REVIEW ARTICLE

Palliative surgical bypass is superior to palliative endoscopic stenting in patients with malignant gastric outlet obstruction: systematic review and meta-analysis

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Abstract

Background Gastrojejunostomy (GJ) and self-expanding metal stents (SEMS) are the two most common palliative treatment options for patients with malignant gastric outlet obstruction (GOO). Randomised trials and retrospective studies have shown discrepant results, so that there is still a controversy regarding the optimal treatment of GOO.

Methods Medline, Web of Science and Cochrane Library were systematically searched for studies comparing GJ to SEMS in patients with malignant GOO. Primary outcomes were survival and postoperative mortality. Secondary outcomes were frequency of re-interventions, major complications, time to oral intake and length of hospital stay.

Results Twenty-seven studies, with a total of 2.354 patients, 1.306 (55.5%) patients in the SEMS and 1.048 (44.5%) patients in the GJ group, were considered suitable for inclusion. GJ was associated with significantly longer survival than SEMS (mean difference 43 days, CI 12.00, 73.70, $p = 0.006$). Postoperative mortality (OR 0.55, CI 0.27, 1.16, $p = 0.12$) and major complications (OR 0.73, CI 0.5, 1.06, $p = 0.10$) were similar in both groups. The frequency of re-interventions, however, was almost three times higher in the SEMS group (OR 2.95, CI: 1.70, 5.14, $p < 0.001$), whereas the mean time to oral intake and length of hospital stay were shorter in the SEMS group (mean differences -5 days, CI -6.75, -3.05 days, $p < 0.001$ and -10 days, CI -11.6, -7.9 days, $p < 0.001$, respectively).

Conclusions Patients with malignant GOO and acceptable performance status should be primarily considered for a palliative GJ rather than SEMS.

Advanced malignant disease in the upper gastrointestinal tract may result in gastric outlet obstruction (GOO). The most common malignancy that results in GOO is pancreatic cancer, with 15% to 20% of patients presenting with GOO [1]. GOO can also be caused by gastric and periampullary cancer, lymphoma, as well as metastatic cancer to the duodenum or jejunum [2–4]. Patients with GOO may present with progressive symptoms, predominantly nausea and vomiting, but also weight loss, early satiety, abdominal discomfort,

cachexia, poor nutritional status and severe dehydration [5]. Given that median survival in the palliative setting may be as short as 3–4 months [6], it is important to re-establish an oral intake quickly in order to improve the patients' quality of life. The traditional treatment approach for the palliation of malignant GOO has been surgical bypass, consisting of an open gastrojejunostomy (OGJ). This was first performed in 1881 by Wolfer for a patient with pyloric carcinoma that had extended into the pancreas [7]. Palliative stent placement for GOO was first reported in the 1990s [8]. Over the years, endoscopic placement of self-expandable metal stents (SEMS) has emerged as an alternative palliative treatment of GOO. However, endoscopic stents, despite the lower initial morbidity, demonstrated complications like obstruction, migration, bleeding and stent fractures [9]. Randomised trials have shown discrepant results, with two trials favouring endoscopic SEMS [10, 11] and one favouring surgical GJ [12]. Similarly, previous systematic reviews

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[13–17] suggested that stent placement is associated with a shorter time to oral intake and a shorter length of hospital stay, whereas the frequency of complications and procedure-related mortality was similar. However, none of these previous systematic reviews has examined the incidence of re-interventions after endoscopic stenting and surgery. Moreover, since the publication of previous reviews, several, large retrospective studies have been published, also examining overall survival in such patients. Therefore, the aim of the present study was to provide an up-to-date systematic review with meta-analysis comparing endoscopic SEMS and GJ regarding time to tolerating oral intake, complication rates, length of hospital stay, re-intervention rates, as well as procedure-related mortality and survival.

Materials and methods

Search strategy

MEDLINE, Web of Science and Cochrane Library were searched using the following search terms: "stent OR stenting OR palliative stenting OR SEMS AND bypass surgery OR surgical bypass OR palliative bypass OR gastrojejunostomy OR gastroenterostomy OR bypass AND PDAC OR pancreatic ductal adenocarcinoma OR pancreatic adenocarcinoma OR pancreatic carcinoma OR pancreatic cancer OR peripancreatic cancer OR periampullary cancer OR periampullary malignancy OR malignant gastric outlet obstruction OR gastric outlet obstruction OR GOO OR gastric outlet". The methodology was developed from the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement [18]. An Institutional Review Board (IRB) approval was not required for this study.

Criteria for considering studies for the review

Peer-reviewed studies comparing endoscopic stenting and gastrojejunostomy as palliative treatment options for malignant gastric outlet obstruction were considered for inclusion. All study designs were eligible for inclusion. Studies were considered eligible for inclusion if either the primary or secondary outcomes were reported. Articles published in languages other than English or German were excluded from the literature review. In the event of duplicate publications, the most recent or more complete publication was used.

The titles and abstracts of all identified citations were screened by two investigators (IM and MM) to determine their relevance. Then, the full texts of potentially relevant articles were retrieved and rescreened by the same authors (IM and MM) separately. In addition, the reference lists of those publications were reviewed in order to identify further relevant articles suitable for inclusion.

Data extraction

The following data were extracted from each eligible study by two investigators (IM and MM): study design, year of publication, study location and accrual period, total sample size, technical and clinical success of each intervention, time to oral intake, length of hospital stay, major complications, re-interventions, postoperative mortality, survival. Primary outcomes were procedure-related mortality and survival. Secondary outcomes were the frequency of major complications and re-interventions in each group, time to oral intake, length of hospital stay and quality of life. Major complications were defined as life-threatening or severe, requiring further treatment or leading to prolonged hospitalisation. Both surgical and non-surgical/medical major complications were included. Time to oral intake in the present meta-analysis refers to the ability to tolerate a soft/solid diet.

Risk of bias assessment

ROBINS-I-tool (risk of bias in non-randomised studies of interventions) was used to assess risk of bias in non-randomised studies. The tool uses "signalling questions" to judge the risk of bias within each domain (bias due to confounding, bias in selection of participants into the study, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in measurement of outcomes, bias in selection of the reported result); the judgements within each domain carry forward to an overall risk of bias judgement [19]. RoB 2.0 tool [20] for individually randomised, parallel group trials was used to assess risk of bias in the three prospective, randomised trials [10–12] included in the present systematic review.

