THERAPEUTIC ADVANCES in
Gastrointestinal Endoscopy

Meta-Analysis

Palliative therapy for malignant gastric outlet obstruction: how does the endoscopic ultrasound-guided gastroenterostomy compare with surgery and endoscopic stenting? A systematic review and meta-analysis

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Ther Adv Gastrointest Endosc

2023, Vol. 16: 1–14

DOI: 10.1177/26317745221149626

Abstract

Introduction: The gold-standard procedure to address malignant gastric outlet obstruction (MGOO) is surgical gastrojejunostomy (SGJJ). Two endoscopic alternatives have also been proposed: the endoscopic stenting (ES) and the endoscopic ultrasound-guided gastroenterostomy (EUS-G). This study aimed to perform a thorough and strict meta-analysis to compare EUS-G with the SGJJ and ES in treating patients with MGOO.

Materials and Methods: Studies comparing EUS-G to endoscopic stenting or SGJJ for patients with MGOO were considered eligible. We conducted online searches in primary databases (MEDLINE, EMBASE, Lilacs, and Central Cochrane) from inception through October 2021. The outcomes were technical and clinical success rates, serious adverse events (SAEs), reintervention due to obstruction, length of hospital stay (LOS), and time to oral intake.

Results: We found similar technical success rates between ES and EUS-G but clinical success rates favored the latter. The comparison between EUS-G and SGJJ demonstrated better technical success rates in favor of the surgical approach but similar clinical success rates. EUS-G shortens the LOS by 2.8 days compared with ES and 5.8 days compared with SGJJ. Concerning reintervention due to obstruction, we found similar rates for EUS-G and SGJJ but considerably higher rates for ES compared with EUS-G. As to AEs, we demonstrated equivalent rates comparing EUS-G and SGJJ but significantly higher ones compared with ES.

Conclusion: Despite being novel and still under refinement, the EUS-G has good safety and efficacy profiles compared with SGJJ and ES.

Keywords: cancer, endoscopic, endoscopic ultrasound, gastric outlet obstruction, palliation, stenting

Received: 16 October 2022; revised manuscript accepted: 13 December 2022.

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Introduction

Gastric and pancreatic neoplasia are among the five leading causes of cancer-related deaths worldwide.[1] It may present as a gastric outlet obstruction (GOO) syndrome in more advanced stages, which entails refractory nausea/vomiting, dehydration, malnutrition, severe weight loss, and cachexia.[2,3] Despite recent improvements in chemoradiotherapy, the prognosis of patients with malignant GOO remains dismal, with the median overall survival ranging from 3 to 6 months. In a palliative setting, this short time frame between diagnosis and death highlights the importance of providing comfort with early oral intake.[4]

The traditional gold-standard procedure to address GOO is the surgical gastrojejunostomy (SGJJ), which was first described by Wolfer in 1881.[5] However, in the 1990s, an endoscopic approach using self-expandable metallic stents became a less invasive but effective alternative to surgery. Endoscopic stenting (ES) consists in deploying a large metallic stent across the whole stenotic area under fluoroscopic guidance.[1] Compared with the SGJJ, the ES seems attractive due to a shorter duration of the procedure, quick resumption of oral intake, and reduced length of hospital stay (LOS).[2] Nonetheless, non-negligible rates of stent-related adverse events, reintervention, and recurring symptoms have been reported.[2,5,6]

More recently, a novel endoscopic alternative has been proposed to mitigate the main AEs of the ES. The endoscopic ultrasound-guided gastroenterostomy (EUS-G) creates a stable gastrojejunal anastomosis by puncturing the first jejunal loop through the stomach under EUS guidance. After confirming the positioning, the endoscopist deploys a lumen-apposing metal stent (LAMS), a fully covered dumbbell-shaped short stent. This LAMS has large proximal and distal flanges to prevent migration and provide a lumen-to-lumen apposition effect.[7] Typically, the puncture site is far from the neoplastic area to avoid tissue overgrowth and prevent a recurrence.

Several trials have compared those methods with somewhat contradictory results.[8–10] Moreover, there are numerous meta-analysis, but few evaluate EUS-G.[11–13] The ones assessing EUS-G outcomes either excluded ES from evaluation,[14] failed to detect and include eligible studies, or mixed benign with malignant cases.[15] Therefore, we aimed to perform a thorough and strict meta-analysis to compare EUS-G with the SGJJ and ES in treating patients with malignant GOO (MGOO).

Materials and methods

Protocol and registration

This study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the registry number CRD42020193130. Also, it follows the guidelines from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Cochrane Handbook for Systematic reviews.[16,17] As only literature data were used, we were granted with a waiver from Ethics Committee approval.

Eligibility criteria

Studies comparing EUS-G to ES or SGJJ for patients with MGOO were considered eligible, despite which malignancy originated the obstruction. Concerning the SGJJ, both open and laparoscopic approaches were included. There were no restrictions as to the year of publication or language. We tried to contact the main authors by email in case of incomplete data.

Given the limited nature of the available literature, different study designs were considered eligible. Our eligibility criteria included published abstracts with complete data, randomized controlled trials (RCTs), and comparative non-randomized studies. The exclusion criteria included animal studies, case reports, and studies including benign causes for GOO.

Literature search

We conducted online searches in primary databases (MEDLINE, EMBASE, Lilacs, and Central Cochrane) from inception through April 2022. The complete search strategy for Medline is outlined ahead. For the other databases, a simpler strategy was employed.

