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Endoscopic ultrasound-guided gastroenterostomy versus duodenal stenting for gastric outlet obstruction

A systematic review, meta-analysis, and meta-regression

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Abstract

Background: Gastric outlet obstruction (GOO) refers to mechanical obstruction at the level of the gastric outlet and is associated with significantly impacted quality of life and mortality. Duodenal stenting (DS) offers a minimally invasive approach to managing GOO but is associated with a high risk of stent obstruction. Endoscopic ultrasound-guided gastroenterostomy (EUS-GE) is a novel intervention that uses lumen-apposing metal stents to open the restricted lumen. The current evidence comparing EUS-GE to DS is limited and inconsistent.

Methods: We conducted a systematic literature search on PubMed, Embase, Cochrane, Scopus, and clinicaltrials.gov to retrieve studies comparing EUS-GE to DS for GOO. Odds ratios (OR) and mean differences (MD) with their 95% confidence intervals (CI) were pooled using the DerSimonian-Laird inverse variance random-effects model. Statistical significance was set at $P < .05$.

Results: Ten studies with a total of 1275 GOO patients (585: EUS-GE and 690: DS) were included. EUS-GE was associated with statistically significant higher clinical success [OR: 2.52; 95% CI: 1.64, 3.86; $P < .001$], lower re-intervention rate [OR: 0.12; 95% CI: 0.06, 0.22; $P < .00001$], longer procedural time [MD: 20.91; 95% CI: 15.48, 26.35; $P < .00001$], and lower risk of adverse events [OR: 0.49; 95% CI: 0.29, 0.82; $P = .007$] than DS. Technical success [OR: 0.62; 95% CI: 0.31, 1.25] and the length of hospital stay [MD: –2.12; 95% CI: –5.23, 0.98] were comparable between the 2 groups.

Conclusion: EUS-GE is associated with higher clinical success, longer total procedural time, lower re-intervention rate, and lower risk of adverse events than DS. Technical success and the length of hospital stay were comparable between the 2 groups. EUS-GE appears to be a safe and effective procedure for managing GOO. Further large, multicentric randomized controlled trials are warranted to investigate the safety and outcomes of EUS-GE in patients with malignant GOO.

Abbreviations: CI = confidence intervals, DS = duodenal stenting, EUS-GE = endoscopic ultrasound-guided gastroenterostomy, GOO = gastric outlet obstruction, LAMS = lumen-apposing metal stents, MD = mean differences, OR = odds ratios, RCT = randomized controlled trial, SEMS = self-expanding metal stent, SGJ = surgical gastrojejunostomy.

Keywords: duodenal stenting, endoscopic ultrasound-guided gastroenterostomy, enteral stenting, gastric outlet obstruction, meta-analysis

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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1. Introduction

Gastric outlet obstruction (GOO), also referred to as pyloric obstruction or stenosis, results from mechanical compression of the distal stomach, pyloric antrum, or duodenum, leading to blockage of the lumen of the gastrointestinal tract.[1,2] This obstruction of the lumen could occur because of an underlying benign etiology, such as peptic ulcers, chronic pancreatitis, or malignant etiology, including pancreatic and gastric cancers. GOO carries a particularly poor prognosis, with a median survival of 3 to 6 months.[3,4] The severity and duration of the blockage determine the spectrum of clinical manifestations, which range from epigastric pain and vomiting to weight loss and a functional decline in the nutritional and hydration status.[5,6] In malignant GOO, curative surgery is feasible in only a small subset of patients; hence, palliation of the obstruction remains the sole modality.[7] The conventional method for palliating GOO involves mechanical bypass of the obstruction by a surgical gastrojejunostomy (SGJ). Unfortunately, owing to its invasive nature and higher likelihood of morbidity, it is becoming less preferred in current practice.[8,9] Duodenal stenting (DS) offers an alternative, minimally invasive, and safe method to open the obstruction using expandable metal stents; however, enteral stent is at risk of stent obstruction and has comparatively higher chances of re-intervention.[10,11]

A novel interventional modality called endoscopic ultrasound-guided gastroenterostomy (EUS-GE) has been described. EUS-GE uses lumen-apposing metal stents (LAMS) deployment under EUS guidance.[3,8,12,13] Recent investigations have demonstrated a favorable safety profile for EUS-GE compared to SGJ and DS.[14–16] Hence, the current guidelines laid down by the European Society of Gastrointestinal Endoscopy recommend EUS-GE as a safe alternative to enteral stent and SGJ for malignant GOO if performed under expert supervision.[17] However, current data comparing EUS-GE with DS are inconsistent, with some studies showing no increased benefit with EUS.[18,19] Hence, this systematic review and meta-analysis aimed to investigate the safety and clinical outcomes of EUS-GE compared with DS in patients with malignant GOO.

2. Materials and methods

This systematic review and meta-analysis were conducted and reported in line with the guidelines laid forth by the Preferred Reporting Items for Systematic Review and Meta-Analysis Statement (PRISMA 2020) (Table S1, Supplemental Digital Content, http://links.lww.com/MD/N679).[20,21] The predefined systematic review and meta-analysis study protocol was registered in the PROSPERO International Registry (CRD42024508282).

2.1. Search strategy

An electronic bibliographic literature search spanning the major online databases such as Medline (via PubMed), Embase, the Cochrane Library, Scopus, and the International Registry of Clinical Trials (www.clinicaltrials.gov) was done, from their inception up to April 2024. A database search strategy was constructed using a combination of specific keywords and medical subject headings (MeSH) which included: "Gastric outlet obstruction," "pyloric stenosis," "endosonography," "endoscopic ultrasonography," "endoscopic ultrasound-guided," "gastroenterostomy," "gastroenteroanastomosis," "surgical gastrojejunostomy," "surgical gastrojejunostomy," "gastric bypass," and "stent." We utilized a combination of Boolean operators like "OR" and "AND" to modulate the search strategy. The detailed specific search strategy is depicted in Table S2, Supplemental Digital Content, http://links.lww.com/MD/N679, which was modified as per the requirements of the specific databases. To ensure completeness, we scrutinized the reference list of the included articles, reviews, and previous meta-analyses to identify potentially relevant articles. We did not impose any restrictions on the publication year of articles and the language of publication.

