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EUS-guided gastroenterostomy versus enteral stent placement for palliation of malignant gastric outlet obstruction

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Abstract

Background EUS-guided gastroenterostomy (EUS-GE) is a novel procedure for palliation of malignant gastric outlet obstruction (GOO); however, data comparing EUS-GE to enteral stent placement are limited. We aimed to compare clinical outcomes between EUS-GE and enteral stent placement in the palliation of malignant GOO.

Methods Retrospective analysis of a prospectively collected database on patients who underwent EUS-GE or enteral stent placement for palliation of malignant GOO from 2014 to 2017 was conducted. Primary outcome was the rate of stent failure requiring repeat intervention. Secondary outcomes included technical and clinical success, time to repeat intervention, length of hospital stay, and adverse events.

Results A total of 100 consecutive patients (mean age 65.9 ± 11.9 years, 44.0% female) were identified, of which 78 underwent enteral stent placement, and 22 underwent EUS-GE. Rate of stent failure requiring repeat intervention was higher in the enteral stent group than the EUS-GE group (32.0% vs. 8.3%, $p = 0.021$). Technical success was achieved in 100% in both groups. Higher initial clinical success was attained in the EUS-GE group than the enteral stent group (95.8% vs. 76.3%, $p = 0.042$). Mean length of hospital stay following stent placement was similar between groups ($p = 0.821$). The enteral stent group trended towards increased adverse events (40.2% vs. 20.8%, $p = 0.098$). Kaplan–Meier analysis showed decreased stent function in the enteral stent group ($p = 0.013$).

Conclusion Compared to enteral stent placement, EUS-GE has a higher rate of initial clinical success and lower rate of stent failure requiring repeat intervention. EUS-GE may be offered for selected patients with malignant GOO in centers with extensive experience.

Keywords Gastroenterostomy · Gastric outlet obstruction · GOO · MGOO · Lumen-apposing metal stent · LAMS · Enteral stent · SEMS · Therapeutic endoscopic ultrasound · Pancreatic cancer

Malignant gastric outlet obstruction (GOO) occurs in up to 20% of patients with various foregut malignancies such as gastric, duodenal, and pancreaticobiliary cancers [1]. The onset of malignant GOO portends a poor prognosis, with patients having a median survival of 3–6 months [2]. Patients with malignant GOO often have severely decreased quality of life due to symptoms such as nausea, vomiting, abdominal pain, and nutritional deficiencies which are often exacerbated by the effects of their primary cancer [3]. As a result, malignant GOO is a feared late complication of these particular cancers.

Enteral stent placement using a self-expanding metal stent (SEMS) is commonly performed for palliation of obstructive symptoms caused by malignant GOO [4, 5]. Recently, endoscopic ultrasound (EUS)-guided gastroenterostomy (EUS-GE) with placement of a lumen-apposing metal stent (LAMS) has emerged as a novel alternative procedure that may offer long-lasting patency with fewer incidence of stent failure [6, 7].

Although several studies have described successful creation of EUS-GE in the setting of malignant GOO, there is

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a paucity of data directly comparing EUS-GE to enteral stent placement, and existing studies have been limited by their heterogeneous nature. We therefore aimed to compare clinical outcomes and adverse events between EUS-GE and enteral stent placement in the endoscopic palliation of malignant GOO.

Patients and methods

Patients

Between January 2014 and November 2017, consecutive adult patients who underwent endoscopic management of malignant gastric outlet obstruction were prospectively enrolled in a registry which was retrospectively analyzed for the purposes of this study. Institutional Review Board approval was obtained for this study.

Patients were included if they presented with symptoms and abdominal imaging consistent with malignant gastric outlet obstruction, and underwent initial endoscopic management with either EUS-GE or enteral stent placement. Patients with benign GOO, gastroparesis, or history of surgical gastroenterostomy were excluded. At our institution, our practice for the endoscopic management of GOO consisted of placement of self-expanding uncovered metal enteral stents (SEMS) prior to 2016, and either enteral stent placement or EUS-GE starting in 2016 following multidisciplinary consultation between the endoscopist and the referring oncologist. There were no specific criteria to exclude performance of EUS-GE provided the patient would otherwise qualify for enteral stent placement.