Search strategy: (‘*Gastric outlet obstruction*’ OR ‘*Gastric outlet obstructions*’ OR ‘*Obstruction, gastric outlet*’ OR ‘*Obstructions, gastric outlet*’ OR ‘*Outlet obstruction, gastric*’ OR ‘*Outlet obstructions, gastric*’ OR ‘*Gastric obstruction*’ OR ‘*Pancreatic obstruction*’ OR ‘*Duodenal obstruction*’ OR ‘*pyloric stenosis*’) AND (‘*endoscopic ultrasound-guided gastroenterostomy*’ OR ‘*endoscopic ultrasound-guided gastrojejunostomy*’ OR ‘*endoscopic ultrasound-guided gastroduodenostomy*’ OR ‘*Endosonography*’ OR ‘*Echo Endoscopies*’ OR ‘*Echo Endoscopy*’ OR ‘*Echo-Endoscopies*’ OR ‘*Echo-Endoscopy*’ OR ‘*Endoscopic Ultrasonographies*’ OR ‘*Endoscopic Ultrasonography*’ OR ‘*Endoscopies, Echo*’ OR ‘*Endoscopies, Ultrasonic*’ OR ‘*Endoscopy, Echo*’ OR ‘*Endoscopy, Ultrasonic*’ OR ‘*Endosonographies*’ OR ‘*Ultrasonic Endoscopies*’ OR ‘*Ultrasonic Endoscopy*’ OR ‘*Ultrasonographies, Endoscopic*’ OR ‘*Ultrasonography, Endoscopic*’) AND (‘*Stents*’ OR ‘*Stent*’ OR ‘*endoscopic stenting*’ OR ‘*Gastroenterostomy*’ OR ‘*Laparoscopic gastroenterostomy*’ OR ‘*Gastric Bypass*’ OR ‘*Bypass, Gastric*’ OR ‘*Bypass, Gastroileal*’ OR ‘*Bypass, Roux-en-Y Gastric*’ OR ‘*Gastrojejunostomies*’ OR ‘*Gastrojejunostomy*’ OR

'*Roux en Y Gastric Bypass*' OR '*Roux-en-Y Gastric Bypass*' OR '*Gastroduodenostomy*').

Two authors (RKM and EA) independently conducted the literature search for eligible articles through title and abstract reading. Any disagreements were solved by consensus consulting a third researcher (ALF). The authors also independently extracted the data of interest using standardized Excel tables.

Outcomes and definitions

Clinical success, defined as the ability to resume a full-liquid or pasty diet without vomiting, was our primary outcome. Secondary outcomes also included:

- Technical success (defined as ability to finish the intended procedure uneventfully; that is, patent anastomosis in case of SGJ; adequate deployment of the LAMS; or successful deployment of the metallic stent across the site of obstruction);
- Adverse events (AEs) and serious adverse events (SAEs) rates according to the Clavien–Dindo classification;[18]
- Reintervention rates due to obstruction;
- LOS;
- Time to oral intake.

A preliminary literature search revealed that only cohort studies fulfilled the eligibility criteria. Therefore, we analyzed the risk of bias using the modified Newcastle Ottawa Scale.[19]

Statistical analysis

Effect sizes for continuous variables were analyzed using the mean difference (MD) and standard deviation (SD) with a 95% confidence interval (CI). For categorical variables, the risk difference (RD) was calculated using the Mantel–Haenszel method with a 95% confidence interval. The RD and MD were considered statistically significant at a p-value < 0.05. Pooling of continuous data required the mean and SD of each study. However, some of the published clinical trials only reported the size of the trial, the median, and the range. Therefore, we obtained estimates of the mean and SD using mathematical formulas.[20]

We assessed heterogeneity among studies using the chi-square (χ^2) test and the I^2 index. Significant heterogeneity was defined as $I^2 > 50\%$. We employed a fixed-effect model to mitigate the impact of high heterogeneity and a random-effect model for homogeneous analyses ($I^2 < 50\%$). We ran all analyses using Review Manager (RevMan) [Computer program], version 5.4, Cochrane Collaboration, 2020.

Results

Study selection and characteristics

The initial search retrieved 5878 articles. After removing duplicates and title/abstract assessment, 121 articles were selected for full-text evaluation. Then, we excluded technical descriptions, letters to the editor, editorials, articles using animal models, studies employing techniques other than ES, SGJJ, and EUS-G, and trials mixing benign and malignant cases with no distinction in outcomes. Ten articles fulfilled the initial eligibility criteria, nine comparing two techniques and one comparing all of them. Figure 1 summarizes the enrollment process.[16]

EUS-G *versus* ES

Six studies comparing EUS-G to ES were pooled for 437 patients. Two of them were published[21,22] in medical journals and four in annals of congresses.[23–26] All six articles were retrospective cohorts, three single centric[21,23,24] and three multicentric.[22,25,26] The primary etiology for the MGOO was pancreatic cancer, followed by gastric cancer. Table 1 summarizes demographics and other information of the eligible studies, and Table 2 reveals the risk of bias assessment.

Clinical success

Five of the studies totalling 400 patients reported clinical success. We found higher rates in favor of EUS-G, despite moderate heterogeneity among studies (91.1% *versus* 78.7%, RD 0.10, 95% CI: 0.03–0.17; $p = 0.003$; $I^2 = 74\%$). Figure 2 shows the forest plot for the analysis of clinical success.