Statistical analysis

Continuous variables are reported as mean (SD) or median (range) and categorical variables as proportions. In studies reporting median and range instead of mean and standard deviation, Hozo's method [21] was used to estimate the mean and variance based on the median, range and sample size. Studies were excluded from the meta-analysis, if the mean and variance could not be obtained. Summary odds ratios with corresponding 95% confidence intervals (CI) were calculated for dichotomous variables using the Mantel–Haenszel method and a random-effects model. Summary mean differences with corresponding 95% CI were calculated for continuous variables, using an inverse variance method and a random-effects model. We assessed statistical heterogeneity using the I^2 statistic [22]. The meta-analyses were conducted in Review Manager (RevMan)

(REF = Review Manager (RevMan) [Computer program]. Version 5.3. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014).

Results

Literature search

MEDLINE, Web of Science and Cochrane Library search identified a total of 794 citations (Fig. 1). Twenty-seven studies [2, 10–12, 23–45] met the inclusion criteria. After screening the references of the full-text articles assessed for eligibility, no further studies potentially suitable for inclusion were identified. Twenty-six studies [2, 10–12, 23–39, 41–45] were included in the meta-analysis (Fig. 1).

Study and patients' characteristics

Twenty-three retrospective cohort studies [2, 23–27, 29–45], three prospective randomised trials [10–12] and one prospective cohort study [28] comprised a total of 2354 patients, 1306 (55.5%) in the SEMS and 1048 (44.5%) in the GJ group. The characteristics of the included studies are shown in Table 1.

Twenty-five of 27 studies [2, 10–12, 23, 25–31, 33–39, 41–45] reported the patients' age (median or mean) in each group. In the SEMS group, patients' age ranged from 63 to 73 years in 16 of 24 studies [10–12, 25–27, 31, 33, 34, 36, 37, 41–45]. Similarly, in the GJ group, in 17 of 24 studies [10–12, 25–28, 30, 31, 33, 34, 36, 37, 39, 41, 42, 44] the patients' age ranged from 63 to 73 years. One study [23] reported a mean age of 67.7 years for the entire cohort, and not for each intervention group separately. Patients' sex in each intervention group was reported in 24 of 27 studies [2, 10–12, 25–31, 33–45]. We noticed a male predominance in the SEMS group in 21 of 24 studies [2, 10, 12, 25–28, 30, 31, 33–43, 45], with male proportions ranging from 50 [42] to 74.7% [38]. Similarly, in the GJ group male preponderance was shown in 18 of 24 studies [2, 10–12, 25–28, 30, 34, 36–41, 43, 45] with male proportions varying from 50 [12] to 87.2% [38].

In 17 of 27 studies [2, 11, 12, 23–25, 29–33, 35, 36, 39, 41, 42, 44], the underlying disease was a pancreatobiliary malignancy in the majority of patients included, the second most common aetiology was gastric cancer in six of

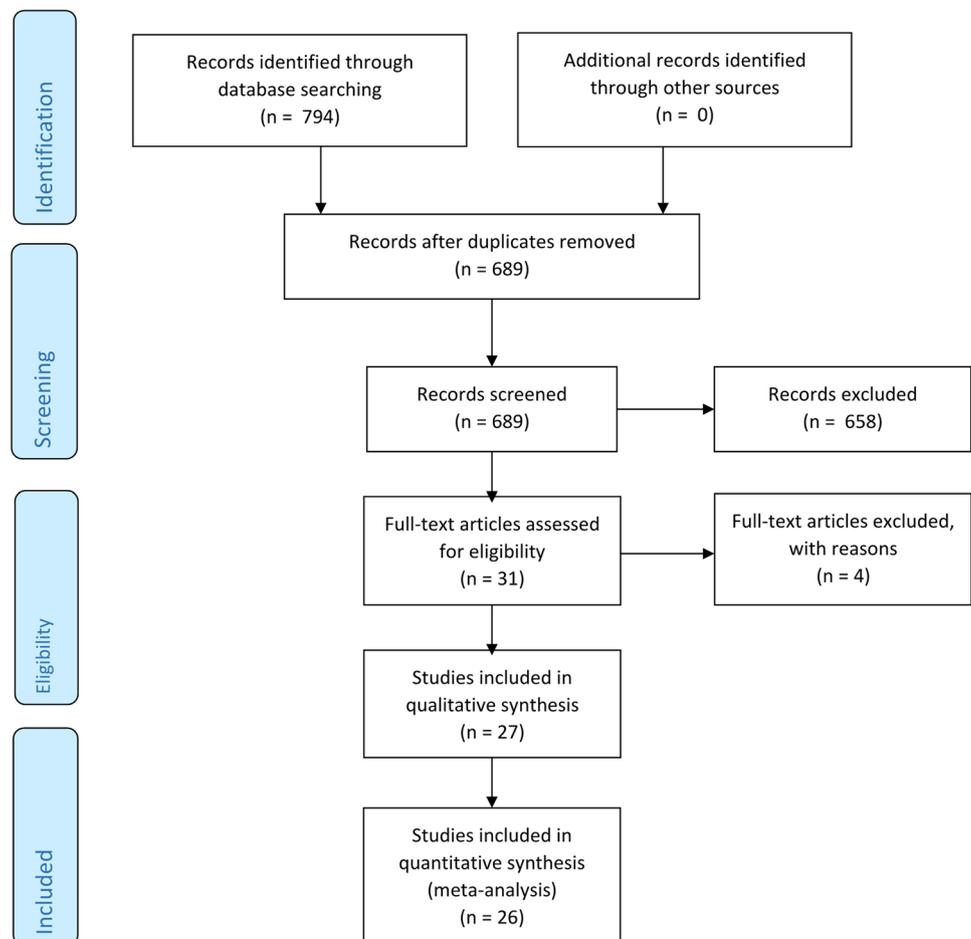**Fig. 1** PRISMA flow chart showing selection process of articles