2.2. Study selection and eligibility criteria

We considered studies adhering to the following inclusion criteria: (i) randomized controlled trials (RCTs) or observational studies, (ii) patients with malignant GOO, (iii) 1 group of patients underwent EUS-GE, (iv) comparator group underwent DS, (v) and reported at least one of the outcomes of interest. Our outcomes of interest included technical success, clinical success, total procedural time, re-intervention rate, length of hospital stay, and adverse events.

2.3. Data extraction and quality assessment

The extracted data from each study included: the author's name, year, study design, number of patients in each group, mean age, males (%), etiology of GOO, and outcomes of interest. To assess the quality of studies, we utilized the Newcastle-Ottawa Scale for observational studies and the Cochrane risk of bias tool for randomized studies (RoB 2) for RCTs.[22,23] Two investigators (D.D. and R.M.O.) conducted this assessment and discrepancies were resolved by involving a third investigator (H.J.).

2.4. Data synthesis

Statistical analyses for the extracted data were performed using the Review Manager Version 5.4 (Nordic Cochrane Center, Copenhagen, Denmark). For outcomes with dichotomous data, we pooled odds ratios (OR) with their corresponding 95% confidence intervals (CI), and for continuous data, we pooled mean differences (MD) with 95% CI. Considering the baseline variability in the study design, we employed a random-effects model to pool data. To quantify statistical heterogeneity for all outcomes, we employed the Higgins I2 statistic, with values over 50% suggesting moderate heterogeneity, and over 75% suggesting severe heterogeneity.[24] To explore the heterogeneity, we utilized the "leave-one-out" method for sensitivity analyses by serially omitting each study to assess which study has the most effect on heterogeneity. To explore publication bias in outcomes, we used Egger regression test, Begg–Mazumdar rank correlation test, and funnel plot asymmetry to estimate the presence of publication bias.[25,26] Statistical significance was considered if the *P*-value was <.05.

3. Results

3.1. Study selection

The primary screening retrieved 1451 potentially relevant records. After deduplication (n = 278), we subjected the remaining (n = 1213) articles to preliminary screening based on title and abstract. Subsequently, 75 records underwent a more comprehensive assessment by evaluating full texts. Finally, we excluded 65 articles due to various reasons: wrong outcomes (n = 34), wrong study design (n = 17), and wrong publication type (n = 14). We included 10 studies in this final meta-analysis, 5 of which are conference meeting abstracts.[13,18,19,27–33]

The process of study selection is depicted in the PRISMA flowchart (Fig. S1, Supplemental Digital Content, http://links.lww.com/MD/N678).

3.2. Study and patient characteristics

A total of 10 studies with 1275 GOO patients (585 in the EUS-GE group and 690 in the DS group) were included. The

Table 1

Baseline characteristics of included studies.

Author name (year)	Study design	Number of patients; n		Age; mean ± SD		Number of males; %		Etiology of GOO		Length of follow-up	
		EUS-GE	DS	EUS-GE	DS	EUS-GE	DS	EUS-GE	DS	EUS-GE	DS
Chan (2021)	Retrospective observational	48	31	63.21 ± 13.74	71.9 ± 10.28	30	42	Pancreatic cancer = 30% Stomach cancer = 27% Others = 43%	Pancreatic cancer = 34.4% Stomach cancer = 48.2% Others = 20.6%	Median = 51.5 days	Median = 48 days
Chen (2016)	Retrospective observational	30	52	70 ± 13.3	64 ± 13.2	56.7	61.5	Gastric cancer = 16.7% Duodenal/ampullary cancer = 6.7% Pancreatic cancer = 56.7% Biliary/gallbladder cancer = 6.7% Extrinsic/metastatic cancer = 13.3% Carcinomatosis = 46.7%	Gastric cancer = 5.8% Duodenal/ampullary cancer = 13.5% Pancreatic cancer = 53.8% Biliary/gallbladder cancer = 7.7% Extrinsic/metastatic cancer = 19.2% Carcinomatosis = 34.6%	Median = 103 days	Median = 23.5 days
Ge (2019)	Retrospective observational	22	78	66.4 ± 9.2	65.7 ± 12.6	40.9	60.3	Gastric cancer = 4.6% Duodenal cancer = 4.6% Pancreatic cancer = 31.8% Ampullary cancer = 0% Biliary (gallbladder or cholangiocarcinoma) = 18.2% Metastatic = 40.9%	Gastric cancer = 10.3% Duodenal cancer = 1.3% Pancreatic cancer = 51.3% Ampullary cancer = 2.6% Biliary (gallbladder or cholangiocarcinoma) = 10.3% Metastatic = 24.4%		NA
Iqbal (2019)	Retrospective observational	8	52	64 ± 14.2	69.1 ± 13.2	62.5	50	Pancreatic cancer = 58% Gastric adenocarcinoma = 13% Chronic pancreatitis = 8% Others = 21%			NA
Marya (2020)	Retrospective observational	172	153	62.4 ± 11.8	62 ± 16.6	60.5	52.9	Pylorus obstruction = 1.7% Duodenal bulb obstruction = 5.2% Second portion of duodenum obstruction = 47.1% Distal duodenum obstruction = 43.6% Other = 2.3%	Pylorus obstruction = 14.4% Duodenal bulb obstruction = 35.9% Second portion of duodenum obstruction = 31.4% Distal duodenum obstruction = 10.5% Other = 7.8%	Median = 234 days	Median = 61 days
Rosas (2021)	Retrospective observational	25	25	69.6	66.9	60	60	Pancreatic cancer = 56% Other = 44%	Pancreatic cancer = 68% Other = 32%	Mean = 6.3 months	Mean = 7.4 months
Sánchez-Aldehuelo (2022)	Retrospective observational	79	97	72.4 ± 10.7	70.8 ± 11.7	54.4	59.8	Pancreatic cancer = 46.4% Gastric cancer = 27.8% Duodenal cancer = 6.2% Biliary tract and gallbladder = 8.2% Other = 11.3%	Pancreatic cancer = 62% Gastric cancer = 19% Duodenal cancer = 6.3% Biliary tract and gallbladder = 6.3% Other = 6.3%	NA (until the last clinical visit, end of study, or death)	
Teoh (2024)	RCT	48	49	69.5 ± 12.6	64.8 ± 13.0	52	43	Pancreatic cancer = 44% Gastric cancer = 29% Duodenal cancer = 10% Periampullary cancer = 8% Cholangiocarcinoma = 4% Gallbladder cancer = 4%	Pancreatic cancer = 47% Gastric cancer = 29% Duodenal cancer = 12% Periampullary cancer = 8% Cholangiocarcinoma = 2% Gallbladder cancer = 2%	Till 6 months or until death	