Enteral stent technique

Enteral stent placement was performed according to previously described standardized techniques by endoscopists at our institution experienced in the endoscopic management of malignant GOO [8]. Following written informed consent, all patients were sedated under general endotracheal anesthesia. The procedure was performed using a therapeutic gastroscope (GIF-XTQ160; Olympus America, Center Valley, PA). Once the area of stenosis was reached endoscopically, a standard cannula (Tandem XL; Boston Scientific, Marlborough, MA) with 0.035 inch guidewire was advanced across the obstruction. Contrast was injected to delineate the length of the stenosis. An appropriately sized uncovered metal duodenal stent (WallFlex Duodenal; Boston Scientific, or Evolution; Cook Medical, Bloomington, IN) was then deployed under direct endoscopic and fluoroscopic guidance across the stenosis.

EUS-GE technique

Following written informed consent, all patients were sedated under general endotracheal anesthesia. All patients received intravenous antibiotics (typically ciprofloxacin and metronidazole) during the procedure.

EUS-GE was performed using a linear echoendoscope (GF-UCT180; Olympus America). Passage of a standard cannula (Tandem XL; Boston Scientific) with 0.035 inch guidewire was attempted across the obstruction into the distal duodenum/proximal jejunum, followed by injection of 500 mL of saline mixed with iodinated contrast. The patient was then administered 0.5 mg of glucagon to reduce intestinal peristalsis. The echoendoscope was then positioned along the greater curvature of the gastric body. From this location, the distended loop of small bowel was identified both endosonographically and fluoroscopically. A 15×10-mm electrocautery-enhanced LAMS (AXIOS; Boston Scientific) was deployed in a "freehand" fashion into the jejunum under endosonographic and fluoroscopic guidance, thus establishing the gastroenterostomy. Electrosurgical generator settings (ERBE USA, Inc, Marietta, GA, USA) included Auto Cut, 100 Watts, effect 5. A 12–15-mm dilating balloon (CRE; Boston Scientific) was then used to expand the LAMS. Correct stent positioning was confirmed endoscopically and fluoroscopically.

Follow-up

All outpatients who underwent EUS-GE were electively hospitalized for observation following the procedure, and were prescribed a 7-day course of broad spectrum antibiotics. Outpatients who underwent enteral stenting were discharged home following the procedure. Inpatients remained in the hospital following either procedure. For those EUS-GE patients who survived beyond 6 months, a repeat endoscopy was performed to exchange the LAMS given concern regarding breakdown of the plastic coating within the metal stent. No routine endoscopic follow-up was scheduled for patients who underwent enteral stent placement.

Study outcomes and definitions

The primary outcome of the study was the rate of stent failure requiring re-intervention following initial clinical success with either EUS-GE or enteral stent placement. Stent failure was defined as recurrent symptoms of GOO such as nausea, vomiting, or inability to tolerate oral intake; the need for unplanned endoscopic or surgical re-intervention for GOO; or the need for palliative venting gastrostomy tube placement for refractory GOO not amenable to further

endoscopic or surgical management. Secondary outcomes included technical success, initial clinical success, time to re-intervention, length of hospital stay, and device-related adverse events. Technical success was defined as adequate positioning and deployment of the EUS-GE or enteral stent. Initial clinical success was defined as the ability to tolerate at least a full-liquid diet for 90 days following the procedure.

Bleeding was defined as clinically significant intraprocedural bleeding, or delayed bleeding causing a drop of hemoglobin by > 2 g/dL, or requiring hospital admission, transfusion, or endoscopic intervention. Perforation was diagnosed either endoscopically or by the presence of extraluminal air seen on radiographic imaging. Mortality was defined as any death deemed related to stent placement and/or complications due to recurrent or persistent malignant GOO.

