International Journal of Colorectal Disease (2024) 39:148
https://doi.org/10.1007/s00384-024-04724-6

REVIEW

Palliative procedures for advanced obstructive colorectal cancer: a systematic review and meta-analysis

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Accepted: 15 September 2024 / Published online: 23 September 2024

Abstract

Purpose Advanced obstructive colorectal cancer (AOCC) presents surgical challenges. Consideration must be given to alleviating symptoms and also quality of life and survival time. This study compared prognostic efficacies of palliative self-expanding metal stents (SEMSs) and surgery to provide insights into AOCC treatment.

Methods PubMed, Web of Science, MEDLINE, and Cochrane Library were searched for studies that met inclusion criteria. Using a meta-analysis approach, postoperative complications, survival rates, and other prognostic indicators were compared between patients treated with SEMSs and those treated surgically. Network meta-analysis was performed to compare prognoses between SEMS, primary tumor resection (PTR), and stoma/bypass (S/B).

Results Twenty-one studies were selected (1754 patients). The odds ratio (OR) of SEMS for clinical success compared with surgery was 0.32 (95% confidence interval [CI] 0.15, 0.65). The ORs for early and late complications were 0.34 (95% CI 0.19, 0.59) and 2.30 (95% CI 1.22, 4.36), respectively. The ORs for 30-day mortality and stoma formation were 0.65 (95% CI 0.42, 1.01) and 0.11 (95% CI 0.05, 0.22), respectively. Standardized mean difference in hospital stay was − 2.08 (95% CI − 3.56, 0.59). The hazard ratio for overall survival was 1.24 (95% CI 1.08, 1.42). Network meta-analysis revealed that SEMS had the lowest incidence of early complications and rate of stoma formation and the shortest hospital stay. PTR ranked first in clinical success rate and had the lowest late-complication rate. The S/B group exhibited the lowest 30-day mortality rate.

Conclusion Among palliative treatments for AOCC, SEMSs had lower early complication, stoma formation, and 30-day mortality rates and shorter hospital stays. Surgery had higher clinical success and overall survival rates and lower incidence of late complications. Patient condition/preferences should be considered when selecting AOCC treatment.

Keyword Advanced obstructive colorectal cancer; Bypass; Palliative; Resection; Self-expanding metal stents; Stoma

Background

Colorectal cancer (CRC) is the third most common cancer in the USA and ranks second in cancer-related mortality. In 2019, approximately 60% of newly diagnosed cases were in advanced stages, and this proportion has been gradually increasing [1]. With the recent enhanced standardization of CRC screening, an increasing number of younger patients have been diagnosed. Moreover, advanced-stage cases are more prevalent in this demographic group. Obstruction is the most common complication of CRC; approximately 30% of patients exhibit symptoms of obstruction, which often correlates with a poor prognosis [2, 3]. The condition of patients with advanced obstructive colorectal cancer (AOCC) is particularly complex. These patients typically require urgent decompression to prevent severe abdominal distension, electrolyte imbalance, septic shock, or even death [4].

The placement of self-expanding metal stents (SEMSs) has increasingly become the standard treatment for relieving the symptoms of CRC obstruction. Initially designed to alleviate obstruction symptoms in patients with advanced stage disease, SEMS placement can serve as a bridge to surgery. For patients with AOCC, SEMS placement undoubtedly offers benefits such as minimal invasiveness, rapid relief, and high patient tolerance. However, clinicians must

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consider potential complications such as reobstruction, perforation, stent migration, and cancer cell dissemination. In addition, considering the long-term complications caused by SEMS, the SEMS is not convincing for the long-term prognosis of patients. In patients with AOCC eligible for chemotherapy and a long life expectancy, palliative treatments other than SEMS should be considered [5].

Traditionally, surgery has been a palliative treatment for AOCC. Procedures may include primary tumor resection and anastomosis, simultaneous stoma creation, simple stoma surgery, Hartmann's procedure, or bypass surgery. Surgical decisions, including the choice of procedure, are typically made by the surgeon based on the intraoperative findings and the patient's overall condition. Some studies have suggested that resection of the primary tumor can lead to better quality of life and improved overall survival rates in patients with advanced-stage disease [6, 7]. However, these benefits warrant further study and detailed discussion, particularly for patients exhibiting obstruction symptoms. Additionally, guidelines and studies investigating direct prognostic comparisons between various surgical approaches for patients with AOCC are lacking.

Several previous meta-analyses [8–11] have compared the palliative effects of SEMS and surgery for malignant colorectal obstruction (MCO). However, some of these studies [8–10] included patients with obstructions caused by other malignancies such as gynecological and urological cancers. Moreover, some studies [8, 11] used mean survival time to compare patient survival duration. We believe that hazard ratios (HR) are more convincing in comparing treatment approaches. Additionally, to our knowledge, no meta-analysis has directly compared the palliative efficacies of different surgical and other treatment methods for AOCC. To address these gaps in research, we conducted a meta-analysis involving a comprehensive search of the most recent comparative literature.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was used to direct this meta-analysis (Online Resource Table 1). The protocol of this meta-analysis had been registered on INPLASY registration. The registration number is INPLASY202470114.

Inclusion criteria

The following are the inclusion criteria:

1) Patients with advanced, incurable colorectal cancer.
2) Patients with obstructive colorectal cancer.
3) Patients who underwent SEMS or surgical procedures, including tumor resection with or without stoma creation, Hartmann's procedure, simple stoma creation, and bypass, among others, and in whom at least one outcome of interest was comparatively analyzed.
4) The study objective(s) addressed alleviating patient symptoms and facilitating prompt systemic treatment.