(*Continued*)

Table 1
(Continued)

Author name (year)	Study design	Number of patients; n		Age; mean ± SD		Number of males; %		Etiology of GOO		Length of follow-up	
		EUS-GE	DS	EUS-GE	DS	EUS-GE	DS	EUS-GE	DS	EUS-GE	DS
Vazquez-Sequerios (2020)	Retrospective observational	46	46	72.7 ± 11.2	69.9 ± 12.6	59	67	Pancreatic cancer = 61% Gastric cancer = 15% Duodenal cancer = 6% Biliary/gallbladder cancer = 9% Other = 9%	Pancreatic cancer = 61% Gastric cancer = 28% Duodenal cancer = 5% Biliary/gallbladder cancer = 6% Other = 0%	Median (IQR) = 76 (34–170) days	Median (IQR) = 91 (58–161) days
Wanrooij (2022)	Retrospective observational	107	107	66 ± 11.8	67 ± 11.2	49.5	45.8	Pancreatic cancer = 46.7% Biliary tract cancer = 14% Gastric cancer = 11.2% Duodenal cancer = 9.3% Other = 18.7%	Pancreatic cancer = 65.4% Biliary tract cancer = 6.5% Gastric cancer = 7.5% Duodenal cancer = 9.3% Other = 11.2%	Median(IQR) = 85 (43–157) days	Median IQR = 57 (18.5–130.5) days

DS = duodenal stenting, EUS-GE = endoscopic ultrasound-guided gastroenterostomy, GOO = gastric outlet obstruction.

detailed baseline characteristics of the included studies and the corresponding follow-up period are tabulated in Table 1.

3.3. Outcomes

3.3.1. Technical success. Technical success was reported in all 10 studies.[13,18,19,27–33] There was no statistically significant difference in the rates of technical success between the 2 groups [OR: 0.62; 95% CI: 0.31, 1.25; $P = .18$; $I^2 = 5\%$] (Fig. 1A). Meta-regression analysis was significant for the mean age of the EUS-GE group as a covariate (coefficient = 0.237; lower bound = 0.044; upper bound = 0.429; $P = .016$), but not significant for the mean age of the DS group (coefficient = 0.194; lower bound = -0.023; upper bound = 0.412; $P = .079$) and publication year (coefficient = 0.057; lower bound = -0.228; upper bound = 0.341; $P = .695$) (Figs. S2–S4, Supplemental Digital Content, http://links.lww.com/MD/N678). Publication bias was insignificant on Egger test ($P = .649$) and Begg–Mazumdar test ($P = .989$), with mild concerns for funnel plot asymmetry (Fig. S5, Supplemental Digital Content, http://links.lww.com/MD/N678).

3.3.2. Clinical success. Clinical success was reported in all 10 studies.[13,18,19,27–33] EUS-GE was associated with statistically significant higher clinical success [OR: 2.52; 95% CI: 1.64, 3.86; $P < .0001$; $I^2 = 0\%$] compared to DS (Fig. 1B). Meta-regression analysis was insignificant for the mean age of the EUS-GE group (coefficient = 0.019; lower bound = -0.104; upper bound = 0.142; $P = .757$), the mean age of the DS group (coefficient = -0.039; lower bound = -0.186; upper bound = 0.108; $P = .601$), and the publication year (coefficient = 0.047; lower bound = -0.156; upper bound = 0.251; $P = .649$) as a covariate (Figs. S6–S8, Supplemental Digital Content, http://links.lww.com/MD/N678). Publication bias was insignificant on Egger test ($P = .064$) and Begg–Mazumdar test ($P = .94$), with no funnel plot asymmetry (Fig. S9, Supplemental Digital Content, http://links.lww.com/MD/N678).

3.3.3. Total procedural time. Total procedural time was reported in 3 studies.[29,30,33] EUS-GE was associated with a significantly higher total procedural time [MD: 20.91; 95% CI: 15.48, 26.35; $P < .00001$; $I^2 = 0\%$] compared to DS (Fig. 1C). Meta-regression analysis was insignificant for the mean age of the EUS-GE group (coefficient = 1.152; lower bound = -4.828; upper bound = 7.132; $P = .706$), the mean age of the DS group (coefficient = 0.467; lower bound = -5.660; upper bound = 6.595; $P = .881$), and the publication year (coefficient = -8.461; lower bound = -17.624; upper bound = 0.702; $P = .070$) as a covariate (Figs. S10–S12, Supplemental Digital Content, http://links.lww.com/MD/N678). Publication bias was insignificant on Egger test ($P = .297$) with no funnel plot asymmetry (Fig. S13, Supplemental Digital Content, http://links.lww.com/MD/N678).