Technical success

Six studies enrolling 437 patients provided data on technical success. After pooling outcomes, we found no difference in technical success rates between groups (EUS-G 93.6% *versus* ES 96.6%; RD: –0.03; 95% CI: –0.07 to 0.02; $p = 0.29$; $I^2 = 12\%$). Figure 3 shows the forest plot for the technical success analysis.

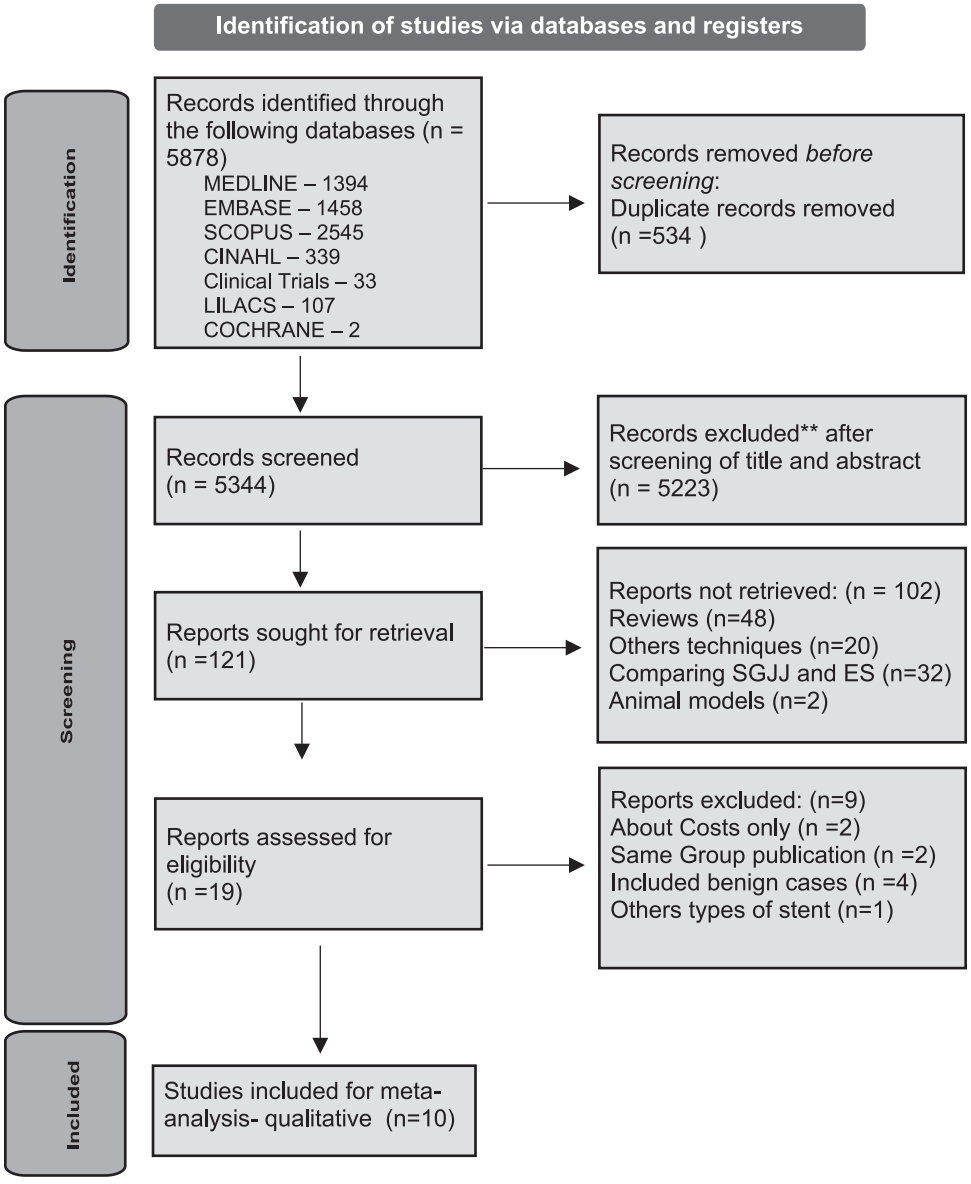

Figure 1. The enrollment flowchart.

Length of hospital stay

Only three articles reported the LOS. We found a significant shorter hospital stay in favor of the EUS-G group (MD: –2.82; 95% CI: – 5.05 to –0.59; $p = 0.01$; $I^2 = 94\%$). Due to the high heterogeneity among studies, we employed the fixed-effect model. Figure 4 depicts the forest plot for the LOS analysis.

Time to tolerate an oral diet

Concerning oral intake, only a single study fulfilled the eligibility criteria.[25] Chan *et al.* demonstrated a shorter time to tolerate soft diet in favor of the ES group. (ES 1.38 ± 1.31 *versus* EUS-G 2.48 ± 0.99 $p = 0.005$).

Reintervention

Regarding the intervention rates due to obstruction, four studies including 295 patients were analyzed. Patients undergoing ES had significantly higher reintervention rates compared with those from the EUS-G group (32.7% *versus* 4.2%, RD: –0.27; 95% CI: –0.36 to –0.19; $p < 0.001$; $I^2 = 41\%$). Figure 5 reveals the forest plot for the reintervention rates.

Table 1. Characteristics of the studies comparing EUS-G and ES.