Data analysis and statistics

Baseline characteristics were recorded including patient age, sex, presenting symptoms, presence of ascites and peritoneal carcinomatosis, and location and etiology of malignant GOO. Clinical outcomes were recorded including technical success, initial clinical success, length of hospital stay, rate of stent failure requiring re-intervention, time to re-intervention, and adverse events. Descriptive statistics were used to characterize the demographics of the study population. Categorical data were summarized using counts and percentages, and continuous data were summarized using means and standard deviation. Statistical analysis was performed using Fisher's exact test when comparing categorical variables, and Student's *t* test when comparing continuous variables. Time to re-intervention analysis comparing LAMS and enteral stents was performed using Kaplan–Meier survival analysis, and survival curves were compared using the Mantel–Haenszel log-rank test. *p* values of < 0.05 were considered statistically significant.

Results

Demographics

Demographics and stent characteristics are shown in Table 1. A total of 100 consecutive patients who underwent endoscopic palliation of malignant GOO during the study period were analyzed, of which 78 patients underwent enteral stent placement, and 22 patients underwent EUS-GE. Mean age was 65.9 ± 11.9 years, and 44.0% of

Table 1 Demographics

	EUS-GE (*n*, %)	Enteral stent (*n*, %)	*p* value
Patients	22 (22.0)	78 (78.0)	–
Age (± SD, years)	66.4 (± 9.2)	65.7 (± 12.6)	0.820
Female	13 (59.1)	31 (39.7)	0.145
Presenting symptoms			
Nausea/vomiting	16 (72.7)	71 (91.0)	**0.035**
Abdominal pain	10 (45.5)	35 (44.9)	1.000
Early satiety	8 (36.4)	35 (44.9)	0.627
Imaging findings			
Ascites	12 (54.6)	38 (48.7)	0.810
Peritoneal carcinomatosis	13 (59.1)	37 (47.4)	0.470
Etiology of malignancy			
Gastric	1 (4.6)	8 (10.3)	0.679
Duodenal	1 (4.6)	1 (1.3)	0.393
Pancreatic	7 (31.8)	40 (51.3)	0.147
Ampullary	0 (0.0)	2 (2.6)	1.000
Biliary (gallbladder or cholangiocarcinoma)	4 (18.2)	8 (10.3)	0.456
Metastatic	9 (40.9)	19 (24.4)	0.178
Location of GOO			
Antrum/pylorus	4 (18.2)	8 (10.3)	0.456
Duodenal bulb	9 (40.9)	33 (42.3)	1.000
Second portion of duodenum	6 (27.3)	19 (24.4)	1.000
Distal duodenum	3 (13.6)	18 (23.1)	0.394

EUS endoscopic ultrasound, *GE* gastroenterostomy, *GOO* gastric outlet obstruction, *LAMS* lumen-apposing metal stent, *SD* standard deviation

patients were female. A total of 121 stents were placed, including 24 LAMS in the EUS-GE group and 97 SEMS in the enteral stent group.

A total of 94.0% of all patients had symptomatic gastric outlet obstruction. Reported symptoms included nausea/vomiting (87.0%), abdominal pain (45.0%), and early satiety (43.0%). Among patients who presented with gastric outlet obstruction, 50.0% had ascites, and 50.0% had evidence of peritoneal carcinomatosis on cross-sectional abdominal imaging. Symptoms of nausea and vomiting were less frequent among patients undergoing EUS-GE compared to patients undergoing enteral stent placement (72.7% vs. 91.0%, $p=0.035$).

The etiology of gastric outlet obstruction included gastric adenocarcinoma (9.0%), duodenal adenocarcinoma (2.0%), ampullary adenocarcinoma (2.0%), pancreatic adenocarcinoma (47.0%), biliary malignancy (12.0%) including cholangiocarcinoma and gallbladder carcinoma, and metastatic cancer (28.0%). The sites of gastric outlet obstruction included antrum/pylorus (12.0%), duodenal bulb/sweep (42.0%), second portion of the duodenum (25.0%), and distal duodenum (21.0%).

