of temporary and permanent stoma formation with SEMS placement. Similarly, a study by Jiménez-Pérez et al.[64] reported an overall complication rate of 7.8%, including perforation, stent migration, bleeding, persistent colonic obstruction, and stent occlusion due to fecal impaction in 3%, 1.2%, 0.6%, 1.8%, and 1.2%, respectively. Additionally, in line with previous analyses,[65,66] our study also demonstrated a reduced risk of 30-day mortality. These findings emphasize that SEMS offer an effective BTS treatment with an acceptable complication rate for patients with acute malignant colonic obstruction.

Another critical parameter influencing the choice between SEMS as a BTS and ES is the feasibility of achieving a successful primary anastomosis. Our analysis showed a significant advantage for stent placement, with an OR of 3.31, confirming and extending the results of previous studies.[4,18] This suggests that patients who undergo SEMS placement are more likely to receive a successful primary anastomosis, avoiding the need for ostomies and potentially improving their overall quality of life postoperatively.

Meta-analyses comparing SEMS as a BTS and ES, which include both left- and right-sided colonic tumors, are sparse in the literature. Two meta-analyses published within the last 2

Table 1. Meta-analysis of colonic stent placement outcomes in malignant colorectal obstruction: pooled rates and comparisons

Outcome	Pooled rate (95% CI)	Study (*n*)	*p*-value (for pooled ratio)	Heterogeneity (I^2 %)
Technical success (%)				
Overall	91.6 (89.5–93.3)	50		66
Unspecified site	92.3 (89.6–94.3)	18		40
Right colon	95.2 (86.1–98.4)	5		35
Left colon	89.9 (64.2–97.8)	27		73
Clinical success (%)				
Overall	88.9 (86–91.2)	21		68
Unspecified site	89.4 (84.9–92.7)	16		59
Right colon	95.3 (90.3–97.8)	5		0
Left colon	86 (80.9–89.9)	42		73
Postoperative adverse events (%)				
Overall	29 (27–31)	48		89
Unspecified site	26 (24–28)	18		86
Right colon	15 (10–21)	4		0
Left colon	33 (30–35)	26		91
Complications: stent vs. surgery, OR (95% CI)				
Overall	0.50 (0.40–0.623)	48	<0.001	70
Unspecified site	0.52 (0.37–0.73)	20	<0.001	70
Right colon	0.28 (0.14–0.55)	4	<0.001	0
Left colon	0.55 (0.41–0.74)	24	<0.001	65
Successful primary anastomosis, OR (95% CI)	3.31 (2.09–5.25)	30	<0.001	67
Postoperative mortality (%)				
Overall	4.6 (3.7–5.9)	53		33
Unspecified site	4.5 (3.1–6.7)	16		37
Right colon	1.5 (0.4–5.1)	4		0
Left colon	5 (2.2–11.3)	23		34
30-Day mortality, OR (95% CI)	0.52 (0.37–0.72)	29	<0.001	10
Tumor recurrence rate, OR (95% CI)	1.04 (0.82–1.33)	21	0.69	42
Anastomotic insufficiency (%)	4.9 (3.9–6.2)	36		29

CI, confidence interval; OR, odds ratio.

Table 2. Subgroup analysis based on study design

Study design	Clinical success rate (%, 95% CI)	I^2 (%)	Technical success rate (%, 95% CI)	I^2 (%)
Observational	89 (87–92)	54	92 (90–94)	63
RCTs	77 (59–89)	80	82 (70–90)	55

CI, confidence interval; RCT, randomized control trial.

Table 3. Subgroup analysis based on location

Location	Clinical success rate (%, 95% CI)	I^2 (%)	Technical success rate (%, 95% CI)	I^2 (%)
Asia	93 (91–96)	46	92 (88–94)	40
Europe	89 (85–92)	74	84 (78–88)	75
United States	88 (74–91)	68	87 (49–98)	82

CI, confidence interval.