Study	Design	Period	Type of publication	Sample (EUS-G)	Stent type	Sample (ES)	Stent type	Age (mean/SD)		Etiology		Presence of carcinomatosis		Follow-up	
								EUS-G	ES	EUS-G	ES	EUS-G	ES	EUS-G	ES
Chen *et al.*[22]	Retrospective, multicenter	2013–2015	Full article	30	Axios-EC * (n=21/70%), non-cautery Axios stent (n=7/23.3%), and Spaxus (n=2/6.6%), all 15 mm diameter	52	Wallstent (n=34 – 66.7%); WallFlex (n=9 – 17.6%); not specified (n=8 – 15.7%), diameter of 22 (96.2%) or 20 mm (3.8%)	70 (13.3)	64 (13.2)	Pancreatic: 56.7%; Gastric: 16.7%; others: 26.6%	Pancreatic: 53.8%; Gastric: 5.8%; Others: 41.4%	14 (46.7%)	18 (34.6%)	103 d	23.5 d
Ge *et al.*[21]	Retrospective, single-center	2014–2017	Full article	22	Hot-Axios 15 × 10 mm	78	Uncovered metal duodenal stent (WallFlex Duodenal; Boston Scientific, or Evolution; Cook Medical, Bloomington, IN)	66.4 (9.2)	65.7 (12.6)	Pancreatic: 31.8%; Gastric: 4.5%; Others: 63.7%	Pancreatic: 51.2%; Gastric: 10.2%; Others: 38.6%	13 (59.1%)	37 (47.4%)	>180 d	
Rosas *et al.*[23]	Retrospective, single-center	2014–2020	Poster	25	LAMS (NS)	25	NR	69.6	66.9	Pancreatic: 56%; Others: 44%	Pancreatic: 68%; Others: 32%	NR	NR	6.6 m	7.4 m
Chan *et al.*[25]	Retrospective, multicenter	2011–2020	Poster	48	NR	31	NR	63.2 (13.7)	71.9 (10.2)	Pancreatic: 29.1%; Gastric: 27%; Others: 43.9%	Pancreatic: 34,4%; Gastric: 48,2%; Others: 17.4%	NR	NR	51.5 d	48 d
Dhir *et al.*[24]	Retrospective, single-center	2019–2020	Poster	18	NR	16	NR	62	67	NR	NR	NR	NR	4 m	
Vazquez-Sequeiros *et al.*[26]	Retrospective, multicenter	2017–2019	Poster	46	Hot-Axios 10–15 mm – n: 15–33%; 10–20 mm – n: 31–67%	46	WallFlex (100%)	72.7 (11.2)	69.9 (12.6)	Pancreatic –: 61%; Gastric: 15%; Others: 24%	Pancreatic: 61%; Gastric: 28%; Others: 11%	NR	NR	76 d	96 d

d, days; ES, endoscopic stenting; EUS-G, endoscopic ultrasound-guided gastroenterostomy; LAMS, lumen-apposing metal stent; m, months; NR, not reported; NS, not specified; SD, standard deviation.

Table 2. Risk of bias of studies comparing EUS-G and ES according to the modified Newcastle Ottawa Scale.[19]

Reference	Representativeness of exposed cohort	Selection of non-exposed cohort	Ascertainment of exposure	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Adequacy of follow-up of cohorts	Total score
Chen *et al.*[22]	1	1	1	2	1	0	6
Ge *et al.*[21]	1	1	1	2	1	0	6
Rosas *et al.*[23]	1	1	1	2	1	0	6
Chan *et al.*[25]	1	1	1	2	1	0	6
Dhir *et al.*[24]	1	1	1	2	0	0	5
Vazquez-Sequeiros *et al.*[26]	1	1	1	2	1	0	6

ES, endoscopic stenting; EUS-G, endoscopic ultrasound-guided gastroenterostomy.

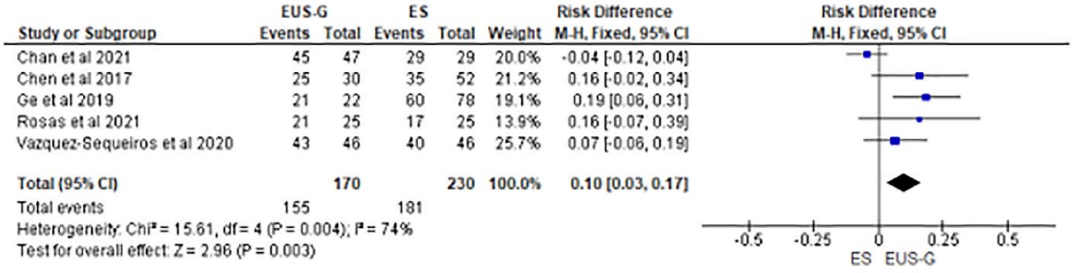

Figure 2. Forest plot comparing clinical success rates between patients undergoing EUS-G and ES.

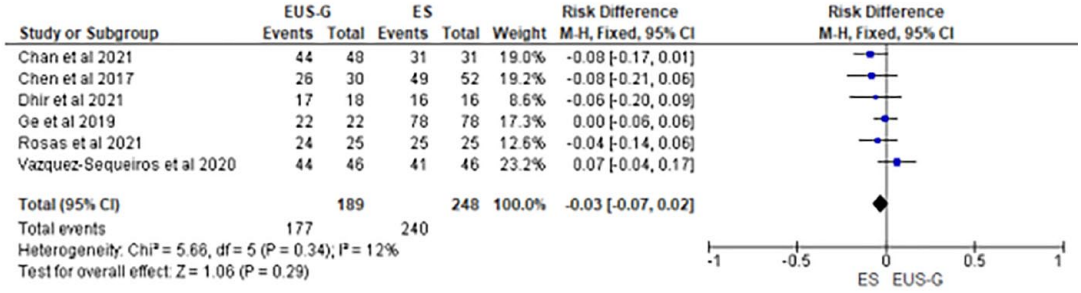

Figure 3. Forest plot comparing technical success between patients undergoing EUS-G and ES.