Among patients who underwent enteral stent placement, 30.9% of SEMS placed were 22 mm × 6 cm stents, 39.2% were 22 mm × 9 cm stents, 26.8% were 22 mm × 12 cm stents, and 3.1% consisted of multiple overlapping stents. Among patients who underwent EUS-GE, all patients received a 15 × 10-mm LAMS. Most EUS-GE procedures (21/22, 95.5%) were performed in an antegrade fashion. In one procedure, the linear echoendoscope was able to traverse across the malignant GOO and therefore a retrograde EUS-enterogastrostomy (EUS-EG) was performed. Most EUS-GE procedures (20/22, 90.9%) involved a freehand deployment of the LAMS into the target small bowel; in two of our initial procedures, the target small bowel was first punctured with a 19-gauge EUS needle, with placement of a 0.035-inch guidewire into the small bowel prior to LAMS deployment.

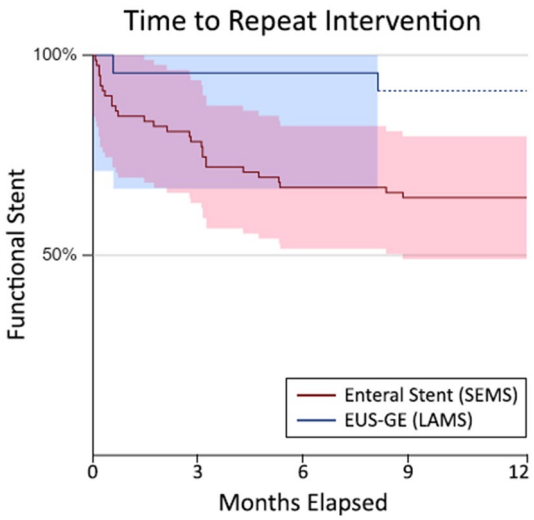

Fig. 1 Kaplan–Meier survival analysis of time to repeat intervention, with blue line indicating EUS-GE (LAMS), and red line indicating enteral stents (SEMS), and shaded areas indicating 95% confidence interval

Clinical and procedural outcomes

Clinical and procedural outcomes are shown in Table 2. The rate of stent failure requiring repeat intervention (primary outcome) was significantly higher in the enteral stent group compared to the EUS-GE group (32.0% vs. 8.3%, $p=0.021$).

Technical success was achieved 100% in both EUS-GE and enteral stent groups. Initial clinical success was higher in the EUS-GE group compared to the enteral stent group (95.8% vs. 76.3%, $p=0.042$). Mean length of hospital stay following stent placement was similar between the two groups (9.1 days in the EUS-GE group vs. 7.9 days in the enteral stent group, $p=0.821$). Mean time to repeat intervention was similar between the two groups (166.5 days in the enteral stent group vs. 157.0 days in the EUS-GE group, $p=0.812$). A Kaplan–Meier survival analysis of

Table 2 Clinical and procedural outcomes

	EUS-GE (*n*, %)	Enteral stent (*n*, %)	*p* value
Primary outcome			
Stent failure requiring re-intervention	2 (8.3)	31 (32.0)	**0.021**
Secondary outcomes			
Stents placed	24 (19.8)	97 (80.2)	–
Technical success	24 (100.0)	97 (100.0)	1.000
Initial clinical success	23 (95.8)	75 (76.3)	**0.042**
Length of hospital stay following stent placement (± SD, days)	7.4 (9.1)	7.9 (8.2)	0.821
Time to re-intervention (± SD, days)	128 (157.0)	99.2 (166.5)	0.812

EUS endoscopic ultrasound, *GE* gastroenterostomy, *LAMS* lumen-apposing metal stent, *SD* standard deviation

time to repeat intervention is shown in Fig. 1, with log-rank test demonstrating statistical significance between the survival curves ($p = 0.013$).