Exclusion criteria

The following are the exclusion criteria:

1) SEMS or surgical procedures intended for bridging to surgery (BTS).
2) Patients without obstructive symptoms.
3) Obstruction caused by malignancies other than AOCC.
4) Studies that did not compare outcomes or single-arm trials.

Search strategy

The following databases were searched: PubMed, Web of Science, MEDLINE, and Cochrane Library. There were no restrictions regarding the publication date or language, and all studies that met the inclusion criteria were included. Our search strategy was formulated based on the following keywords: "colorectal cancer," "advanced," "incurable," "obstruction," "palliative," "stent," "surgery," "stoma," and several related phrases (the search strategy is detailed in Online Resource Table 2). Two authors (BQ-M and CJ-C) independently conducted the literature search, eliminating duplicate publications and culminating in a database of studies for review.

Data extraction

Initially, two independent reviewers (BQ-M and CJ-C) individually read the titles and abstracts of the studies in the aforementioned databases and excluded literature that clearly did not meet the inclusion criteria. Subsequently, the two reviewers read the full texts to determine whether the remaining studies met the inclusion criteria. Two separate lists of eligible studies were produced using this process. Studies common to both lists were included; any discrepancies were resolved by a third reviewer (TX-R), and the final inclusion was decided through discussion. The following information was extracted from the studies: first author, year of publication, number of patients, tumor location, type and occurrence of complications, and study type. Specifically, for survival data, we compared the overall survival (OS) using the HR value and its 95% confidence interval (CI). We directly extracted studies in which HR data was included. If not available directly, Engauge Digitizer software was

used to analyze survival curves; a method detailed by Tierney et al. [12] was applied for computation. For continuous outcomes (length of hospital stay), the means and standard deviations were extracted. If outcomes could not be directly obtained, the method described by Hozo et al. [13] was used for computation. If the original study used nonparametric testing or if the data did not follow a normal distribution, the results were excluded.

Outcomes of interest

The following are the outcomes of interest:

Clinical success
Early complications: complications within 30 days after intervention
Late complications: complications 30 days after intervention
30-day mortality
Stoma formation rate
Hospital stay
Overall survival rate

Quality assessment

The Newcastle–Ottawa scale (NOS) was used to assess the quality of nonrandomized controlled trials (non-RCTs), while the Cochrane tools (risk of bias tool, Rob tool) were used for evaluating RCTs.

Statistical analysis: SEMS vs. surgery

All analyses were conducted using the meta package [14] in R software, version 4.3.1. The chi-square test and Student's *t*-test were used to compare differences between the two groups, with a p value < 0.05 indicating statistical significance. For the binary variable results, the odds ratio (OR) or risk ratio (RR) and their respective 95% CIs were used for meta-analysis and comparison. Continuous variables were compared using standardized mean difference (SMD) and 95% CI. If the 95% CI of the OR and RR did not cross 1 and the 95% CI of SMD did not cross 0, the results were deemed statistically significant. The combined outcomes are shown in forest figures.

Heterogeneity between studies was assessed using the I^2 statistic and Q-test. $I^2 > 50\%$ was considered indicative of heterogeneity. To mitigate the risk of bias, results with notable heterogeneity were combined using a random-effects model. Results without discernible heterogeneity were aggregated using a fixed-effects model. For results that exhibited heterogeneity, subgroup analyses were performed based on the publication year, tumor location, and type of study. Sensitivity analyses were also performed to evaluate the heterogeneity.

Funnel plots and *Egger's* test were used to evaluate publication bias. A p value < 0.05 was considered indicative of potential publication bias.

Statistical analysis: SEMS vs. PTR vs. S/B

Surgical interventions were further stratified into two categories: primary tumor resection (PTR) and stoma creation/bypass (S/B). The objective of this analysis was to discern any differences in the prognosis of AOCC between these two procedures and compare them with that of SEMS placement.

We used Bayesian Network Analysis to analyze the outcomes of these three interventions. All analyses were performed using R software (version 4.3.1), specifically the BUGSnet package [15]. For analysis of the binary and continuous data, outcomes were compared through ln (OR) and mean difference (MD) with their respective 95% CIs. If the 95% CI did not exceed 0, the difference was considered statistically significant. Each outcome set was aggregated using a random-effects model.

For each outcome type, we constructed network plots and developed ranking diagrams to show the results. Leverage plots were used to assess the fit of the models.

Results

We identified 1605 studies using the described search strategy. Initially, 774 duplicate studies were excluded. After screening titles and examining abstracts, we excluded 784 irrelevant studies. Of the remaining 47 articles that underwent a full-text assessment, 26 were excluded because they did not meet the inclusion criteria. Among these, 9 included patients without obstructive symptoms, 8 were reviews or meta-analyses, 3 were single-arm studies, 3 pertained to BTS research, and 3 involved patients with cancers other than colorectal. Finally, 21 [16–36] studies were included in this meta-analysis (Fig. 1). This included 2 RCT [21, 26] and 19 non-RCT studies [16–20, 22–25, 27–36]. Among them, 20 studies [17–32, 34–36] compared SEMS placement to surgery (with 3 [27, 34, 36] focusing on SEMS vs. PTR and 5 [17, 19, 26, 30, 35] focusing on SEMS vs. S/B), and 1 [33] study compared PTR with S/B.