Serious adverse events

Four studies with a total of 308 patients were included. Individuals receiving ES had significantly higher rates of SAEs compared with those undergoing EUS-G (34.8% *versus* 12%, RD: –0.18; 95% CI: –0.28 to –0.09]; $p < 0.001$; $I^2 = 78\%$). Figure 6 shows the forest plot for the SAEs rate analysis.

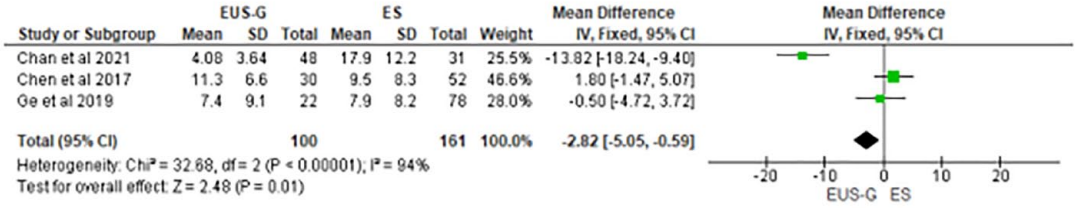

Figure 4. Forest plot comparing the length of hospital stay between EUS-G and ES groups.

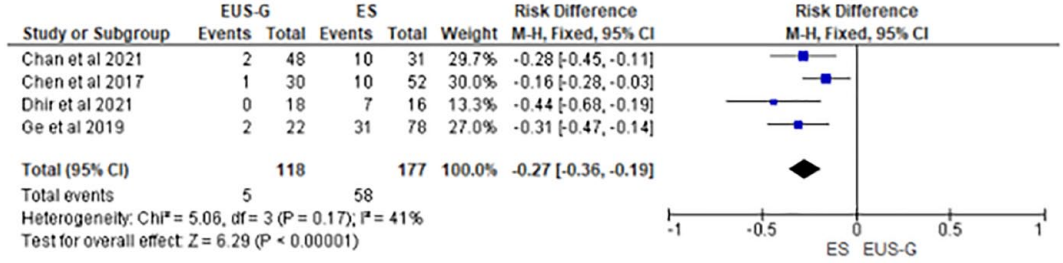

Figure 5. Forest plot comparing reintervention rates due to obstruction between patients undergoing EUS-G and ES.

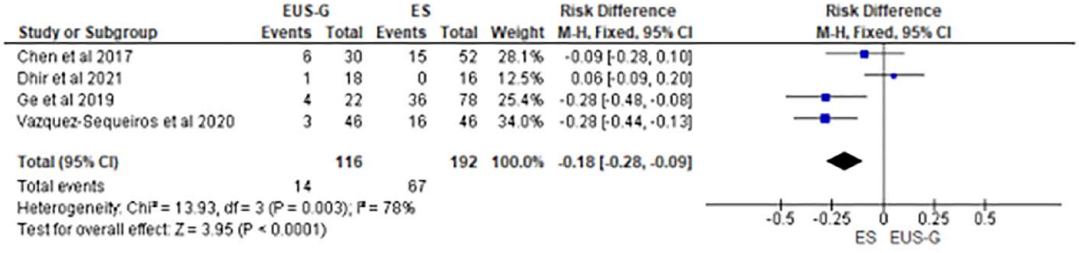

Figure 6. Forest plot comparing serious adverse events rates between patients undergoing EUS-G and ES.

EUS-G *versus* SGJJ

Five studies comparing EUS-G and SGJJ fulfilled the eligibility criteria and were enrolled.[25,27–30] A total of 305 patients received one of the above-mentioned procedures. All articles were retrospective cohorts, three single centric and two multicentric. Table 3 summarizes demographics and other information of the included studies, while Table 4 reveals the assessment of the risk of bias for the included studies.

Clinical success

All studies reported data on clinical success. After pooling the results, we found no difference between EUS-G and SGJJ in terms of clinical success rate (90.7% *versus* 88.6%; RD: 0.03; 95% CI: –0.04 to 0.10; $p = 0.37$; $I^2 = 59\%$). Figure 7 depicts the forest plot analysis for clinical success.

Technical success

All five studies provided data concerning technical success. In a highly homogeneous meta-analysis, we found a significantly higher technical success rate for SGJJ as compared with EUS-G (99% *versus* 91.5%, RD: –0.08; 95% CI: –0.14 to –0.02; $p = 0.008$; $I^2 = 0\%$). Figure 8 shows the forest plot for technical success rates.

Table 3. Characteristics of the studies and patients included in the comparison between EUS-G and SGJJ.