Table 1 General characteristics of the studies included in the systematic review

Author	Year	Country	Study accrual period	Study type	Patients (total, n)	SEMS	GJ	Tumour type (%)
Yim et al. [23]	2001	Boston and Singapore	1996–1999	RCS	27	12	15	41.4% PDAC
Wong et al. [24] s	2002	Massachusetts, USA	1988–1998	RCS	23	6	17	PDAC
Fiori et al. [10]	2004	Rome, Italy	2001–2002	RCT	18	9	9	Various
Maetani et al. [25]	2004	Tokyo, Japan	1993–2002	RCS	39	20	19	Pancreatobiliary
Maetani et al. [26]	2005	Tokyo, Japan	1994–2004	RCS	44	22	22	Gastric cancer
Mehta et al. [11]	2006	Norwich, UK	2002–2004	RCT	27	13	14	63% pancreatobiliary
Mittal et al. [27]	2004	Auckland, New Zealand	1989–2002	RCS	46	16	30	Various
Johnsson et al. [28]	2004	Sweden	1999–2004	PCS	36	21	15	52.8% gastric cancer
Del Piano et al. [2]	2005	Novara, Italy	1997–2002	RCS	47	24	23	80.9% pancreatobiliary
Espinel et al. [29]	2006	Leon, Spain	1999–2004	RCS	41	24	17	65.9% pancreatobiliary
El-Shabrawi et al. [30]	2006	Graz, Austria	2001–2004	RCS	39	22	17	53.8% pancreatobiliary
Jeurnink et al. [31]	2007	Rotterdam, Netherlands	1994–2006	RCS	95	53	42	74.7% PDAC
Schmidt et al. [32]	2009	NY, USA	2006–2008	RCS	40	24	16	75% pancreatobiliary
Jeurnink et al. [12]	2010	Netherlands	2006–2008	RCT	39	21	18	76.9% pancreatobiliary
Rudolph et al. [33]	2011	Mannheim and Hamburg, Germany	2001–2007	RCS	87	44	43	54% pancreatobiliary
Chandrasegaram et al. [34]	2012	Penrith, Australia	1998–2008	RCS	45	26	19	68.9% gastroduodenal
Roy et al. [35]	2012	Alabama, USA	2007–2008	RCS	104	29	75	Pancreatobiliary
Khashab et al. [36]	2013	Baltimore, USA	2001–2010	RCS	347	120	227	83% pancreatobiliary
No et al. [37]	2013	Seoul, Korea	2001–2010	RCS	113	72	41	Gastric cancer
Park et al. [38]	2015	Seoul, Korea	2005–2012	RCS	256	217	39	Gastric cancer
Tsauo et al. [39]	2016	Seoul, Korea	2009–2014	RCS	107	75	32	PDAC
Jang et al. [40]	2017	Seoul, Korea	2009–2013	RCS	144	99	45	Gastric cancer
Yoshida et al. [41]	2017	Shizuoka, Japan	2010–2016	RCS	53	23	30	PDAC
Uemura et al. [42]	2018	Japan	2008–2017	RCS	99	64	35	PDAC
Yukimoto et al. [43]	2018	Saga, Japan	2010–2016	RCS	65	38	27	61.5% gastroduodenal cancer
Jang et al. [44]	2018	Seoul, Korea	2011–2017	RCS	310	183	127	48.1% PDAC
Leiyuan et al. [45]	2018	Chongqing, China	2008–2014	RCS	63	29	34	85.7% gastric cancer

RCS retrospective cohort study, *RCT* randomised controlled trial, *PCS* prospective cohort study, *PDAC* pancreatic ductal adenocarcinoma)

27 studies [26, 28, 37, 38, 40, 45], as shown in Table 1. Gastroduodenal cancer was reported in two studies [34, 43], various pathologies in one [27], whereas in one study [10] the cause of malignant gastric outlet obstruction was not specified (Table 1). Gastrojejunostomy was performed as an open procedure in 15 of 27 studies [2, 10, 12, 23–26, 28–30, 32–35, 42], in 9 [27, 31, 36–41, 44] studies both laparoscopic and open, in 2 studies only laparoscopic [11, 45], whereas in one study [43] the operational access method was not reported.

Eleven of 27 studies [11, 23, 28–34, 43, 45] did not provide information regarding the performance status of the included patients. Six studies [38–42, 44] reported the ECOG performance status of the patients in each group, for most patients the ECOG performance status ranged

from 0 to 2. Five studies [2, 10, 24, 27, 37] reported the ASA score for each group, with most patients ranging between ASA II and III. The remaining five studies reported the Charlson Comorbidity Index [35, 36], Karnofsky Index [25, 26] and WHO Score [12].

The technical success of each treatment modality was reported in 19 of 27 studies [2, 10–12, 24–26, 28, 29, 31, 36–39, 41–45]. In the SEMS group, technical success varied from 83.3 [11] to 100% [10, 24–26, 28, 29, 38, 39, 43, 45], in the GJ group from 88.9 [12] to 100% [2, 10, 11, 24–26, 28, 29, 31, 38, 39, 41–43, 45]. The clinical success was reported in 17 of 27 studies [2, 10, 25, 26, 29–31, 35–44], ranging from 75 [31, 36] to 100% [10, 29, 30, 35] after endoscopic palliation and 56% [2] to 100% [10, 35, 41] after surgical bypass.

Primary outcomes

Nine studies [24, 25, 27, 28, 34, 37, 39, 41, 43] provided sufficient information for analysis. Gastrojejunostomy was associated with significantly longer survival than SEMS (mean difference 43 days, CI 12.00, 73.70, $p = 0.006$, Fig. 2A). Fifteen studies [2, 10, 11, 24–34, 36] reported the procedure-related mortality. Surgical bypass was not associated with increased postoperative mortality (OR 0.55, CI 0.27, 1.16, $p = 0.12$, Fig. 2B).

Secondary outcomes

Major complications were reported in twenty-one of twenty-seven studies [2, 10, 12, 24–27, 29–31, 33–39, 41, 42, 44, 45]. There was no significant difference in the incidence of major complications between GJ and SEMS (OR 0.73, CI 0.5, 1.06, $p = 0.10$, Fig. 3). In the SEMS group, the most frequent procedure-related complications included stent migration/dislocation in 41 of 120 (34.2%) patients, bowel perforation in 15 (12.5%) patients and stent occlusion/obstruction in 17 (14.2%) patients (Table 2). In the GJ group, haemorrhage was the most frequent surgical complication

reported in 21 of 113 (18.6%) patients, dysfunction of anastomosis/anastomotic obstruction was reported in 19 (16.8%) patients and anastomotic leakage in 18 (15.9%) patients. Non-surgical complications, including myocardial infarction, respiratory and urinary tract infections as well as renal failure, were seen more often in the GJ group (26.6% vs 10.8%, see also Table 2). Incidence of re-interventions was reported in 15 studies [12, 28, 30–39, 41, 42, 44] and was significantly higher in the SEMS group (OR 2.95, CI 1.70, 5.14, $p < 0.001$, Fig. 4).