Characteristics of selected studies

The details of the 21 studies are shown in Table 1. Twenty-one studies from the years 2003–2022 were considered for analysis, encompassing 1754 patients. Of these, 865 patients underwent SEMS placement, and 889 underwent surgical intervention. The average age of patients in the SEMS group

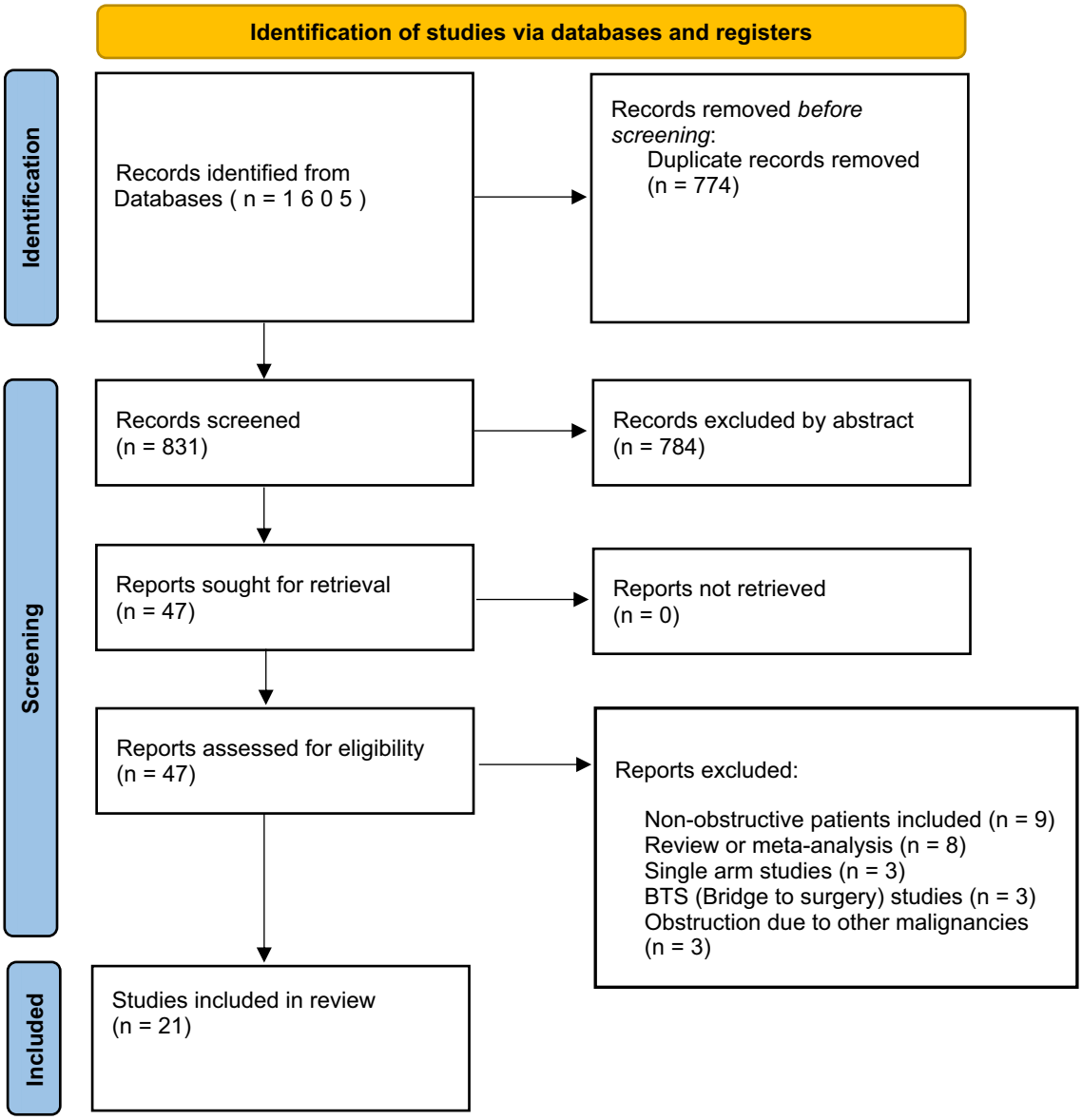

Fig. 1 PRISMA flow diagram

was 67.74 years, and those in the surgical group had an average age of 63.43 years.

Seven studies [16, 18, 19, 21, 22, 26, 36] specifically investigated left-sided colorectal cancer, whereas 10 studies [20, 24, 25, 27–31, 33, 35] included cecal tumors. In the SEMS group, the most frequently reported outcome was stent-related complications. Seventeen studies [16–18, 20–25, 27–32, 34, 35] provided individual reports on these complications, including reobstruction, perforation, migration, narrowing, and fracture. In the surgical group, the most common outcome was complications related to infection, with wound infections being predominant, as highlighted in 15 studies [16, 17, 22–25, 27–31, 33–36]. In the non-RCTs, the NOS scores ranged from 5 to 8, with 13 studies scoring 6 or above. Hooft et al.'s RCT was rated as low risk, and Fiori et al.'s prospective randomized trial was rated as moderate risk (some concerns). The detailed information of the NOS/Rob assessments can be found in Online Resource Table 3 and Online Resource Fig. 1.