Study	Design	Period	Type of publication	Sample (EUS-G)	Stent type	Sample (SGJJ)/ laparoscopic	Age (mean/SD)		Etiology		Presence of carcinomatosis		Follow-up	
							EUS-G	SGJJ	EUS-G	SGJJ	EUS-G	SGJJ	EUS-G	SGJJ
Khashab *et al.*[28]	Retrospective multicenter	2006–2015	Full article	30	Hot-Axios ($n=21/70\%$), Axios stent ($n=7/23.3\%$), and Spaxus ($n=2/6.6\%$), all 15 mm diameter	63/0	70 (13.3)	68 (9.6)	Pancreatic: 56.7%; Gastric: 16.7%; Other: 26.6%	Pancreatic: 84.1%; Other: 15.9%	13/30 (43.3%)	7/63 (11.1%)	115 ± 63	196 ± 155
Kouanda *et al.*[27]	Retrospective single-center	2014–2020	Full article	36	Electrocautery-enhanced lumen-apposing metal stent (LAMS), 15 mm	14/0	70.4 (11.8)	71.5 (15.6)	Pancreatic: 72%; Other: 28%	Pancreatic: 21.4%; Gastric: 57.1%; Other: 21.5%	4/36 (11.1%)	6/14 (42.9%)	94.5 d	77 d
Chan *et al.*[25]	Retrospective, multicenter	2011–2020	Poster	48	NR	38/38	63.2 (13.7)	68.3 (10.6)	Pancreatic: 29.1%; Gastric: 27%; Other: 43.9%	Pancreatic: 18.4%; Gastric: 65.7%; Other: 15.9%	NR	NR	51.5 d	163 d
Bondi *et al.*[29]	Retrospective, single-center	2000–2019	Poster	18	Electrocautery-enhanced lumen-apposing metal stent (LAMS)	34/NR	64 (11)	61.3 (14)	Pancreatic: 22%; Gastric: 11%; Other: 67%	Pancreatic: 32%; Gastric: 24%; Other: 44%	100%	100%	NR	
Widmer *et al.*[30]	Retrospective, single-center	2015–2018	Poster	10	Electrocautery-enhanced lumen-apposing metal stent (LAMS)	14/3	63 (12.5)	68 (9.75)	Pancreatic: 40%; Gastric: 20%; Other: 40%	Pancreatic: 28.6%; Gastric: 7%; Other: 64.4%	NR	NR	NR	

d, days; EUS-G, endoscopic ultrasound-guided gastroenterostomy; LAMS, lumen-apposing metal stent; NR, not reported; SD, standard deviation; SGJJ, surgical gastrojejunostomy.

Table 4. Risk of bias for the comparison between EUS-G and SGJJ according to the modified Newcastle Ottawa Scale.[19]

Reference	Representativeness of exposed cohort	Selection of non-exposed cohort	Ascertainment of exposure	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Adequacy of follow up of cohorts	Total score
Khashab *et al.*[28]	1	1	1	2	1	0	6
Bondi *et al.*[29]	1	1	1	2	1	0	6
Widmer *et al.*[30]	1	1	1	2	1	0	6
Kouanda *et al.*[27]	1	1	1	2	1	0	6
Chan *et al.*[25]	1	1	1	2	1	0	6

EUS-G, endoscopic ultrasound-guided gastroenterostomy; SGJJ, surgical gastrojejunostomy.

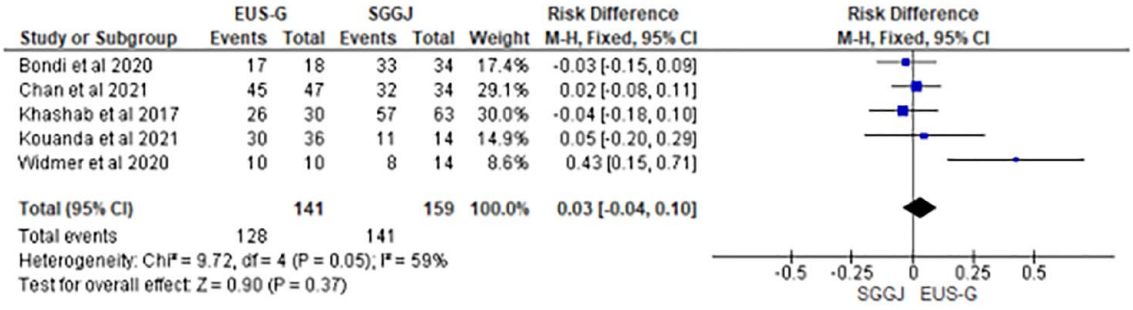

Figure 7. Forest plot comparing clinical success between patients undergoing EUS-G and SGJJ.

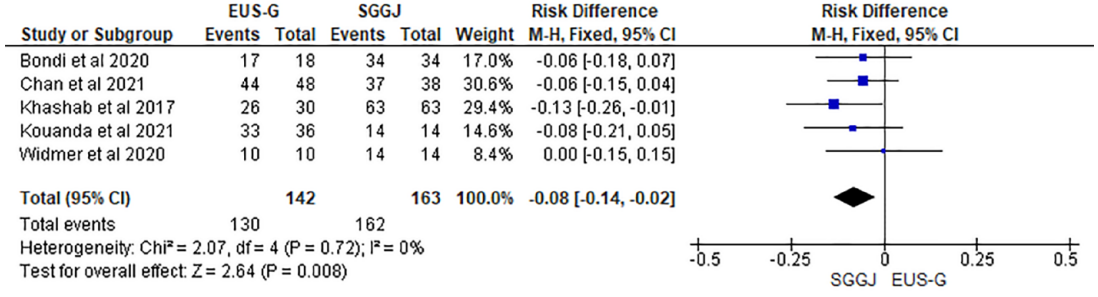

Figure 8. Forest plot comparing technical success rates between patients undergoing EUS-G and SGJJ.