Eleven studies [25–27, 29, 30, 34, 37, 38, 41–43] provided sufficient information regarding time to oral intake. Mean time to oral intake was significantly shorter in the SEMS group compared to the GJ group (mean difference − 5 days, CI − 6.75, − 3.05 days, $p < 0.001$, Fig. 5). Twenty studies [2, 11, 23–32, 34, 36–39, 41, 42, 45] reported the length of hospital stay in each group. Mean length of hospital stay was significantly shorter in the SEMS group than in the GJ group (mean difference − 10 days, CI − 11.6, − 7.9 days, $p < 0.001$, Fig. 6). Seven studies [12, 23, 27, 28, 30, 36, 45] compared the medical costs (median/mean) between the two groups, five of which [12, 23, 28, 30, 45] showed significantly lower expenses in favour of the SEMS
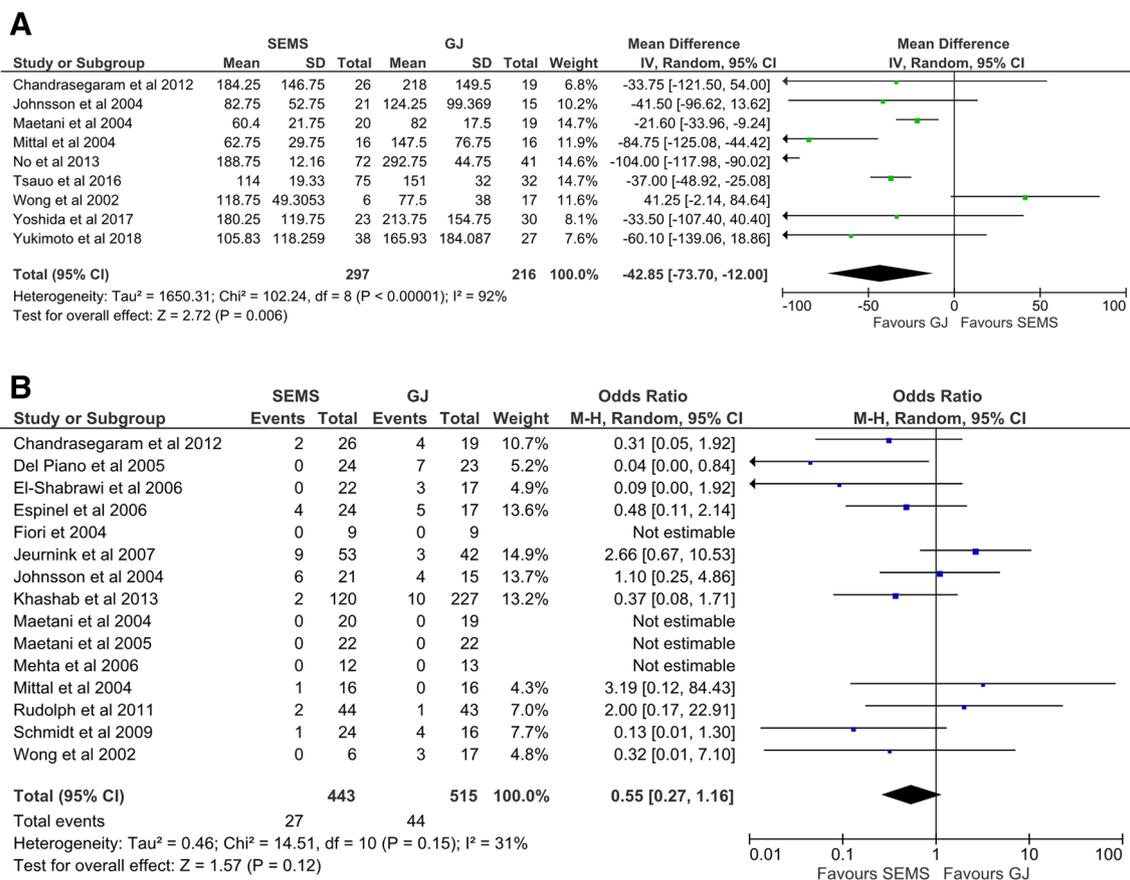

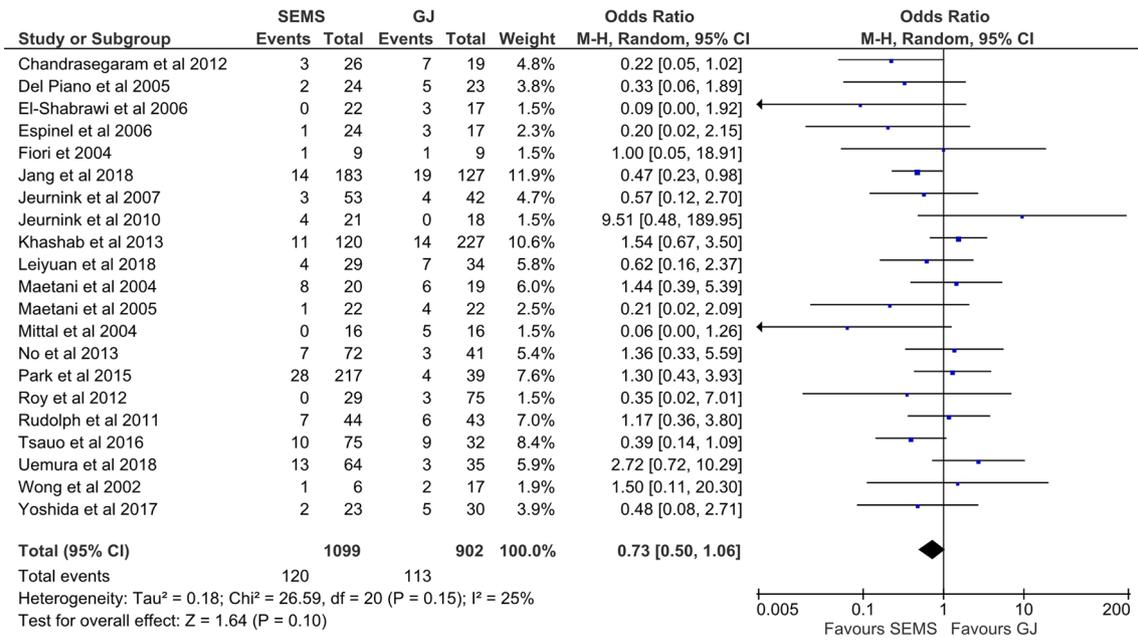Fig. 2 A Survival and B postoperative mortality after palliative surgery (GJ) and endoscopic stenting (SEMS)