Clinical success

Twelve studies [19–28, 30, 31, 34–36] reported on the clinical relief success rates. A total of 1105 patients out of 1142 (96.8%) patients successfully achieved symptom relief. The SEMS group had a lower clinical success rate than the surgical group (94.8% vs. 98.8%, p value < 0.001). The

Table 1 Basic characteristics of included studies

First author	Year of publication	Country	Treatment	Cancer site[a]	Sample size	Age	Outcomes and complications[b]		Study design	NOS/Rob
							SEMS	Surgical		
Law	2003	China	SEMS vs. surgical	cd	30 vs. 31	75 vs. 70	ACH	EHIJ	Prospective	8
Johnson	2004	UK	SEMS vs. surgical (S/B)	bc	20 vs. 18	–	AB	E	Retrospective	6
Carne	2004	New Zealand	SEMS vs. surgical	cd	25 vs. 19	66 vs. 68	ABC	–	Retrospective	5
Han	2006	Korea	SEMS vs. surgical (S/B)	cd	14 vs. 16	61 vs. 66	–	BG	Retrospective	5
Ptok	2006	Germany	SEMS vs. surgical	abcd	40 vs. 38	79 vs. 74	AB	–	Prospective	8
Hooft	2008	The Netherlands	SEMS vs. surgical	c	11 vs. 10	67.8 vs. 61.5	ABC	B	RCT	Low risk
Faragher	2008	Australia	SEMS vs. surgical	cd	29 vs. 26	70 vs. 67	ABCH	EFGHIJ	Retrospective	6
Súarez	2010	Spain	SEMS vs. surgical	bcd	45 vs. 53	–	ABC	DEFGHI	Retrospective	7
Vemulapalli	2010	USA	SEMS vs. surgical	abcd	53 vs. 70	61 vs. 57	AB	BEFHIJ	Retrospective	5
Lee	2011	Korea	SEMS vs. surgical	abcd	71 vs. 73	64.1 vs. 62	AB	BDEIJ	Retrospective	7
Fiori	2012	Italy	SEMS vs. surgical (S/B)	cd	11 vs. 11	77.2 vs. 76	BD	CG	RCT	Some concerns
Lee	2012	Korea	SEMS vs. surgical (PTR)	abc	36 vs. 52	60.3 vs. 62.6	AB	BDEF	Prospective	7
Zhang	2012	China	SEMS vs. surgical	abcd	97 vs. 89	61 vs. 52	ABEJ	DEFIJ	Retrospective	6
Llano	2015	Colombia	SEMS vs. surgical	abcd	24 vs. 23	–	AC	BEFH	Retrospective	5
Tian	2016	China	SEMS vs. surgical (S/B)	abcd	35 vs. 35	–	AB	E	Retrospective	5
Ahn	2016	Korea	SEMS vs. surgical	abcd	73 vs. 41	67.3 vs. 64.3	AB	BEF	Retrospective	7
Finlayson	2016	New Zealand	SEMS vs. surgical	bcd	65 vs. 63	76 vs. 71	ABD	–	Retrospective	5
Chen	2019	China	S/B vs. PTR	abc	23 vs. 23	–	–	CDEGH	Prospective	6
Seoane	2020	Spain	SEMS vs. surgical (PTR)	bcd	46 vs. 49	68.9 vs. 65.2	ABC	BDE	Prospective	6
Pattarajierapan	2022	Thailand	SEMS vs. surgical (S/B)	abc	105 vs. 97	70 vs. 63	AB	CDEFG	Prospective	7
Mahfouz	2022	Egypt	SEMS vs. surgical (PTR)	cd	35 vs. 29	69.0 vs. 67.2	BDE	BDE	Retrospective	7

[a]Cancer site, a: cecum, b: right colon, c: left colon, d: rectum

[b]Outcomes and complications

A: Stent-related: perforation, migration, narrowing, fracture.

B: Re-obstruction or ileus.

C: Functional disorders: diarrhea, pain, tenesmus.

D: Bleeding or anemia.

E: Infectious diseases: pulmonary infection, urethra infection, wound infection, abdominal infection, abscess, sepsis.

F: Surgery-related: anastomotic leakage, perforation, fistula, hernia.

G: Stoma-related: stoma prolapse, skin irritation, skin necrosis, stenosis, ischemic.

H: Cardiovascular diseases: myocardial infarction, arrhythmia, stroke.

I: Organ failure: hepatic failure, heart failure, respiratory failure, renal failure.

J: VTE

meta-analysis revealed an OR of 0.32 (95% CI 0.15, 0.65), indicating a statistically significant difference (Fig. 2A).

Early complications (within 30 days)

Eleven studies [21–26, 28, 31, 34–36] reported the incidence of early complications. Of the 1124 patients, 219 (19.5%) experienced early complications. The SEMS group had a lower incidence of early complications than the surgical group (11.3% vs. 28.1%, p value < 0.001). The meta-analysis revealed an OR of 0.34 (95% CI 0.19, 0.59), showing a statistically significant difference (Fig. 2B).

Late complications (after 30 days)

Ten studies [21–26, 28, 31, 34, 35] reported the incidence of late complications. This included 202 of 1060 (19.1%). The SEMS group exhibited a higher incidence of late complications than the surgical group (24.0% vs. 13.9%, p value < 0.001). Meta-analysis showed an OR of 2.30 (95% CI 1.22, 4.36), demonstrating a statistically significant difference (Fig. 2C).

Thirty-day mortality

Seventeen studies [16–26, 28, 31, 32, 34–36] reported the 30-day mortality rate. Of the 1503 patients included, 86 (5.7%) died. The SEMS group had a lower mortality rate than the surgical group (4.5% vs. 7.0%, p value = 0.057). The meta-analysis revealed an OR of 0.65 (95% CI 0.42, 1.01), and the difference was not statistically significant (Fig. 2D).

Stoma formation

Fifteen studies [16, 18–27, 29, 31, 32, 34] reported on the stoma formation rate. Out of the 1227 patients included, 392 had stoma formation, translating to 31.9% of the study population. The stoma formation rate was lower in the SEMS group than in the surgical group (11.7% vs. 53.0%, p value < 0.001). According to the meta-analysis, the OR was 0.11 (95% CI 0.05, 0.22), and the difference was statistically significant (Fig. 2E).