Table 4. Eggers regression analysis including publication bias

Parameter	Value
Intercept	−1.08405
Standard Error	0.52233
95% lower limit (2-tailed)	−2.13544
95% upper limit (2-tailed)	−0.03265
t-value	2.07541
Degrees of freedom (df)	46
p-value (1-tailed)	0.02178
p-value (2-tailed)	0.04357

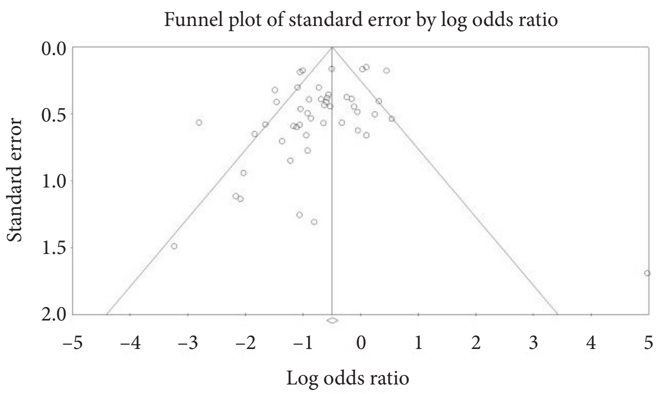


Fig. 9. Funnel plot for the postoperative adverse events between the emergency surgery vs. self-expanding metallic stents as a bridge to surgery for colorectal cancer obstruction.

years compared SEMS as a BTS and ES in only the right-sided colon and included less than 20 studies.[67,68] A meta-analysis published in 2020 compared surgical outcomes in patients with colonic malignancies regardless of site specification.[66] Our study extends the literature by confirming and extending that stent implantation is effective regardless of the site of obstruction.[65-68] This finding is crucial as it implies that the benefits of SEMS placement are not limited to a specific site in the colorectal tract, making it a versatile option for a variety of clinical scenarios.

Our systematic review and meta-analysis investigating the utilization of SEMS as a BTS for malignant colorectal obstruction, including both right- and left-sided CRC lesions, represents a significant advancement compared to prior meta-analyses.[65-68] Although previous meta-analyses have reported on the efficacy of SEMS, our analysis uniquely illuminates a higher success rate for primary anastomosis when SEMS was used as a BTS and provides a more comprehensive understanding of the benefit of SEMS at different anatomic sites, an aspect that has been relatively understudied in previous studies.[4,18]

However, similar to previous meta-analyses,[65-68] our study has some limitations. We encountered common challenges associated with large-scale studies of this nature. The inclusion of observational studies and RCTs could introduce bias into the analysis. Additionally, the significant heterogeneity observed in certain outcomes might be due to variations in study design, patient populations, and stent placement techniques. The strengths of this study lie in the careful selection of a large number of studies, along with subgroup analysis based on the site of malignancy. We believe the results of this study establish the role of SEMS in surgical candidates with malignant obstruction of the colon.

In conclusion, in our meta-analysis of 57 studies, including 7,223 patients, the use of SEMS as a BTS in patients with malignant colon obstruction was associated with excellent pooled clinical and technical success, with lesser chances of postoperative adverse events and 30-day mortality, regardless of the site of obstruction (right colon, left colon). Additionally, primary anastomosis was significantly better when SEMS was used preoperatively. In this day and age of healthcare, our study findings support that minimally invasive and clinically effective solutions to manage gastrointestinal conditions in a multidisciplinary manner are paramount for optimal patient outcomes.

Supplementary Material

Supplementary Material 1. Literature search strategy.

Supplementary Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.

Supplementary Table 1. Baseline characteristics of the studies.

Supplementary Table 2. Newcastle Ottawa scale for reporting observational studies.

Supplementary Table 3. Jaded scale for reporting randomized control trials.

Supplementary materials related to this article can be found online at https://doi.org/10.5946/ce.2024.120.

Ethical Statements

Not applicable.

Conflicts of Interest

Douglas G. Adler is a consultant for Boston Scientific. The other authors have no potential conflicts of interest.

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None.

Author Contributions

Conceptualization: SM, BPM; Data curation: HK, AHS; Formal analysis: PL; Methodology: PL, BPM; Project administration: BPM; Resources: SM; Software: PL; Supervision: DGA, SK; Validation: BPM, SM; Visualization: DGA, SK, PY, SC; Writing–original draft: SM, PY, SC, SK; Writing–review & editing: all authors.

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