Adverse events

Adverse events are shown in Table 3. The enteral stent group had greater number of adverse events (40.2% vs. 20.8%, $p = 0.098$) and incidence of stent ingrowth (16.5% vs. 4.2%, $p = 0.189$) compared to the EUS-GE group; however, this did not reach statistical significance. Additional adverse events occurring in the enteral stent group included stent obstruction (7.2%), stent migration (2.1%), inadequate stent length requiring repeat intervention (2.1%), stent-related bleeding (1.0%), and stent-related biliary obstruction (2.1%). The incidence of stent failure resulting in venting gastrostomy tube placement was 5.2% in the enteral stent group, compared to 4.2% in the EUS-GE group ($p = 1.000$). One patient (1.0%) in the enteral stent group ultimately underwent conversion to EUS-GE following stent failure. There were three deaths within 30 days in the enteral stent group. All three deaths occurred following patient transition to comfort measures; however, at the time of death, two of the three patients still had symptomatic GOO.

Among patients who underwent EUS-GE, there was one case of LAMS mesh erosion (4.2%) that subsequently required LAMS replacement. Misdeployment resulting in perforation occurred in two cases of EUS-GE (8.3%); however, both cases were managed endoscopically with successful LAMS deployment in the same session, and neither case required surgery. No deaths occurred within 30 days in the EUS-GE group.

Discussion

Malignant GOO is both a distressing condition for the patient and a therapeutic challenge for the gastroenterologist and oncologist. Until recently, malignant GOO was treated either with surgical gastroenterostomy or endoscopic enteral stent placement [5]. Surgical gastroenterostomy, often combined with choledochojejunostomy in patients with concomitant biliary obstruction, carries considerable morbidity and mortality. Delayed gastric emptying and postoperative ileus occurs in up to 58% of patients, leading to a prolonged hospital stay [9]. In multiple larger series, the median procedure-related hospital stay for patients undergoing surgical gastroenterostomy has ranged from 14 to 24 days [10, 11].

Endoscopic placement of a self-expanding metal stent has been described since 1992, [12] and has since become first-line therapy for malignant gastric outlet obstruction. Multiple series have demonstrated technical success rates of 92–100% [13]. However, clinical success has been much lower, with reports ranging from 75 to 91% depending on the definition of clinical success. Adverse events of enteral stent placement include both immediate/early as well as late adverse events, and range from 11 to 43% in various series [13]. Immediate/early adverse events include problems with sedation, stent obstruction, stent malposition, perforation, aspiration, and bleeding. Late adverse events include stent obstruction, bleeding, stent migration, perforation, and fistula formation. A meta-analysis comparing enteral stent placement versus surgical gastroenterostomy showed no statistically significant difference in clinical success, length of survival, mortality, or major complications between the two groups [5]. However, enteral stent placement was associated with shorter time to oral intake and length of survival. Given similar clinical outcomes and adverse events, enteral

Table 3 Adverse events

	EUS-GE (*n*, %)	Enteral stent (*n*, %)	*p* value
Total adverse events	5 (20.8)	39 (40.2)	0.098
Stent ingrowth	1 (4.2)	16 (16.5)	0.189
Stent obstruction (not including ingrowth)	0 (0.0)	7 (7.2)	0.342
Stent migration	0 (0.0)	2 (2.1)	1.000
Inadequate stent length	0 (0.0)	2 (2.1)	1.000
Bleeding	0 (0.0)	1 (1.0)	1.000
Biliary obstruction	0 (0.0)	2 (2.1)	1.000
PEG placement	1 (4.2)	5 (5.2)	1.000
Conversion to EUS-GE (enteral stent only)	–	1 (1.0)	–
LAMS mesh erosion (EUS-GE only)	1 (4.2)	–	–
LAMS misdeployment (EUS-GE only)	2 (8.3)	–	–
Death within 30 days	0 (0.0)	3 (3.1)	1.000

EUS endoscopic ultrasound, *GE* gastroenterostomy

stent placement thus became established as first-line treatment for malignant GOO.