3.3.4. Re-intervention rate. The rate of re-intervention was reported in 6 studies.[13,18,19,28,29,33] EUS-GE was associated with a significantly lower rate of re-intervention [OR: 0.12; 95% CI: 0.06, 0.22; $P < .00001$; $I^2 = 0\%$] compared to DS (Fig. 1D). Meta-regression analysis was insignificant for the mean age of the EUS-GE group (coefficient = 0.054; lower bound = -0.166; upper bound = 0.274; $P = .628$), the mean age of the DS group (coefficient = 0.066; lower bound = -0.124; upper bound = 0.256; $P = .497$), and the publication year (coefficient = -0.074; lower bound = -0.373; upper bound = 0.225; $P = .627$) as a covariate (Figs. S14–16, Supplemental Digital Content, http://links.lww.com/MD/N678). Publication bias was significant on Egger test ($P = .0001$), but not on Begg–Mazumdar test ($P = .984$), with minor concerns for funnel plot asymmetry (Fig. S17, Supplemental Digital Content, http://links.lww.com/MD/N678).

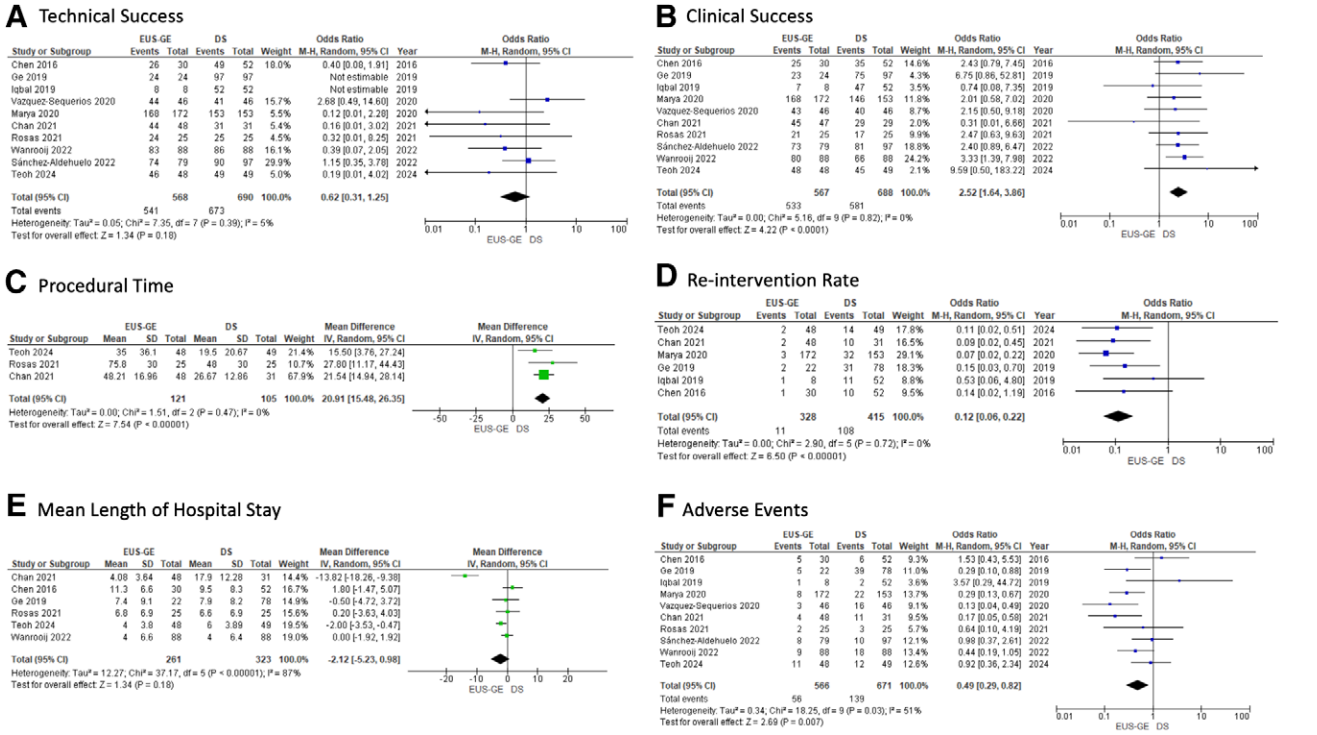

Figure 1. Forest plots depicted individual and pooled analyses comparing endoscopic ultrasound-guided gastroenterostomy (EUS-GE) versus duodenal stenting (DS) for gastric outlet obstruction. The odds ratios (OR) and mean differences (MD) with their 95% confidence intervals (CI) are depicted on a logarithmic scale. The diamond symbolizes the combined or overall effect. (A) Technical success; (B) clinical success; (C) procedural time; (D) re-intervention rate; (E) mean length of hospital stay; (F) adverse events.