Length of hospital stay

All studies reported the LOS and were included in this analysis. The EUS-G group presented a shorter LOS compared with the SGJJ group (MD: –5.95; 95% CI: –6.99 to –4.91; $p < 0.001$; $I^2 = 95\%$). Figure 9 demonstrates the forest plot for the LOS analysis.

Time to tolerate an oral diet

Two studies with 136 patients reported data regarding time to tolerate oral diet. After pooling results, we found a shorter time to resume oral intake in favor of the EUS-G procedure (MD: –2.89; 95% CI: –3.79 to –1.99; $p < 0.001$; $I^2 = 0\%$). Figure 10 reveals the forest plot for this analysis.

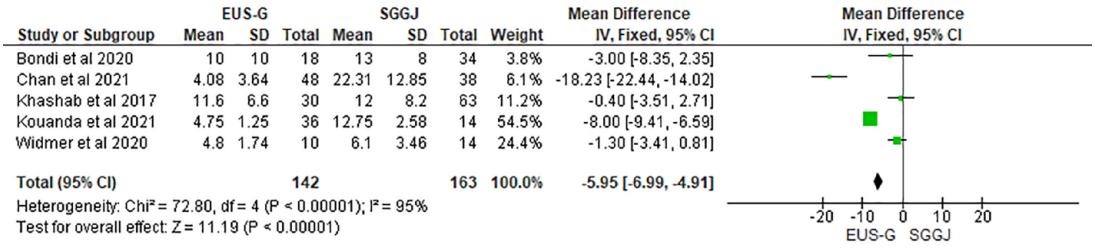

Figure 9. Forest plot comparing the length of hospital stay between patients undergoing EUS-G and SGJJ.

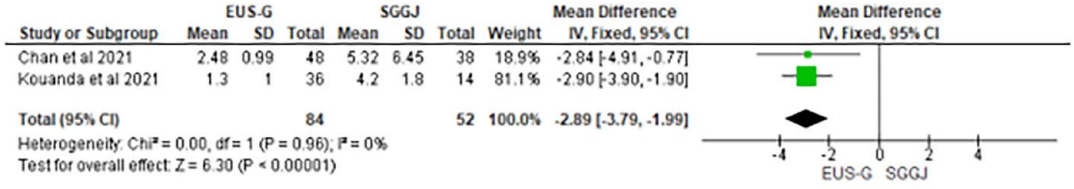

Figure 10. Forest plot comparing time to tolerate oral diet between patients undergoing EUS-G and SGJJ.

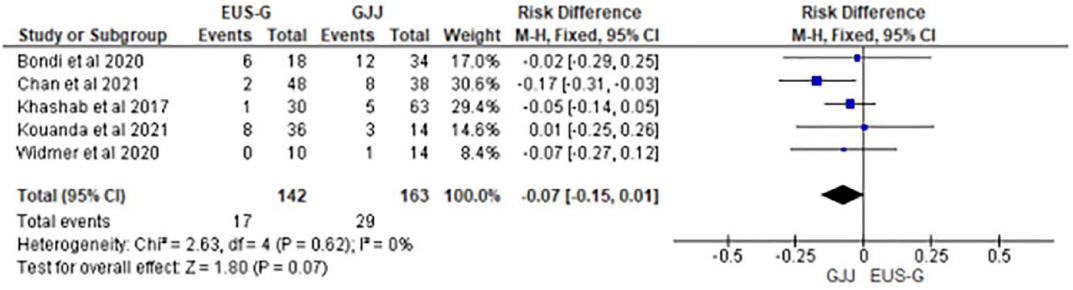

Figure 11. Forest plot comparing reintervention rates between patients undergoing EUS-G and SGJJ.

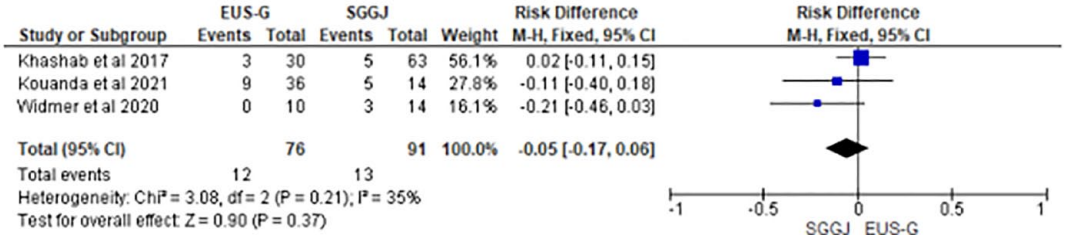

Figure 12. Forest plot comparing serious adverse events rates between patients undergoing EUS-G and SGJJ.

Reintervention rates due to obstruction

All studies described reinterventions due to obstruction, thus were included. There was trend toward lower reintervention rates in favor of the SGJJ group, but no actual statistical difference (17.7% *versus* 11.9%; RD: –0.07; 95% CI: –0.15 to 0.01; $p = 0.07$; $I^2 = 0\%$). Figure 11 shows the forest plot for the reintervention rate analysis.

Serious adverse events

Three studies with a total of 167 individuals were assessed for SAEs. After pooling the results, we found no statistical difference between groups (EUS-G 15.7% *versus* SGJJ 14.2%; RD: –0.05; 95% CI: –0.17 to 0.06; $p = 0.37$; $I^2 = 35\%$). Figure 12 depicts the forest plot analysis for SAEs rates.