Study or Subgroup	SEMS Events	Total	GJ Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Chandrasegaram et al 2012	3	26	7	19	4.8%	0.22 [0.05, 1.02]
Del Piano et al 2005	2	24	5	23	3.8%	0.33 [0.06, 1.89]
El-Shabrawi et al 2006	0	22	3	17	1.5%	0.09 [0.00, 1.92]
Espinel et al 2006	1	24	3	17	2.3%	0.20 [0.02, 2.15]
Fiori et 2004	1	9	1	9	1.5%	1.00 [0.05, 18.91]
Jang et al 2018	14	183	19	127	11.9%	0.47 [0.23, 0.98]
Jeurnink et al 2007	3	53	4	42	4.7%	0.57 [0.12, 2.70]
Jeurnink et al 2010	4	21	0	18	1.5%	9.51 [0.48, 189.95]
Khashab et al 2013	11	120	14	227	10.6%	1.54 [0.67, 3.50]
Leiyuan et al 2018	4	29	7	34	5.8%	0.62 [0.16, 2.37]
Maetani et al 2004	8	20	6	19	6.0%	1.44 [0.39, 5.39]
Maetani et al 2005	1	22	4	22	2.5%	0.21 [0.02, 2.09]
Mittal et al 2004	0	16	5	16	1.5%	0.06 [0.00, 1.26]
No et al 2013	7	72	3	41	5.4%	1.36 [0.33, 5.59]
Park et al 2015	28	217	4	39	7.6%	1.30 [0.43, 3.93]
Roy et al 2012	0	29	3	75	1.5%	0.35 [0.02, 7.01]
Rudolph et al 2011	7	44	6	43	7.0%	1.17 [0.36, 3.80]
Tsauo et al 2016	10	75	9	32	8.4%	0.39 [0.14, 1.09]
Uemura et al 2018	13	64	3	35	5.9%	2.72 [0.72, 10.29]
Wong et al 2002	1	6	2	17	1.9%	1.50 [0.11, 20.30]
Yoshida et al 2017	2	23	5	30	3.9%	0.48 [0.08, 2.71]
Total (95% CI)		1099		902	100.0%	0.73 [0.50, 1.06]
Total events	120		113			

Heterogeneity: Tau² = 0.18; Chi² = 26.59, df = 20 (P = 0.15); I² = 25%
Test for overall effect: Z = 1.64 (P = 0.10)

Fig. 3 Major complications

Table 2 Major complications, surgical and non-surgical, in each treatment group

SEMS (n = 120)	Patients (n, %)	GJ (n = 113)	Patients (n, %)
Stent dislocation/migration	41 (34.2%)	Dysfunction of anastomosis/obstruction	19 (16.8%)
Stent occlusion/obstruction	17 (14.2%)	Anastomotic leakage	18 (15.9%)
Stent fracture	7 (5.8%)	Haemorrhage	21 (18.6%)
Other stent related (collapse, perforation)	4 (3.3%)	Wound infection	8 (7.1%)
Bowel perforation	15 (12.5%)	Sepsis/septic shock	6 (5.3%)
Bleeding	10 (8.3%)	Other surgical	11 (9.7%)[b]
Other surgical	13 (10.8%)[a]	Non-surgical/medical	30 (26.6%)[d]
Non-surgical/medical	13 (10.8%)[c]		

[a]Includes pancreatitis, peritonitis, ileus, severe jaundice

[b]Includes severe pain, cholangitis, faecal fistula, hepatic abscess, perforation, peritonitis, abscess, severe jaundice, ileus, intra-abdominal infection

[c]Includes aspiration pneumonia, DVT, cardiac complications

[d]Includes myocardial infarction, renal failure, liver failure, aspiration pneumonia, respiratory failure, HIT, urinary tract infection

group. Quality of life was only addressed in three studies [11, 12, 32]. In one study [11], where the mean changes in Physical Health score and Mental Health score for each intervention were examined, mean physical health score was significantly higher in the stenting group after 1 month (p < 0.01). The second study [12] used standardised quality-of-life questionnaires (QLQ-C30, EuroQol-5D, EuroQol-VAS, QLQ-PAN26) to assess the health-related quality of life (HRQoL). HRQoL scores remained stable after both treatments, with no differences between GJJ and stent placement. Schmidt et al. [32] showed that endoscopic stent

placement was associated with significant improvement in dysphagia (DH), eating restrictions (EA), dry mouth (DM) and reflux, whereas surgical bypass was associated with significant improvements in DH and EA and improved scores without statistical significance for DM.