3.3.5. Length of hospital stay. The length of hospital stay was reported in 6 studies.[13,18,29–31,33] EUS-GE was associated with a slightly lower, though not statistically significant difference in the mean length of hospital stay [MD: -2.12; 95% CI: -5.23, 0.98; $P = .18$; $I^2 = 87\%$] than DS (Fig. 1E). Meta-regression was significant for publication bias (coefficient = -0.913; lower bound = -1.350; upper bound = -0.477; $P < .001$) as a covariate, but insignificant for the mean age of the EUS-GE group (coefficient = 0.538; lower bound = -0.171; upper bound = 1.248; $P = .137$) and the DS group (coefficient = -0.509; lower bound = -1.195; upper bound = 0.178; $P = .147$) as covariates (Figs. S18–S20, Supplemental Digital Content, http://links.lww.com/MD/N678). To explore high heterogeneity ($I^2 = 87\%$), omitting Chan et al (2021) dropped the I^2 to 30% (Fig. S21, Supplemental Digital Content, http://links.lww.com/MD/N678). Publication bias was significant on Egger test ($P = .0127$) with major funnel plot asymmetry, but not on Begg–Mazumdar test ($P = .8519$) (Fig. S22, Supplemental Digital Content, http://links.lww.com/MD/N678).

3.3.6. Adverse events. Adverse events were reported in all 10 studies.[13,18,19,27–33] EUS-GE was associated with a significantly lower rate of adverse events [OR: 0.49; 95% CI: 0.29, 0.82; $P = .007$; $I^2 = 51\%$] (Fig. 1F). Meta-regression analysis was insignificant for the mean age of the EUS-GE group (coefficient = 0.085; lower bound = -0.018; upper bound = 0.189; $P = .107$), the mean age of the DS group (coefficient = -0.042; lower bound = -0.195; upper bound = 0.111; $P = .594$), and the publication year (coefficient = -0.008; lower bound = -0.240; upper bound = 0.224; $P = .947$) as a covariate (Figs. S23–25, Supplemental Digital Content, http://links.lww.com/MD/N678). To explore moderate heterogeneity ($I^2 = 51\%$), omitting Vazquez-Sequerios 2020 dropped the I^2 to 44% (Fig. S26, Supplemental Digital Content, http://links.lww.com/MD/N678). Publication bias was significant on Egger test ($P = .01258$) with mild funnel plot asymmetry, but not on Begg–Mazumdar test ($P = .99$) (Fig. S27, Supplemental Digital Content, http://links.lww.com/MD/N678).

3.4. Quality assessment

We utilized the Risk Of Bias In Non-randomized Studies of Interventions (ROBINS-1) tool for observational studies and Cochrane Risk of Bias-2 (RoB-2) tool for RCTs.[34,35] The Rob-2 and ROBINS-I plots are depicted in Fig. S28–S31, Supplemental Digital Content, http://links.lww.com/MD/N678.

4. Discussion

This meta-analysis concludes that EUS-GE is associated with higher clinical success, longer total procedural time, lower re-intervention rate, and lower risk of adverse events than DS. The technical success rate and the length of hospital stay were comparable between the 2 groups.

Both endoscopic methods, EUS-GE and DS achieved similar technical success rates despite a significantly higher clinical success rate for the EUS-GE approach. This can be attributed to several factors: firstly, the use of LAMS in EUS-GE which is shorter than self-expanding metal stent (SEMS) used in DS, thereby facilitating better food passage into the small intestine.[36] Secondly, the LAMS is placed at a distance from the tumor and expands to its full diameter, whereas, compression by the tumor may hinder the SEMS from reaching its full diameter, potentially impending food passage.[37] Total procedural time was significantly longer for EUS-GE compared to DS. This might reflect the considerable procedural complexity and more invasive nature of the former. Meta-regression analysis revealed that the mean age of the patient population was a significant covariate for the technical success of EUS-GE. This finding likely reflects the impact of age-related factors on the anatomical and physiological characteristics

of the gastrointestinal tract, such as increased presence of diverticula, changes in mucosal integrity, or reduced motility, which can affect the feasibility and outcomes of endoscopic procedures.[38] EUS-GE exhibited a significantly lower re-intervention rate than DS, which can be attributed to better stent patency associated with EUS-GE and a lower incidence of stent dysfunction due to issues such as tumor in- or overgrowth, food impaction, or migration, which are more common after DS placement.[39] Adverse events, as defined by the American Society for Gastrointestinal Endoscopy classification of adverse events associated with endoscopic procedures, were significantly less frequent in the EUS-GE group compared to the DS approach, which may be correlated with the increased need for re-intervention in the DS approach, a factor consistent with the findings from our study.[40] DS has higher re-intervention rates primarily due to re-obstruction since, unlike EUS-GE, which bypasses the obstruction site, DS allows food passage through the neoplastic tissue.[41] It is important to note that 30-day all-cause mortality did not differ between the 2 groups.[42,43]