Hospital stay

Nine studies [19, 20, 25–28, 30, 31, 36] compared the duration of hospital stay. A total of 796 hospital stays were analyzed. The mean length of hospital stay was significantly shorter in the SEMS group than in the surgical group. The SMD in the meta-analysis was − 2.08 (95% CI − 3.56, 0.59), indicating a statistically significant difference (Fig. 2F).

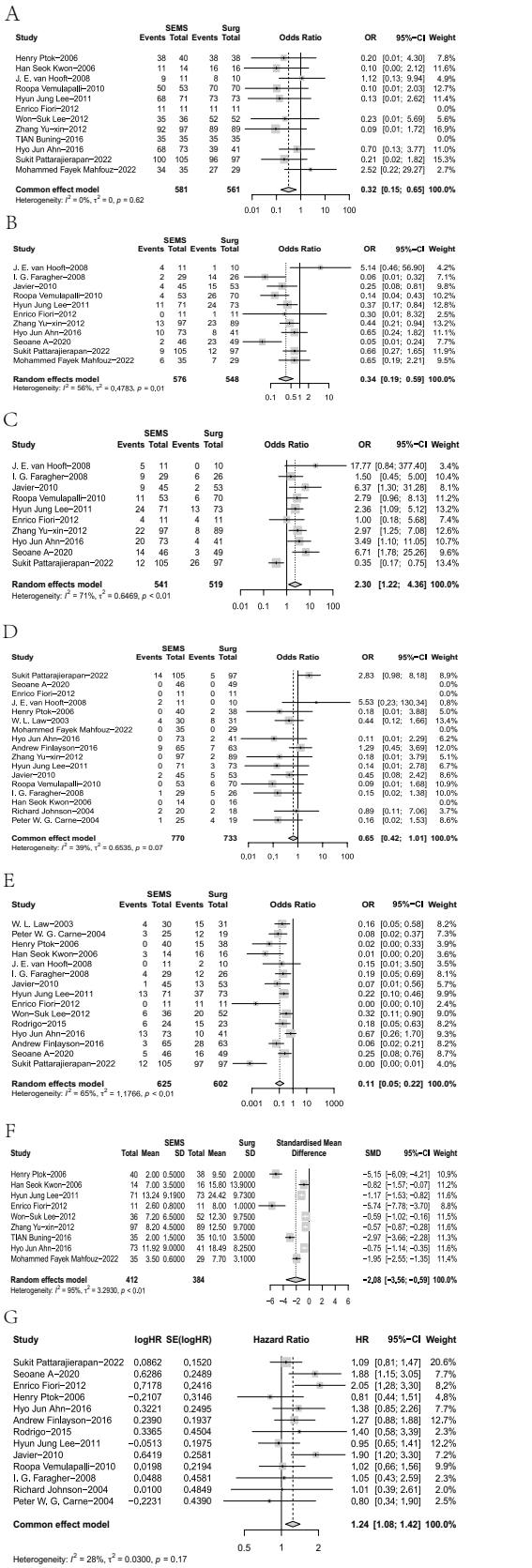

Fig. 2 Forest plots of each outcome. **A** Clinical success; **B** early complications; **C** late complications; **D** 30-day mortality; **E** stoma formation; **F** hospital stay; **G** overall survival

Overall survival

Thirteen studies [17, 18, 20, 22–26, 29, 31, 32, 34, 36] included a comparison of patient survival rates. Of these, all 13 met the previously described data extraction criteria. Ultimately, the meta-analysis found a lower OS rate in the SEMS group than in the surgical group, with an HR of 1.24 (95% CI 1.08, 1.42). This difference was statistically significant (Fig. 2G).

Heterogeneity and publication *bias*

Heterogeneity and publication bias for various outcomes are summarized in Table 2. The funnel plots are shown in Online Resource Fig. 2.

From the mentioned outcomes, "early complications," "late complications," "stoma formation," and "hospital stay" showed evidence of heterogeneity across the different research studies. The P_{egger}(s) for "stoma formation" and "hospital stay" were < 0.001 and 0.010, respectively, indicating that the heterogeneity may be due to publication bias. Conversely, the P_{egger}(s) for "early" and "late" complications were 0.629 and 0.133, respectively, indicating no significant publication bias. Thus, heterogeneity may arise from other factors not related to publication bias.

Regardless of the observed heterogeneity, we performed a subgroup analysis of the results that showed heterogeneity to provide further insights.

Subgroup analysis

For the four results that exhibited heterogeneity, we conducted a subgroup analysis based on publication year, tumor location, and study type. The results are summarized in Online Resource Table 4. Subgroups with no significant heterogeneity and statistically significant conclusions are highlighted in bold font.

1) Early complications: Nine studies, published after 2010, comprised this subgroup. The SEMS group showed a lower probability of early complications than the surgical group (I^2 = 41%, OR 0.35, 95% CI 0.19, 0.63).
2) Of the 7 retrospective studies, a similar conclusion was drawn (I^2 = 40%, OR 0.33, 95% CI 0.17, 0.65).
3) Late complications: Among the 6 retrospective studies, the SEMS group was more likely to experience late complications than the surgical group (I^2 = 0%, OR 2.73, 95% CI 1.87, 3.99).
4) Stoma formation: Of the 6 studies focusing on left-sided CRC, the SEMS group showed a lower rate of stoma formation than the surgical group (I^2 = 35%, OR 0.11, 95% CI 0.03, 0.34).
5) A similar conclusion was drawn from the 6 studies published before 2010 (I^2 = 4%, OR 0.11, 95% CI 0.04, 0.28).
6) Hospital stay: We could not identify the factors explaining the heterogeneity between studies for this outcome.