Risk of bias assessment

Eleven of 27 studies [2, 24–27, 37, 39–42, 44] were considered to be of low or moderate risk of bias, whereas 12 studies [23, 28–36, 38, 43, 45] were considered to be at serious but
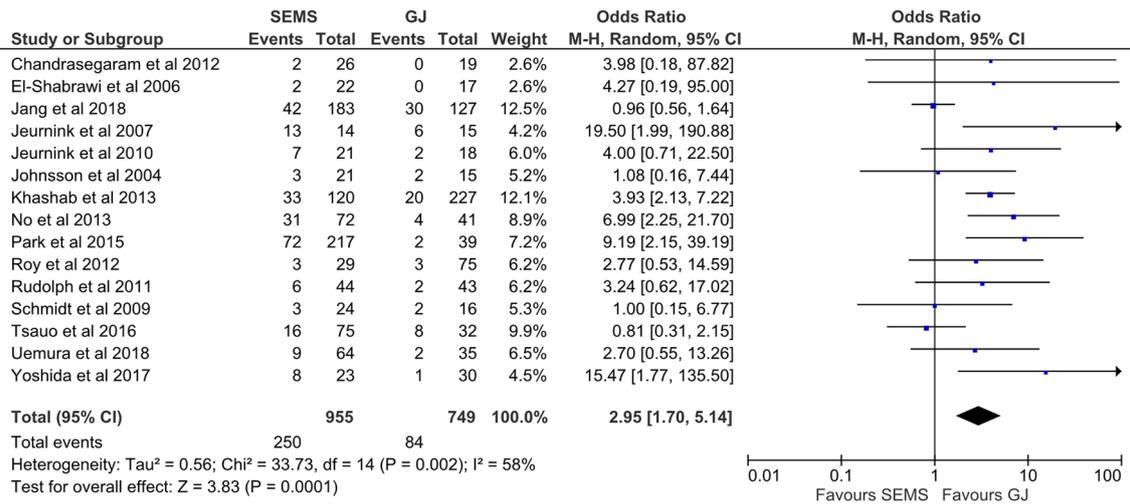
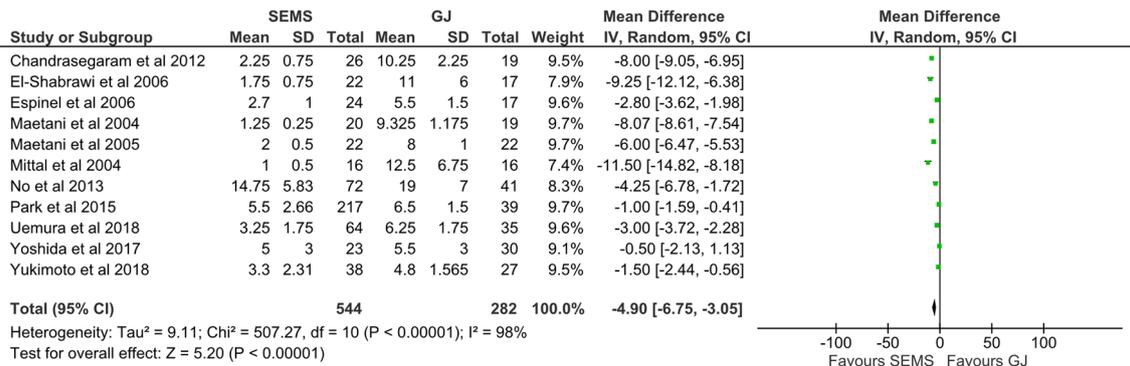| Study or Subgroup	SEMS Events	Total	GJ Events	Total	Weight	Odds Ratio M-H, Random, 95% CI	Odds Ratio M-H, Random, 95% CI
Chandrasegaram et al 2012	2	26	0	19	2.6%	3.98 [0.18, 87.82]	
El-Shabrawi et al 2006	2	22	0	17	2.6%	4.27 [0.19, 95.00]	
Jang et al 2018	42	183	30	127	12.5%	0.96 [0.56, 1.64]	
Jeurnink et al 2007	13	14	6	15	4.2%	19.50 [1.99, 190.88]	
Jeurnink et al 2010	7	21	2	18	6.0%	4.00 [0.71, 22.50]	
Johnsson et al 2004	3	21	2	15	5.2%	1.08 [0.16, 7.44]	
Khashab et al 2013	33	120	20	227	12.1%	3.93 [2.13, 7.22]	
No et al 2013	31	72	4	41	8.9%	6.99 [2.25, 21.70]	
Park et al 2015	72	217	2	39	7.2%	9.19 [2.15, 39.19]	
Roy et al 2012	3	29	3	75	6.2%	2.77 [0.53, 14.59]	
Rudolph et al 2011	6	44	2	43	6.2%	3.24 [0.62, 17.02]	
Schmidt et al 2009	3	24	2	16	5.3%	1.00 [0.15, 6.77]	
Tsauo et al 2016	16	75	8	32	9.9%	0.81 [0.31, 2.15]	
Uemura et al 2018	9	64	2	35	6.5%	2.70 [0.55, 13.26]	
Yoshida et al 2017	8	23	1	30	4.5%	15.47 [1.77, 135.50]	
Total (95% CI)		955		749	100.0%	2.95 [1.70, 5.14]	
Total events	250		84				

Heterogeneity: Tau² = 0.56; Chi² = 33.73, df = 14 (P = 0.002); I² = 58%
Test for overall effect: Z = 3.83 (P = 0.0001)

Fig. 4 Re-interventions

Study or Subgroup	SEMS Mean	SD	Total	GJ Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI	Mean Difference IV, Random, 95% CI
Chandrasegaram et al 2012	2.25	0.75	26	10.25	2.25	19	9.5%	-8.00 [-9.05, -6.95]	
El-Shabrawi et al 2006	1.75	0.75	22	11	6	17	7.9%	-9.25 [-12.12, -6.38]	
Espinel et al 2006	2.7	1	24	5.5	1.5	17	9.6%	-2.80 [-3.62, -1.98]	
Maetani et al 2004	1.25	0.25	20	9.325	1.175	19	9.7%	-8.07 [-8.61, -7.54]	
Maetani et al 2005	2	0.5	22	8	1	22	9.7%	-6.00 [-6.47, -5.53]	
Mittal et al 2004	1	0.5	16	12.5	6.75	16	7.4%	-11.50 [-14.82, -8.18]	
No et al 2013	14.75	5.83	72	19	7	41	8.3%	-4.25 [-6.78, -1.72]	
Park et al 2015	5.5	2.66	217	6.5	1.5	39	9.7%	-1.00 [-1.59, -0.41]	
Uemura et al 2018	3.25	1.75	64	6.25	1.75	35	9.6%	-3.00 [-3.72, -2.28]	
Yoshida et al 2017	5	3	23	5.5	3	30	9.1%	-0.50 [-2.13, 1.13]	
Yukimoto et al 2018	3.3	2.31	38	4.8	1.565	27	9.5%	-1.50 [-2.44, -0.56]	
Total (95% CI)			544			282	100.0%	-4.90 [-6.75, -3.05]	

Heterogeneity: Tau² = 9.11; Chi² = 507.27, df = 10 (P < 0.00001); I² = 98%
Test for overall effect: Z = 5.20 (P < 0.00001)