The optimal modality for palliating malignant GOO remains under active investigation. Although conventional laparoscopic SGJ approaches have been considered the gold standard for decades, factors such as the poor nutritional status and prognosis of these patients often render surgery either impossible or undesirable due to relatively high perioperative morbidity.[44,45] Endoscopic DS placement offers a minimally invasive alternative to surgical approaches. Studies have demonstrated higher rates of clinical and technical success, lower re-intervention rates, and a better safety profile for DS compared to surgical approaches.[11,46,47] While DS placement using SEMS has been performed for around 3 decades, EUS-GE is a relatively novel and technically complex procedure developed as an alternative to DS placement, albeit necessitating a steep learning curve.[48,49] Therefore, EUS-GE should be restricted to specialized endoscopy centers with high procedural volumes and endoscopists trained in this advanced therapeutic EUS approach.[50] The presence of ascites is considered an absolute contraindication to EUS-GE since it can create technical challenges during the LAMS placement by pushing the target loop away from the gastric wall, while peritoneal carcinomatosis is regarded as a relative contraindication to EUS-GE, as it may hinder bowel manipulation.[51,52] Nonetheless, Basha et al found no significant differences in technical or clinical success when comparing patients with and without ascites.[51] Similarly, carcinomatosis with ascites portends a poorer prognosis in patients undergoing SEMS placement for malignant GOO.[53] The presence and quantity of ascites can be accessed via cross-imaging to evaluate potential interference with the trajectory of the electrocautery-enhanced LAMS.[54] Clinical studies have suggested that due to lower re-intervention rates associated with EUS-GE, which aligns with our findings, patients with a life expectancy exceeding 2 months should be considered for EUS-GE.[13] Conversely, patients with a lower life expectancy, widespread metastasis, or uncontrolled ascites may be better suited for DS over EUS-GE. Takamatsu et al concluded from a real-world clinical study that patients with a Glasgow Prognostic Score of 0 to 1 are suitable candidates for DS placement.[55] The 2021 American Gastroenterology Association Clinical Practice Update on the Optimal Management of Malignant Alimentary Tract Obstruction advises that for life expectancies exceeding 2 months and good functional status, SGJ using a laparoscopic approach should be considered.[9] In expert settings, EUS-GE is an acceptable alternative, as recommended by the European Society of Gastrointestinal Endoscopy, while patients who are unsuitable for either EUS-GE or SGJ should be considered for DS placement.[9,17] Conversely, surgery may be reserved for patients with expected prolonged survival for whom less invasive procedures are not feasible or have failed.[9] Given the lack of consensus guidelines regarding the management of mGOO, it remains imperative to consider multiple factors when selecting either EUS-GE or DS to individualize the management approach.

4.1. Future directions

The overall complexity of the EUS-GE procedure and ongoing technical modifications highlight the need for an improved and standardized method before its widespread adoption can be recommended. Additionally, LAMS used in EUS-GE are not FDA-approved for treating gastrointestinal anastomosis.[56] Despite this, numerous hospitals have already adopted EUS-GE as the primary choice for the palliation of malignant GOO.[57] Future research should prioritize outcomes that are important from the patient's perspective, such as hospital stay and time to resumption of oral intake. Ideally, randomized controlled trials with longer follow-up periods should be employed to address these questions, although this remains challenging given the palliative nature of these interventions. Two RCTs currently underway (NCT03823690, NCT03259763) may offer more insights into the rates of GOO recurrence and the need for re-interventions. The etiology of mGOO should be considered in future studies. EUS-GE can be performed using at least 3 different techniques, including direct EUS-GE, device-assisted EUS-GE, and EPASS double balloon-occluded gastrojejunostomy bypass.[58] A comparative analysis of the various types and modifications in the EUS-GE procedure may further assist in establishing an optimal strategy. An individual patient data analysis might be helpful in this regard, as it can provide strategies tailored to individual patients.

5. Limitations

The results of this meta-analysis should be interpreted with caution due to some limitations. First, 5 of the included studies were conference abstracts, considered as a form of gray literature, with full-text not available and insufficient reporting which poses significant limitations on the validity of the study and its design. Second, this is a study-level meta-analysis with no individual patient-level data available, hence individual variations in outcomes and the evaluation of effect modifiers were not conducted. Third, most of the studies included in the analysis were observational. Observational studies are inherently at a higher risk of bias due to the absence of randomization and are liable to physician-decision-controlled enrollment. Fourth, the total sample size of the included studies is small, which restricts the external validity of the results. Finally, the variable follow-up period limits the validity of the results, in part, by introducing study heterogeneity.

6. Conclusion

This study demonstrates that EUS-GE is associated with higher clinical success, longer total procedural time, lower re-intervention rate, and lower risk of adverse events than DS. No significant difference in technical success and the length of hospital stay were found between the 2 groups. This meta-analysis underscores the safety and effectiveness of EUS-GS as a potential first-line procedure for managing GOO. Endoscopic guidance improves the accuracy of the stent placement and, hence is associated with lower re-intervention requirements. The summary of this meta-analysis is depicted in the graphical abstract (Graphical Abstract, Supplemental Digital Content). Considering the availability of limited randomized evidence for EUS-GE, further large-scale, multicentric trials are necessary to investigate EUS-GE in a varied patient population.