Table 2 The heterogeneity and publication bias of the outcomes

Outcomes	I^2	Model type	P_{egger}
Clinical success	0%	Fixed	0.057
Early complications	56%	Random	0.629
Late complications	71%	Random	0.133
30-day mortality	39%	Fixed	0.011
Stoma formation	65%	Random	< 0.001
Hospital stay	95%	Random	0.010
Overall survival	28%	Fixed	0.997

Sensitivity analysis

For the above four results with heterogeneity, we conducted sensitivity analyses. Sensitivity analyses were conducted by removing each individual study to evaluate whether any single study had a significant impact on combined estimates. There was no significance detected for the outcomes of early complications, stoma formation, and hospital stay. Notably, we found that the study of Pattarajierapan et al. [35] had a large impact on combined estimate of late complications (I^2 = 0 without this study). The results are detailed in Online Resource Fig. 3.

Network *meta*-analysis

Using a network meta-analysis, multiple treatment interventions were compared by assessing the direct and indirect evidence from multiple studies. These results provide more comprehensive insights than those of pairwise meta-analyses.

Inclusion

Ten studies that compared three treatment strategies (SEMS, PTR, and S/B) were included. The breakdown of study inclusion was as follows: SEMS vs. PTR in 3 studies [27, 34, 36] and SEMS vs. S/B in 5 studies [17, 19, 26, 30, 35]. Two studies [20, 33] included comparisons between PTR and S/B. The treatment-ranking probabilities for the various outcomes are shown in Fig. 3.

Interpretation of network *meta*-analysis results

Clinical success: A higher rank indicated a better rate of clinical symptom relief. PTR appeared to be superior in clinical success in alleviating symptoms.

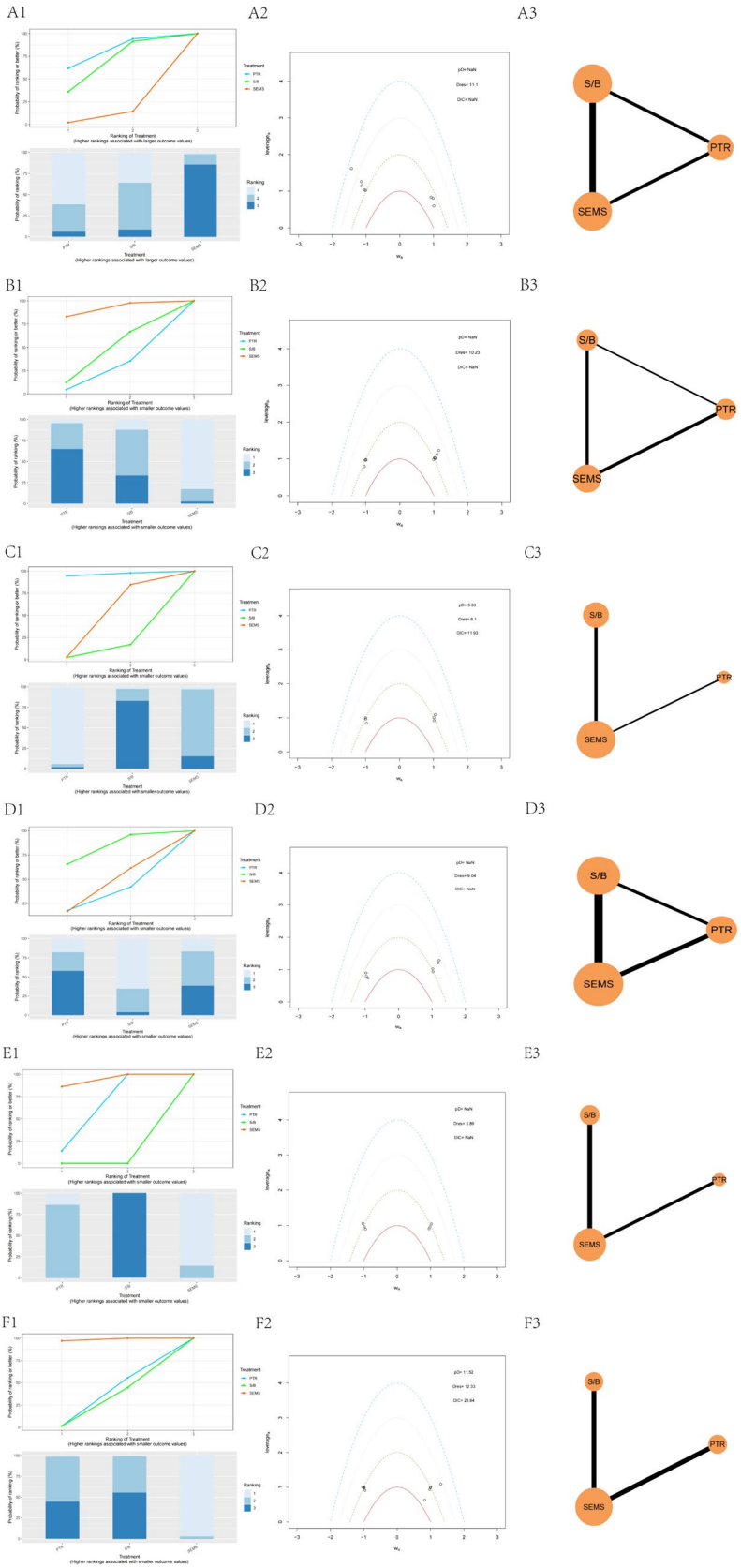

Fig. 3 Results of network meta-analysis. The (1) ranking diagrams, (2) leverage plots, and (3) network plots between SEMS, PTR, and S/B. **A** Clinical success; **B** early complications; **C** late complications; **D** 30-day mortality; **E** stoma formation; **F** hospital stay

Complications: A higher rank implied fewer complications and a shorter duration of hospital stay. The PTR group showed the lowest rate of late complications. The S/B group had the lowest early mortality rate.
Advantages of SEMS: SEMS placement resulted in fewer early complications, shorter hospital stays, and a lower rate of stoma formation.