Discussion

Our study is the most thorough and updated systematic review assessing the safety and efficacy of the EUS-G in addressing malignant GOO. Only articles comparing EUS-G and ES or SGJJ in a head-to-head fashion were included, avoiding indirectness and strengthening our findings.[31] This study stands out among similar previous ones as it compares all three techniques and includes all available eligible data. Therefore, we provide the most reliable data for clinical decision-making.

Our meta-analysis demonstrated similar technical success rates between ES and EUS-G but clinical success rates favoring the latter. Unsurprisingly, we expected those results as the ES has several drawbacks, such as tumor ingrowth and stent migration, that diminishes clinical success.[2,5,6] In fact, those shortcomings fostered the development of alternative procedures such as the EUS-G.

On the contrary, the comparison between EUS-G and SGJJ demonstrated better technical success rates for the surgical approach but similar clinical success rates. Some factors may explain such a difference between groups. First, five different EUS-G techniques have been described to date, creating heterogeneity among centers.[32] Second, since this is a novel technique, some of the included studies may have reported learning curve data, even in specialized centers. As experience grows, better technical success rates may arise, approximating it to the SGJJ. Finally, the extremely high technical success rate of the SGJJ group (99%) might suggest a selection bias, probably due to a preoperative exclusion of patients with carcinomatosis. In those individuals, SGJJ is particularly challenging and less effective.[33] Despite this technical inferiority, EUS-G seems feasible and effective as it presented both technical and clinical success rates of over 90%.

Also, we demonstrated that the EUS-G shortens the LOS by 2.8 days compared with ES and 5.8 days compared with SGJJ. The difference in the first comparison is probably due to adverse events arising from stenting a stenotic neoplastic area, such as pain and bleeding. On the contrary, the difference in the comparison against SGJJ is probably due to the longer time to tolerate an oral diet. Our meta-analysis assessing the time to resume oral intake supports those hypotheses, as the ES has the shortest time, and SGJJ has the longest.

Concerning reintervention due to obstruction, we found similar rates for EUS-G and SGJJ but considerably higher rates for ES. Unlike EUS-G and SGJJ, that bypass the obstruction site, the ES allows food passage through neoplastic tissue. That fact results in a lower overall patency rate mainly due to tumor ingrowth. In this sense, we demonstrated that the rate of re-obstruction requiring intervention after ES is 32%. Nonetheless, most of those cases can be managed endoscopically either with a stent-in-stent technique or enteral tube placement.[34] In 2012, Khashab *et al.*[34] demonstrated that those patients could even be discharged on the same day of the procedure.

With regard to AEs, we demonstrated similar rates comparing EUS-G and SGJJ but significantly higher rates compared with ES. The Clavien–Dindo classification defines SAEs as those requiring intervention.[18] Since ES has higher reintervention rates mainly due to re-obstruction, one should expect that result. Of note, the SAEs rate of ES (34%) is very close to its reintervention rate (32%). Although SAEs rates were similar between EUS-G and SGJJ, we noted more serious events in the first group. Those reports include stent misdeployment in the peritoneum and perforation (five cases). Since the learning curve for EUS-G ranges from 25 to 40 cases, this finding may represent the operator's learning curve.[35] Unfortunately, procedure-related mortality within 30 days could not be analyzed once most studies did not describe whether deaths occurred due to an AE or to the baseline disease.

From an evidence-based perspective, the treatment decision-making process should also entail costs, which have been poorly explored in this literature. Indirectly, ES may lower the initial costs due to the reduced LOS. However, a higher reintervention rate may counter-balance that fact.[34] In this sense, the EUS-G may stand out as LOS is similar to ES but with a lower need for reintervention. Compared with SGJJ, Perez-Miranda *et al.*[36] demonstrated costs are three times higher for the surgical group than for EUS-G.

This study is not exempt from limitations. First and foremost, this literature lacks randomized studies, which diminishes the level of evidence and certainty of the results and conclusions. Although only comparative studies were enrolled, non-randomized data are always amenable to

selection bias that can intensify or reduce the clinical effect based on a desired or anticipated outcome. Another limitation concerns the heterogeneity among studies, mainly due to the variety of EUS-G techniques currently being performed worldwide and due to the inclusion of open and laparoscopic SGJJ approaches. Also, the definition of clinical success was not standardized across the studies. While some articles used the Adler and Brandon index higher or equal to 2, others only reported amelioration of oral intake. Similarly, the time to tolerate an oral diet differed substantially: some articles considered it as the ability to eat solid food, others to eat pasty food. At the same time, some did not define it at all. In this sense, a multi-society international standardization could improve the report of outcomes, thus solving those limitations for upcoming meta-analyses.

Conclusion

Despite being a novel and still under refinement procedure, the EUS-G has good safety and efficacy profiles compared with SGJJ and ES. With improvement in technique, devices, and availability, it could soon become the gold-standard endoscopic approach instead of ES and a similar alternative to the surgical GJJ.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Author contributions

Rafael Krieger Martins: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Writing – original draft; Writing – review & editing.

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André Luis Fernandes: Investigation; Methodology; Resources; Writing – original draft; Writing – review & editing.

José Pinhata Otoch: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Writing – review & editing.

Everson Luiz de Almeida Artifon: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.

Acknowledgements

Not applicable.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Competing interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Availability of data and materials

Not applicable.

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