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References

[1] Papanikolaou IS, Siersema PD. Gastric outlet obstruction: current status and future directions. Gut Liver. 2022;16:667–75.
[2] Kumar A, Annamaraju P. Gastric Outlet Obstruction. In: StatPearls. StatPearls Publishing; 2024. http://www.ncbi.nlm.nih.gov/books/NBK557826/. Accessed April 11, 2024.
[3] Miller C, Benchaya JA, Martel M, et al. EUS-guided gastroenterostomy vs. surgical gastrojejunostomy and enteral stenting for malignant gastric outlet obstruction: a meta-analysis. Endosc Int Open. 2023;11:E660–72.
[4] Warshaw AL, Fernández-del Castillo C. Pancreatic carcinoma. N Engl J Med. 1992;326:455–65.
[5] Brimhall B, Adler DG. Enteral stents for malignant gastric outlet obstruction. Gastrointest Endosc Clin N Am. 2011;21:389–403.
[6] Koop AH, Palmer WC, Stancampiano FF. Gastric outlet obstruction: a red flag, potentially manageable. Cleve Clin J Med. 2019;86:345–53.
[7] Schnelldorfer T, Ware AL, Sarr MG, et al. Long-term survival after pancreatoduodenectomy for pancreatic adenocarcinoma: is cure possible? Ann Surg. 2008;247:456.
[8] Chandan S, Khan SR, Mohan BP, et al. EUS-guided gastroenterostomy versus enteral stenting for gastric outlet obstruction: systematic review and meta-analysis. Endosc Int Open. 2021;9:E496–504.
[9] Ahmed O, Lee JH, Thompson CC, Faulx A. AGA clinical practice update on the optimal management of the malignant alimentary tract obstruction: expert review. Clin Gastroenterol Hepatol. 2021;19:1780–8.
[10] Nagaraja V, Eslick GD, Cox MR. Endoscopic stenting versus operative gastrojejunostomy for malignant gastric outlet obstruction-a systematic review and meta-analysis of randomized and non-randomized trials. J Gastrointest Oncol. 2014;5:92–8.
[11] Khashab M, Alawad AS, Shin EJ, et al. Enteral stenting versus gastrojejunostomy for palliation of malignant gastric outlet obstruction. Surg Endosc. 2013;27:2068–75.
[12] Jaruvongvanich V, Mahmoud T, Dayyeh BKA, et al. Endoscopic ultrasound-guided gastroenterostomy for the management of gastric outlet obstruction: a large comparative study with long-term follow-up. Endosc Int Open. 2023;11:E60.
[13] Ge PS, Young JY, Dong W, Thompson CC. EUS-guided gastroenterostomy versus enteral stent placement for palliation of malignant gastric outlet obstruction. Surg Endosc. 2019;33:3404–11.
[14] Irani S, Baron TH, Itoi T, Khashab MA. Endoscopic gastroenterostomy: techniques and review. Curr Opin Gastroenterol. 2017;33:320–9.
[15] Itoi T, Baron TH, Khashab MA, et al. Technical review of endoscopic ultrasonography-guided gastroenterostomy in 2017. Digest Endoscop. 2017;29:495–502.
[16] Kerdsirichairat T, Irani S, Yang J, et al. Durability and long-term outcomes of direct EUS-guided gastroenterostomy using lumen-apposing metal stents for gastric outlet obstruction. Endosc Int Open. 2019;7:E144–50.
[17] van der Merwe SW, van Wanrooij RLJ, Bronswijk M, et al. Therapeutic endoscopic ultrasound: European Society of Gastrointestinal Endoscopy (ESGE) Guideline. Endoscopy. 2022;54:185–205.
[18] Chen YI, Itoi T, Baron TH, et al. EUS-guided gastroenterostomy is comparable to enteral stenting with fewer re-interventions in malignant gastric outlet obstruction. Surg Endosc. 2017;31:2946–52.
[19] Iqbal U, Berger A, Confer B, Diehl DL, Khara HS. 918 endoscopic ultrasound-guided gastroenterostomy vs. enteral stenting for treatment of gastric outlet obstruction: a retrospective review. Off J Am Coll Gastroenterol ACG. 2019;114:S536.
[20] Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol. 2009;62:e1–34.
[21] Goyal A, Shahbaz H, Jain H, et al. The impact of chronic total occlusion in non-infarct related arteries on patient outcomes following percutaneous coronary intervention for STEMI superimposed with cardiogenic shock: a pilot systematic review and meta-analysis. Curr Probl Cardiol. 2024;49:102237.
[22] Jain H, Odat RM, Goyal A, et al. Association between psoriasis and atrial fibrillation: a Systematic review and meta-analysis. Curr Probl Cardiol. 2024;49:102538.
[23] Ahmed M, Javaid H, Talha Maniya M, et al. Optical coherence tomography-guided versus angiography-guided percutaneous coronary intervention: a meta-analysis of randomized controlled trials. IJC Heart Vasc. 2024;52:101405.
[24] Ahmed M, Shafiq A, Javaid H, et al. Clinical outcomes with once-weekly insulin icodec versus once-daily insulin glargine U100 in insulin-naïve and previously insulin-treated individuals with type 2 diabetes: a meta-analysis of randomised controlled trials. Endocrinol Diabetes Metab. 2024;7:e00480.
[25] Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. Biometrics. 1994;50:1088–101.
[26] Lin L, Chu H. Quantifying publication bias in meta-analysis. Biometrics. 2018;74:785–94.
[27] Vazquez-Sequeiros E, Sanchez-Aldehuelo R, Santiago ER de, et al. Su1286 endoscopic ultrasound-guided gastrojejunostomy is superior to duodenal self expandable metal stent for pallitaive treatment of malignant gastric outlet obstruction: a comparative case control study. Gastrointest Endosc. 2020;91:AB312–3.
[28] Marya N, Jaruvongvanich V, Dayyeh BKA, et al. Su1268 a multicenter international study comparing clinical outcomes of Eus-Guided Gastrojejunostomy, surgical gastrojejunostomy, and enteral stenting for patients with gastric outlet obstruction. Gastrointest Endosc. 2020;91:AB302–3.
[29] Chan SM, Dhir V, Chan YYY, et al. ID: 3522027 Eus-Guided Gastrojejunostomy (EUS-GJ) achieved, lower complication rates and need for reintervention when compared to Laparoscopic Gastrojejunostomy (LAP-GJ) and endoscopic stenting (PCDS) for palliation of Gastric Outlet Obstruction (GOO). Gastrointest Endosc. 2021;93:AB218–9.
[30] Rosas US, Paski S, Gaddam S, et al. ID: 3525459 comparing reinterventions and readmissions for Eus-Guided Gastrojejunostomy (GJ) using Lumen-Apposing Metal Stent (LAMS) vs duodenal stent for management of gastric outlet obstruction. Gastrointest Endosc. 2021;93:AB225.
[31] van Wanrooij RLJ, Vanella G, Bronswijk M, et al. Endoscopic ultrasound-guided gastroenterostomy versus duodenal stenting for malignant gastric outlet obstruction: an international, multicenter, propensity score-matched comparison. Endoscopy. 2022;54:1023–31.
[32] Sánchez-Aldehuelo R, Subtil Iñigo JC, Martínez Moreno B, et al. EUS-guided gastroenterostomy versus duodenal self-expandable metal stent for malignant gastric outlet obstruction: results from a nationwide multicenter retrospective study (with video). Gastrointest Endosc. 2022;96:1012–20.e3.
[33] Teoh AYB, Lakhtakia S, Tarantino I, et al. Endoscopic ultrasonography-guided gastroenterostomy versus uncovered duodenal metal stenting for unresectable malignant gastric outlet obstruction (DRA-GOO): a multicentre randomised controlled trial. Lancet Gastroenterol Hepatol. 2024;9:124–32.
[34] ROBINS-I | Cochrane Bias. https://methods.cochrane.org/bias/risk-bias-non-randomized-studies-interventions. Accessed March 17, 2024.
[35] Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366:l4898.
[36] She YM, Ge N. Clinical application and follow-up of electrocautery-enhanced lumen-apposing metal stents for endoscopic ultrasonography-guided interventions. Ann Med. 2023;55:2282748.
[37] Mussetto A, Fugazza A, Fuccio L, Triossi O, Repici A, Anderloni A. Current uses and outcomes of lumen-apposing metal stents. Ann Gastroenterol. 2018;31:535–40.
[38] Hawkins AT, Wise PE, Chan T, et al. Diverticulitis – an update from the age old paradigm. Curr Probl Surg. 2020;57:100862.
[39] van de Pavert YL, Moons LMG, Bogte A, Vleggaar FP. Innovations in the treatment of gastric outlet obstruction: is this the era of endoscopic ultrasonography-guided gastroenterostomy? Curr Treat Options Gastroenterol. 2023.