The advent of lumen-apposing metal stents (LAMS), coupled with advancements in therapeutic/interventional EUS, have recently allowed for the development of a novel EUS-guided gastroenterostomy procedure [6, 7, 14]. EUS-GE theoretically provides the same benefits as surgical gastroenterostomy by allowing for a complete enteral bypass around the region of the malignancy, without the substantial morbidity and mortality associated with surgical intervention in complex and often severely ill oncological patients. EUS-GE, combined with EUS-guided biliary drainage, also potentially allows for same session double endoscopic bypass for combined malignant gastric outlet obstruction and biliary obstruction, a technique which has been reported by our group and by others [15, 16].

Several recent studies have described the feasibility, efficacy, and safety of EUS-GE for malignant GOO [17–22]. In the largest multicenter series to date, Chen et al. described a total of 74 patients from seven centers (six from the United States, one from Europe) [22]. Of the 74 patients, 52 underwent EUS-GE using a direct gastroenterostomy technique, and 22 underwent balloon-assisted gastroenterostomy with either a stone retrieval or dilating balloon to facilitate localization and puncture of the small bowel. The study showed similar technical success, clinical success, and adverse events between the two groups, with shorter procedure time with the direct gastroenterostomy technique, leading the authors to suggest that this may be the preferred method for EUS-GE.

A few studies have additionally compared EUS-GE vs other existing modalities for the management of malignant GOO [19–21]. These have demonstrated EUS-GE to be an effective alternative to surgical gastroenterostomy [19, 20], and to enteral stent placement [21]. However, these studies have had notable limitations, which have included wide heterogeneity in techniques, reuse of previously published data, and comparison to older generation enteral stents which are no longer in use.

Our current study was specifically designed to overcome many of the limitations in the existing published literature. In an effort to minimize heterogeneity among existing stents and techniques, our study represents the first to directly compare EUS-GE specifically using the electrocautery-enhanced AXIOS lumen-apposing metal stent, versus enteral stent placement specifically using current generation enteral stents (Boston Scientific WallFlex or Cook Evolution). We furthermore utilized a nearly uniform EUS-GE technique of freehand antegrade LAMS deployment without guidewire assistance, and a pure-cut electrosurgical generator current. Our results demonstrate a higher rate of stent failure requiring repeat intervention among patients undergoing enteral stent placement compared to EUS-GE (32.0% vs. 8.3%, $p=0.021$). Additionally, initial clinical success was higher among patients undergoing EUS-GE compared to enteral stent placement (95.8% vs. 76.3%, $p=0.042$), with a trend towards lower number of adverse events (20.8 vs. 40.2%, $p=0.098$). Kaplan–Meier survival curve analysis furthermore demonstrated greater stent durability among patients who underwent EUS-GE ($p=0.013$). The length of hospital stay was similar between the two procedures, although this may have been due to the severity of patients' underlying diseases, as most patients were already admitted at the time of EUS-GJ, rather than solely due to recovery from the procedure. There were no reported incidences of post-procedure ileus.

Given the complexity and difficulty of the EUS-GE technique, various aspects of the technique are continually evolving. In Japan, Itoi et al. have reported extensively on the EUS-guided balloon-occluded gastroenterostomy bypass (EPASS) system to facilitate EUS-GE; [17, 23, 24] however, this is currently not available in the United States. Two of our initial EUS-GE cases were performed using guidewire assistance, in which EUS-guided puncture of the target bowel was achieved using a 19-gauge needle, followed by advancement of a guidewire to maintain the EUS-GE tract. However, this technique was abandoned after the initial two cases as guidewire placement caused the target small bowel to be pushed away from the stomach, resulting in misdeployment of the LAMS with perforation. Both cases were managed endoscopically with successful LAMS deployment in the same session, and neither case required surgery. Since then, we have adhered to a standardized protocol for the creation of EUS-GE, with "freehand" deployment of the LAMS without guidewire assistance. We have since also utilized only a pure-cut electrosurgical generator current rather than a blended cutting current, in order to optimize penetration of the target small bowel and reduce the risk of stent misdeployment and perforation.