Fig. 5 Time to oral intake

Study or Subgroup	SEMS Mean	SD	Total	GJ Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI	Mean Difference IV, Random, 95% CI
Chandrasegaram et al 2012	11.25	2.25	26	25.25	5.75	19	6.1%	-14.00 [-16.73, -11.27]	
Del Piano et al 2005	3	1.4	24	24.2	10.4	23	5.1%	-21.20 [-25.49, -16.91]	
El-Shabrawi et al 2006	6	4	22	19.25	10.75	17	4.4%	-13.25 [-18.63, -7.87]	
Espinel et al 2006	11.55	7	24	12.75	4	17	5.7%	-1.20 [-4.59, 2.19]	
Jeurnink et al 2007	6	10.1	53	18	13.3	42	4.7%	-12.00 [-16.86, -7.14]	
Johnsson et al 2004	10	6.75	21	19.75	12.46	15	3.5%	-9.75 [-16.68, -2.82]	
Khashab et al 2013	10.1	9.8	120	13	9.2	227	6.5%	-2.90 [-5.02, -0.78]	
Leiyuan et al 2018	6.1	3.3	29	10.9	4.7	34	6.5%	-4.80 [-6.78, -2.82]	
Maetani et al 2004	21.65	10	20	31.875	6.375	19	4.5%	-10.23 [-15.46, -4.99]	
Maetani et al 2005	19.125	4.625	22	28.375	4.875	22	6.1%	-9.25 [-12.06, -6.44]	
Mehta et al 2006	5.2	1.1	12	11.4	2.4	13	6.8%	-6.20 [-7.65, -4.75]	
Mittal et al 2004	5.75	4.25	16	16.75	7.75	16	5.1%	-11.00 [-15.33, -6.67]	
No et al 2013	22.5	8.3	72	35.25	21.75	41	3.5%	-12.75 [-19.68, -5.82]	
Park et al 2015	15.5	8	217	31.5	24.5	39	3.1%	-16.00 [-23.76, -8.24]	
Schmidt et al 2009	7	5.75	24	14	7.5	16	5.1%	-7.00 [-11.34, -2.66]	
Tsauo et al 2016	7.25	1.16	75	14.5	2	32	7.0%	-7.25 [-7.99, -6.51]	
Uemura et al 2018	24.75	17.75	64	35.25	17.25	35	3.4%	-10.50 [-17.68, -3.32]	
Wong et al 2002	4	1.154	6	19.25	7.75	17	5.4%	-15.25 [-19.05, -11.45]	
Yim et al 2001	6.75	5.71	12	22.25	15.473	15	2.8%	-15.50 [-23.97, -7.03]	
Yoshida et al 2017	13.75	8.25	23	20.25	11	30	4.5%	-6.50 [-11.68, -1.32]	
Total (95% CI)			882			689	100.0%	-9.75 [-11.60, -7.90]	

Heterogeneity: Tau² = 12.63; Chi² = 143.28, df = 19 (P < 0.00001); I² = 87%
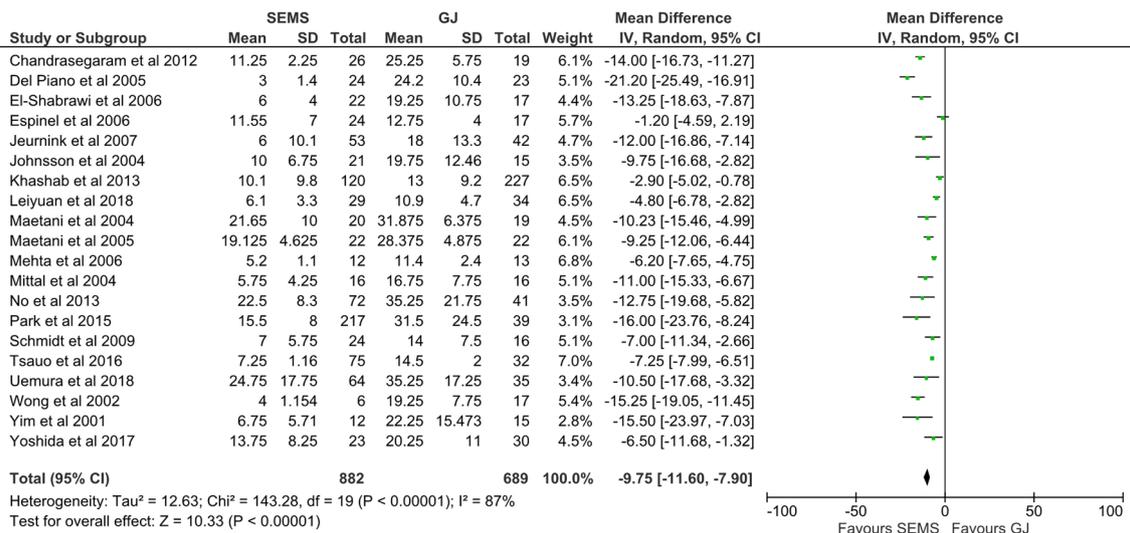Test for overall effect: Z = 10.33 (P < 0.00001)

Fig. 6 Length of hospital stay

not critical risk of bias, regarding confounding and selection of participants into the study. Among the three prospective randomised trials included in the systematic review, one [10] was considered to be at high risk of bias regarding bias due to deviations from intended interventions and another one [11] at high risk of bias with regard to bias due to missing data. The summarised results of the risk of bias assessment are provided in Table 3a and b.

Discussion

The present systematic review compared the two most common palliative treatment options in patients with malignant gastric outlet obstruction, endoscopic stenting and gastrojejunostomy. Technical and clinical success rates were comparable in both groups, patients were more likely to tolerate a soft/solid diet earlier (average 5 days) after palliative stenting than patients undergoing bypass surgery. Moreover, endoscopic stenting was significantly associated with a shorter hospital stay (average 10 days), as shown in previous meta-analyses [13–17]. Those in favour of endoscopic treatment, would then argue that, since the ability to restore oral intake is of paramount importance in such patients, then endoscopic treatment should be the treatment of choice in such patients. This would be however, a simplified way to address a rather complex issue. With the use of laparoscopic approach, studies [11, 45] have shown promising results regarding time to oral intake and length of hospital stay. Leiyuan et al. [45] showed no difference in the two groups, whereas Mehta et al. [11] showed that endoscopic treatment was associated with shorter hospital stay. Since the ability to restore oral intake and the post-procedural length of hospital stay are directly connected to one another, one could argue that the presumed benefits of endoscopic stenting could be eliminated with the use of the minimally invasive approach, but further studies need to address this issue.