[40] Bolliger M, Kroehnert JA, Molineus F, Kandioler D, Schindl M, Riss P. Experiences with the standardized classification of surgical complications (Clavien-Dindo) in general surgery patients. Eur Surg. 2018;50:256–61.
[41] Malgras B, Lo Dico R, Pautrat K, et al. Gastrointestinal stenting: current status and imaging features. Diagn Interv Imaging. 2015;96:593–606.
[42] Khashab MA, Baron TH, Binmoeller KF, Itoi T. EUS-guided gastroenterostomy: a new promising technique in evolution. Gastrointest Endosc. 2015;81:1234–6.
[43] Khashab MA, Kumbhari V, Grimm IS, et al. EUS-guided gastroenterostomy: the first U.S. clinical experience (with video). Gastrointest Endosc. 2015;82:932–8.
[44] Piesman M, Kozarek RA, Brandabur JJ, et al. Improved oral intake after palliative duodenal stenting for malignant obstruction: a prospective multicenter clinical trial. Am J Gastroenterol. 2009;104:2404–11.
[45] Adler DG, Merwat SN. Endoscopic approaches for palliation of luminal gastrointestinal obstruction. Gastroenterol Clin North Am. 2006;35:65–82, viii.
[46] Jaruvongvanich V, Chesta F, Baruah A, et al. Palliative treatment for malignant gastrointestinal obstruction with peritoneal carcinomatosis: enteral stenting versus surgery. Endosc Int Open. 2020;8:E1487–94.
[47] Jaruvongvanich V, Chesta F, Baruah A, et al. Palliative treatment for malignant gastrointestinal obstruction with peritoneal carcinomatosis: enteral stenting versus surgery. Endosc Int Open. 2020;8:E1487–94.
[48] Jovani M, Ichkhanian Y, Parsa N, et al. Assessment of the learning curve for EUS-guided gastroenterostomy for a single operator. Gastrointest Endosc. 2021;93:1088–93.
[49] Topazian M, Ring E, Grendell J. Palliation of obstructing gastric cancer with steel mesh, self-expanding endoprostheses. Gastrointest Endosc. 1992;38:58–60.
[50] Wang J, Hu JL, Sun SY. Endoscopic ultrasound guided gastroenterostomy: technical details updates, clinical outcomes, and adverse events. World J Gastrointest Endosc. 2023;15:634–40.
[51] Basha J, Lakhtakia S, Yarlagadda R, et al. Gastric outlet obstruction with ascites: EUS-guided gastro-enterostomy is feasible. Endosc Int Open. 2021;9:E1918–23.
[52] Kouanda A, Binmoeller K, Hamerski C, Nett A, Bernabe J, Watson R. Endoscopic ultrasound-guided gastroenterostomy versus open surgical gastrojejunostomy: clinical outcomes and cost effectiveness analysis. Surg Endosc. 2021;35:7058–67.
[53] Park CH, Park JC, Kim EH, et al. Impact of carcinomatosis and ascites status on long-term outcomes of palliative treatment for patients with gastric outlet obstruction caused by unresectable gastric cancer: stent placement versus palliative gastrojejunostomy. Gastrointest Endosc. 2015;81:321–32.
[54] Bronswijk M, van Wanrooij RLJ, Vanella G. Van der Merwe S. EUS-guided gastroenterostomy in patients with ascites: what lies beneath? Endosc Int Open. 2022;10:E294.
[55] Takamatsu Y, Fujimori N, Miyagahara T, et al. The Glasgow Prognostic Score and stricture site can predict prognosis after endoscopic duodenal stent placement for malignant gastric outlet obstruction. Sci Rep. 2022;12:9746.
[56] Hindryckx P, Degroote H. Lumen-apposing metal stents for approved and off-label indications: a single-centre experience. Surg Endosc. 2021;35:6013–20.
[57] Vanella G, Bronswijk M, van Wanrooij RL, et al. Combined endoscopic mAnagement of BiliaRy and gastrIc OutLET obstruction (CABRIOLET Study): a multicenter retrospective analysis. DEN Open. 2023;3:e132.
[58] Tonozuka R, Tsuchiya T, Mukai S, Nagakawa Y, Itoi T. Endoscopic ultrasonography-guided gastroenterostomy techniques for treatment of malignant gastric outlet obstruction. Clin Endosc. 2020;53:510–8.