Further detailed pairwise comparisons of the three treatment strategies are shown in Table 3.

Discussion

The clinical success rate of SEMS is 82–94.4% [37, 38]; our study showed a 94.8% success rate. The key reasons for failure were constipation and postoperative stent-related complications [39]. Kwon et al.'s research [38] identified peritoneal metastatic cancer as a risk factor for failure of clinical relief (OR, 0.33; 95% CI 0.17, 0.65). Both peritoneal cancer and a stent expansion > 90% on day one predicted postoperative reintervention due to the risk of stent migration. Another study confirmed that extrinsic colonic compression and stent length are the key factors influencing the success rate of stent relief [40]. This finding suggests that the efficacy of the application of stents to relieve extrinsic compression requires further investigation. Moreover, the stent placement technique matters; direct endoscopic vision resulted in a higher success (81% vs. 77%) and fewer complications (20% vs. 38%) than radiographic guidance [41].

Complications are a significant factor affecting the application of SEMS for CRC obstruction. Particularly when SEMS placement is used as a palliative treatment, complications can lead to a poor prognosis and are predictive factors for lower postoperative survival rates [41, 42]. A study of 434 patients found no notable differences in the clinical outcomes between SEMS placement for palliative care or as a BTS [43]. Our study indicates that there are fewer early complications caused by SEMS placement than those caused by surgery (11.3% vs. 28.1%). However, in the long term, the rate of complications was higher than that of surgery (24.0% vs. 13.9%). This conclusion, which is consistent with that of previous studies, underscores the need for a comprehensive understanding of SEMS applications based on both immediate and extended postoperative timelines.

Reobstruction is the most common complication of palliative treatment with SEMS and is more often a late-stage complication. The median patency period for palliation is between 55 and 343 days [42, 44, 45]. Early obstructions are associated with stent placement failure and stent occlusion, whereas late obstructions are mainly caused by tumor growth into the stent, which can reobstruct the area. Suh et al. [46] used a Cox regression analysis to explore the causes of stent occlusion. The results showed that a stent expansion of less than 70% within 48 h is a significant factor for stent occlusion (OR 12.55, 95% CI 2.52, 62.48). Tumor ingrowth occurs over time. For patients with AOCC, using covered stents may minimize tumor ingrowth; however, this approach presents an increased migration risk [47–49]. Endoscopic electrocoagulation therapy or secondary stent placement can be performed for reobstruction. For patients in palliative care, secondary stent placement, including the replacement/placement of a new stent inside the existing stent, is an effective treatment method. The success rate is 75–86%, and patency is generally maintained until the end of life [44].

Perforation is the most severe complication of SEMS placement and can lead to severe peritonitis. This complication often requires emergency surgical intervention and may require procedures such as ostomy or Hartmann's [45]. Perforation is more frequent in patients with AOCC, particularly in those with poor bowel preparation and significant narrowing attributed to guidewire or catheter damage. Thus, thorough bowel cleaning, preventive antibiotic use, combined

Table 3 Pairwise comparisons of the three treatment strategies

Outcomes		SEMS	S/B
Clinical success	SEMS	–	1.08 (−0.21, 2.70)
	PTR	**−2.15 (−4.21, −0.51)**	−1.06 (−2.54, 0.26)
Early complications	SEMS	–	**0.82 (0.04, 1.65)**
	PTR	**−1.51 (−2.29, −0.80)**	−0.70 (−1.56, 0.18)
Late complications	SEMS	–	0.77 (−1.03, 2.30)
	PTR	1.99 (−0.34, 4.50)	2.76 (−0.25, 5.61)
30-day mortality	SEMS	–	−0.70 (−2.46, 1.10)
	PTR	−0.33 (−3.64, 2.45)	−1.02 (−3.86, 1.22)
Stoma formation	SEMS	–	**133.84 (36.89, 234.58)**
	PTR	−1.31 (−5.88, 3.17)	**132.46 (35.60, 233.25)**
Hospital stay	SEMS	–	**7.07 (1.13, 13.64)**
	PTR	−6.68 (−13.34, −0.96)	0.43 (−8.82, 8.86)

The values in the table are *ln* (OR) and 95%CI. Bold values indicate statistical significance

endoscopy, and radiology are crucial for precise tumor location assessment [48]. Analgesics and sedatives are beneficial during the procedure and an expert endoscopist should guide the process [50]. Late-stage perforations are mainly caused by stent-associated tumor erosion of the intestinal wall and ischemic necrosis of the intestinal tissue. While traditional stents made from nickel-titanium and stainless steel offer strong support, they may also cause foreign body reactions, leading to perforation. Newer biodegradable and polymeric stents aim to combat this problem. However, their mechanical strength and support require further optimization.