One patient in our series notably underwent a retrograde EUS-EG approach rather than the usual antegrade EUS-GE approach. We considered this retrograde approach given that it is less technically demanding as the stomach is a larger and more stable target for electrocautery-enhanced LAMS puncture than the small bowel. However, for this approach to be more routinely considered, earlier referral from the patient's primary oncologist would be necessary. From an oncological perspective, we believe this approach to be potentially advantageous as it may offset the waxing and waning nutritional deficits and poor functional status that often precedes symptomatic GOO and which results in prolonged withholding of chemotherapy. From an endoscopic perspective, we believe this approach to potentially have a shorter learning curve and more favorable safety profile compared to the antegrade approach, although larger studies evaluating this technique

are warranted. The overall complexity of the EUS-GE procedure and ongoing technical modifications illustrate the need for an improved and standardized method before widespread adoption can be recommended. At the present time, while we consider EUS-GE to be conceptually less invasive than laparoscopic gastrojejunostomy, it remains more invasive and technically challenging than enteral stent placement.

Our study has some notable limitations due to its retrospective nature and lack of randomization. Not all endoscopists in our study had expertise in EUS-GE, which may have introduced selection bias; however, these procedures were rarely urgent and this factor likely did not impact which procedure was performed. In fact, comfort level regarding the limited clinical evidence for EUS-GE on the part of the referring oncologist or surgeon was the most common factor in determining which approach was used. Procedure times were also not recorded as a part of this study, although due to its technical difficulty, EUS-GE is likely associated with longer procedure time than enteral stent placement. The EUS-GE group also had a lower incidence of pre-procedure nausea and vomiting, which may have biased initial clinical success in favor of EUS-GE. Furthermore, despite our technical and clinical success with EUS-GE, this technique remains challenging even for experienced endosonographers and therefore our results may not be generalizable beyond similar centers with extensive experience. Moving forward, a uniform EUS-GE method should be developed and validated. Finally, prospective studies comparing EUS-GE with enteral stent placement and surgical gastroenterostomy are needed, along with additional studies on training and learning curve in this technique, although we believe the learning curve of EUS-GE is likely steeper than for other procedures that employ the use of a LAMS.

In conclusion, EUS-GE has a higher rate of initial clinical success and lower rate of stent failure requiring repeat intervention when compared to standard enteral stent placement. EUS-GE should be considered as a minimally invasive alternative for selected patients with malignant GOO in centers with extensive therapeutic EUS experience.

Compliance with ethical standards

Disclosures Phillip S. Ge: Boston Scientific (Consultant). Christopher C. Thompson: Boston Scientific (Consultant), Medtronic (Consultant), USGI Medical (Consultant, Advisory Board Member, Research Support), Olympus (Consultant, Research Support), Apollo Endosurgery (Consultant, Research Support), GI Windows (Ownership Interest), Aspire Bariatrics (Research Support), Fractyl (Consultant, Advisory Board Member), Spatz (Research Support), EndoTAGSS (Ownership Interest), GI Dynamics (Consultant). Joyce Y. Young and William Dong have no conflicts of interest or financial ties to disclose.