Palliative surgery was not associated with increased perioperative morbidity and mortality, since the rates of major complications and the procedure-related mortality were comparable in both groups. Surgery was more often associated with medical complications than endoscopic stenting, e.g. aspiration pneumonia, cardiovascular infectious complications, whereas the majority of complications in the stenting group were procedure-related. The higher rates of medical complications in surgical patients did not however, affect the thirty-day mortality, which was similar in both groups. These results are in line with those of previous meta-analyses [13–15].

Contrary to previous meta-analyses [13–16] though, this is the first one to examine the frequency of re-interventions between the two groups. The present meta-analysis shows a three-times higher incidence of re-interventions in patients

undergoing endoscopic stenting. These results can possibly be explained by the fact that tumour ingrowth/outgrowth is not unusual after endoscopic treatment in such patient collectives. Moreover, procedure-related complications, such as stent migration, occlusion or fracture, which in the present systematic review were as high as 34.2%, 14.2% and 5.8%, respectively, can result in multiple endoscopic procedures leading to repeated readmissions, which will ultimately and inevitably affect the patient's quality of life. A previous meta-analysis [14] suggested that with longer follow-up one would expect greater rates of re-interventions in the SEMS group, but the data were at that point insufficient and inconclusive.

This is also the first meta-analysis to show a significant difference in survival rates in both groups. Patients undergoing bypass surgery lived significantly longer (average 43 days) than those receiving palliative stenting. These results need to be interpreted with caution. As known, most patients undergoing palliative procedures for malignant gastric outlet obstruction have a short life expectancy. Moreover, different pathologies affect survival in different ways, with pancreatic ductal adenocarcinoma being associated with worse survival than gastric cancer [13, 14]. Pancreatobiliary and gastric cancers were the most common causes of malignant gastric outlet obstruction in the present systematic review, which is in line with previous meta-analyses [13–17]. Unfortunately, we could not perform separate meta-analyses for each underlying pathology, since data extraction for each distinct primary disease separately was not possible. This should be acknowledged as a limitation of the present meta-analysis, as of others [14, 15]. However, the fact that surgery was significantly associated with longer overall survival has several possible explanations. As already mentioned above, we showed for the first time that re-intervention rates were significantly higher in patients undergoing palliative stenting than in patients, where bypass surgery was performed. Surgery seems to offer therefore, more robust results than endoscopy, therefore allowing the patient to receive further treatment, which in the palliative setting consists mainly of palliative chemotherapy. So it is probably not the intervention itself, which results in longer survival rates, rather than the long-term efficacy of the intervention, which enables the patient to receive palliative chemotherapy, whereas repeated readmissions and the need for multiple re-interventions could refrain the patient from completing the systemic therapy needed. This issue was addressed in the study of Uemura et al. [42], where administration of chemotherapy was an independent predictor of survival in patients with malignant gastric outlet obstruction due to pancreatic ductal adenocarcinoma. Interestingly, Yukimoto et al. [43] showed that significantly more patients could receive palliative chemotherapy after surgical bypass than endoscopic treatment. Tsauo et al. [39] and Yoshida et al. [41] on the other hand showed no significant differences in the number of patients receiving

Table 3 Risk of bias judgement for (a) non-randomised and (b) randomised studies included in the systematic review

Author	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall risk of bias
(a) Non-randomised studies								
Yim et al. [23]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Wong et al. [24]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious
Maetani et al. [25]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Maetani et al. [26]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Mittal et al. [27]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Johnsson et al. [28]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious
Del Piano et al. [2]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Espinel et al. [29]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious
El-Shabrawi et al. [30]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious
Jeurnink et al. [31]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious
Schmidt et al. [32]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious
Rudolph et al. [33]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious
Chandrasegaram et al. [34]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious
Roy et al. [35]	Moderate	Serious	Moderate	Low	Low	Moderate	Low	Serious
Khashab et al. [36]	Moderate	Serious	Moderate	Low	Low	Moderate	Low	Serious
No et al. [37]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Park et al. [38]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious
Tsauo et al. [39]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Jang et al. [40]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Yoshida et al. [41]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Uemura et al. [42]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Yukimoto et al. [43]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious
Jang et al. [44]	Moderate	Moderate	Moderate	Low	Low	Moderate	Low	Low or moderate
Leiyuan et al. [45]	Serious	Serious	Moderate	Low	Low	Moderate	Low	Serious

Table 3 (continued)

Author	Bias due to randomisation process	Bias due to deviations from intended interventions (effect of assignment)	Bias due to deviations from intended interventions (effect of adhering)	Bias due to missing outcome data	Bias in measurement of the outcome	Bias in selection of the reported result
(b) Randomised studies						
Fiori et al. [10]	Low	Some concerns	High risk	Low	Low	Low
Mehta et al. [11]	Low	Low	Low	High	Low	Low
Jeurnink et al. [12]	Low	Low	Low	Low	Low	Low

chemotherapy in each group. Further studies, which will focus on the ability to receive systemic treatment in each intervention group, would possibly shed light on this unresolved issue and tip the scales in favour of the treatment modality associated with higher rates of systemic treatment.

Furthermore, the performance status of the patient obviously affects survival, and since palliative patients with malignant GOO have a poor prognosis, it is likely that underlying comorbidities also play a somewhat crucial role when deciding the treatment of choice, e.g. palliative surgery or stenting. A risk-adjusted, individualised palliative treatment approach is, without a doubt, in the best interest of the patient.

The present meta-analysis has certain limitations that need to be addressed. The retrospective nature of most studies included as well the inclusion of patients with mixed pathologies should be acknowledged as limitations of the present as well as of all previous [13–16] meta-analyses addressing this issue. Moreover, baseline imbalance within studies due to the inclusion of both randomised and non-randomised studies should also be acknowledged as a limitation of the present systematic review.

In conclusion, the present meta-analysis shows that palliative surgery in patients with malignant gastric outlet obstruction is superior to endoscopic treatment with regard to re-interventions and survival, with comparable perioperative morbidity and mortality. Patients with an acceptable performance status, where systemic chemotherapy is likely to prolong survival, should therefore be primarily considered for a palliative surgical treatment, ideally in a minimally invasive approach. Further studies are needed in order to assess the role of minimally invasive surgery compared to endoscopic stenting for malignant GOO in the palliative setting.

Compliance with ethical standards

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