Comprehensive chemotherapy is the primary treatment method for patients with AOCC. Compared with surgery, SEMS can significantly shorten the time before initiating chemotherapy because of its minimal invasiveness and quick recovery of patients, as verified in multiple studies [25, 31, 32, 34, 35]. Although there are concerns regarding increased complications when pairing SEMS placement with chemotherapy, this approach prolongs patient survival [42]. However, the combination of SEMS and targeted drugs, such as bevacizumab (a monoclonal antibody), remains controversial. Given the role of bevacizumab in hindering blood vessel growth and the potential of SEMSs to erode the intestinal walls, there is an increased risk of ischemic perforation [51]. A systematic study including 682 patients showed that in patients with AOCC with SEMS, combining chemotherapy and bevacizumab increased the risk of perforation (63.4% vs. 25.7%). However, survival increased: 12.8–43 months vs. 18–20 months [52]. We suggest that, for patients with AOCC undergoing chemotherapy, SEMS should not be ruled out entirely given its alleviation ability and potential survival benefits.

The surgical treatment of CRC obstruction considers factors such as patient condition, tumor type, stage, personal preferences, and hospital facilities. For patients with AOCC, who typically have poor prognoses, surgical decisions demand caution [53]. For example, in advanced asymptomatic CRC, PTR does not offer significant benefits for patients compared with those for patients who only receive chemotherapy [54, 55]. However, this conclusion requires further investigation in patients with AOCC. Our study found that the patients who underwent surgery had better clinical success rates, fewer long-term complications, and higher survival rates. Although surgery shows only partial advantages over SEMS placement, it provides a basis for individualized treatment.

The optimal selection of surgical approaches is currently conflicting, and there is a lack of refined strategies for selecting the optimal surgical method. According to our meta-analysis, the selection of the surgical method was largely based on the intraoperative conditions and the surgeon's individual preferences [16, 18, 20–25, 28, 29, 31, 32]. This introduces significant unpredictability into patient prognosis. In our network meta-analysis, PTR exhibited the best clinical success rate and decreased late complications, revealing the benefits of tumor removal. This effectively diminishes the uncertainty introduced by the continued tumor growth in patients with AOCC. Regarding early complications and short-term mortality, the S/B stands out for its rapid procedure, minimal invasiveness, and quick recovery (Fig. 3). Thus, from different postoperative perspectives, PTR and S/B each have their advantages.

Surgery for CRC obstruction has shown promise in extending survival rates compared with those of SEMS placement, despite the inherent risks of complications and postoperative mortality. Our study's HR of 1.24 (95% CI 1.08, 1.42) further highlights this potential advantage, challenging previous meta-analyses [8, 10, 11], yet being consistent with several other studies [23, 26, 31, 32, 34]. Although stents effectively alleviate obstruction symptoms, they do not affect the growth or metastasis of primary tumors. Surgical removal decreases the tumor size and reduces the number of tumors, thereby delaying tumor growth and spread. Additionally, selection bias in patients is a factor; those with better health and longer life expectancies are more likely to choose surgery (after consulting with their physicians for treatment options). Thus, the decision between SEMS and surgery should be collaborative, with full consideration of the impact of both options on the survival duration.

In terms of heterogeneity, we found significant heterogeneity ($I^2 > 50\%$) in four outcomes: early complications, late complications, stoma formation, and length of hospital stay. Subgroup and sensitivity analyses were conducted accordingly. In subgroup analysis, we identified publication year, tumor location, and study type as potential sources of heterogeneity. Left CRC are more prone to obstruction, and SEMS in left CRC is more recommended based on previous studies. Conversely, in other sites of the colon, SEMS is less common due to the higher risks of stent migration and technical difficulties. Regarding publication year and study type, heterogeneity is an inevitable factor.

In sensitivity analyses, we found that the study by Pattarajierapan et al. [35] had a significant impact on the outcomes of late complications, as reflected in the combined result forest plot (Fig. 2C). This study compared SEMS versus S/B procedures. In network analysis, S/B procedures showed the highest rate of late complications (Fig. 3C1), while PTR procedures showed the lowest, which could be a source of heterogeneity. Additionally, since the study population was Asian, racial differences may also be a contributing factor.

Our study had the following limitations:

1. Heterogeneity was observed among the included studies. Although we attempted to explain some of the heterogeneity

among the research results through a subgroup analysis, some heterogeneities remain unexplained.
2. RCTs are lacking in the literature. In our meta-analysis, only two met the inclusion criteria. Future research requires more RCTs to provide high-quality evidence.
3. Regarding survival rate studies, higher-quality research is needed. This entails balancing the differences in baseline patient status and tumor conditions across groups. Long-term follow-up is also essential to validate our conclusions.

In conclusion, our meta-analysis showed that SEMS placement has advantages in terms of the incidence of early postoperative complications, postoperative mortality, stoma formation rate, and postoperative hospitalization time in patients with AOCC. However, surgical treatment is superior to SEMS placement in clinical symptom remission, late complication rates, and overall survival rates. PTR can improve the rate of remission of clinical symptoms and decrease the incidence of late complications when selecting specific surgical methods. Patients who underwent S/B had a lower incidence of early complications and 30-day mortality after surgery. These results emphasize that patient condition, patient/physician preferences, and risk factors should be considered when selecting AOCC treatment.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00384-024-04724-6.

Author contribution MBQ and RTX carried out research design and article writing. CB and CCJ revised and proofread the manuscript. ZJX is responsible for guiding the overall research.

Data availability No datasets were generated or analysed during the current study.

Declarations

Research involving human participants This research did not involve experimentation with human participants. Rather, this was a meta-analysis which only involved data from previous studies. No ethical approval was required.

Informed consent Informed consent was not required due to the nature of the study.

Competing interests The authors declare no competing interests.

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