References

1. van Hooft JE, Uitdehaag MJ, Bruno MJ et al (2009) Efficacy and safety of the new WallFlex enteral stent in palliative treatment of malignant gastric outlet obstruction (DUOFLEX study): a prospective multicenter study. Gastrointest Endosc 69:1059–1066
2. Warshaw AL, Fernandez-del Castillo C (1992) Pancreatic carcinoma. N Engl J Med 326:455–465
3. Chekan EG, Clark L, Wu J et al (1999) Laparoscopic biliary and enteric bypass. Semin Surg Oncol 16:313–320
4. Jeurnink SM, Steyerberg EW, van Hooft JE et al (2010) Surgical gastrojejunostomy or endoscopic stent placement for the palliation of malignant gastric outlet obstruction (SUSTENT study): a multicenter randomized trial. Gastrointest Endosc 71:490–499
5. Zheng B, Wang X, Ma B et al (2012) Endoscopic stenting versus gastrojejunostomy for palliation of malignant gastric outlet obstruction. Dig Endosc 24:71–78
6. Binmoeller KF, Shah JN (2012) Endoscopic ultrasound-guided gastroenterostomy using novel tools designed for transluminal therapy: a porcine study. Endoscopy 44:499–503
7. Khashab MA, Kumbhari V, Grimm IS et al (2015) EUS-guided gastroenterostomy: the first U.S. clinical experience (with video). Gastrointest Endosc 82:932–938
8. Soetikno RM, Carr-Locke DL (1999) Expandable metal stents for gastric-outlet, duodenal, and small intestinal obstruction. Gastrointest Endosc Clin N Am 9:447–458
9. Wong YT, Brams DM, Munson L et al (2002) Gastric outlet obstruction secondary to pancreatic cancer: surgical vs endoscopic palliation. Surg Endosc 16:310–312
10. Yim HB, Jacobson BC, Saltzman JR et al (2001) Clinical outcome of the use of enteral stents for palliation of patients with malignant upper GI obstruction. Gastrointest Endosc 53:329–332
11. Del Piano M, Ballare M, Montino F et al (2005) Endoscopy or surgery for malignant GI outlet obstruction? Gastrointest Endosc 61:421–426
12. Topazian M, Ring E, Grendell J (1992) Palliation of obstructing gastric cancer with steel mesh, self-expanding endoprostheses. Gastrointest Endosc 38:58–60
13. Gaidos JK, Draganov PV (2009) Treatment of malignant gastric outlet obstruction with endoscopically placed self-expandable metal stents. World J Gastroenterol 15:4365–4371
14. Teoh AYB, Dhir V, Kida M et al (2018) Consensus guidelines on the optimal management in interventional EUS procedures: results from the Asian EUS group RAND/UCLA expert panel. Gut 67(7):1209–1228
15. Abidi WM, Thompson CC (2016) Endoscopic choledochoduodenostomy and gastrojejunostomy in the treatment of biliary and duodenal obstruction. Gastrointest Endosc 83:1287–1288
16. Brewer Gutierrez OI, Nieto J, Irani S et al (2017) Double endoscopic bypass for gastric outlet obstruction and biliary obstruction. Endosc Int Open 5:E893–E899
17. Itoi T, Ishii K, Ikeuchi N et al (2016) Prospective evaluation of endoscopic ultrasonography-guided double-balloon-occluded gastrojejunostomy bypass (EPASS) for malignant gastric outlet obstruction. Gut 65:193–195
18. Tyberg A, Perez-Miranda M, Sanchez-Ocana R et al (2016) Endoscopic ultrasound-guided gastrojejunostomy with a lumen-apposing metal stent: a multicenter, international experience. Endosc Int Open 4:E276–E281
19. Khashab MA, Bukhari M, Baron TH et al (2017) International multicenter comparative trial of endoscopic ultrasonography-guided gastroenterostomy versus surgical gastrojejunostomy for the treatment of malignant gastric outlet obstruction. Endosc Int Open 5:E275–E281

20. Perez-Miranda M, Tyberg A, Poletto D et al (2017) EUS-guided gastrojejunostomy versus laparoscopic gastrojejunostomy: an international collaborative study. J Clin Gastroenterol 51:896–899
21. Chen YI, Itoi T, Baron TH et al (2017) EUS-guided gastroenterostomy is comparable to enteral stenting with fewer re-interventions in malignant gastric outlet obstruction. Surg Endosc 31:2946–2952
22. Chen YI, Kunda R, Storm AC et al (2018) EUS-guided gastroenterostomy: a multicenter study comparing the direct and balloon-assisted techniques. Gastrointest Endosc 87:1215–1221
23. Itoi T, Itokawa F, Uraoka T et al (2013) Novel EUS-guided gastrojejunostomy technique using a new double-balloon enteric tube and lumen-apposing metal stent (with videos). Gastrointest Endosc 78:934–939
24. Itoi T, Tsuchiya T, Tonozuka R et al (2016) Novel EUS-guided double-balloon-occluded gastrojejunostomy bypass. Gastrointest Endosc 83:461–462