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ABOUT COVER

Editorial Board Member of *World Journal of Gastrointestinal Surgery*, Kun-Ming Chan, MD, Professor, Department of General Surgery and Chang Gung Transplantation Institute, Chang Gung Memorial Hospital at Linkou, Chang Gung University College of Medicine, Taoyun 33305, Taiwan. chankunming@cgmh.org.tw

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Endoscopic ultrasound guided gastrojejunostomy for gastric outlet obstruction

Sebastian Stefanovic, Peter V Draganov, Dennis Yang

Sebastian Stefanovic, Department of Gastroenterology and Hepatology, University Medical Center Ljubljana, Ljubljana 1000, Slovenia

Peter V Draganov, Dennis Yang, Division of Gastroenterology, Hepatology, and Nutrition, University of Florida College of Medicine, Gainesville, FL 32608, United States

Corresponding author: Dennis Yang, MD, Doctor, Division of Gastroenterology, Hepatology, and Nutrition, University of Florida College of Medicine, 1329 SW 16th Street, Room #5252, Gainesville, FL 32608, United States. dennis.yang@medicine.ufl.edu

Abstract

Gastric outlet obstruction (GOO) is a clinical syndrome secondary to luminal obstruction at the level of the stomach and/or duodenum. GOO can be caused by either benign or malignant etiologies, often resulting in early satiety, nausea, vomiting and poor oral intake. GOO is associated with decreased quality of life and has been shown to significantly impact survival in patients with advanced malignancies. Traditional treatment options for GOO can be broadly divided into surgical [surgical gastrojejunostomy (GJ)] and endoscopic interventions (dilation and/or placement of luminal self-expanding metal stents). While surgical GJ has been shown to provide a more lasting relief of symptoms when compared to luminal stenting, it has also been associated with a higher rate of adverse events. Furthermore, many patients with advanced metastatic disease are not good surgical candidates. More recently, endoscopic ultrasound (EUS)-guided GJ has emerged as a potential alternative to traditional surgical and endoscopic approaches. This review focuses on the new advances and technical aspects of EUS-GJ and clinical outcomes in the management of both benign and malignant disease.

Key Words: Gastric outlet obstruction; Interventional endoultrasonography; Gastrojejunostomy; Duodenal stenting; Balloon dilatation

Core Tip: Gastric outlet obstruction (GOO) can significantly decrease the quality of life and also significantly impact survival of patients with malignant etiology. Endoscopic

luminal stenting and surgery are considered standard therapy; however, issues remain. Luminal stenting is minimally invasive but often requires reinterventions whereas longer-lasting surgical bypass procedures are associated with higher morbidity. Endoscopic ultrasonography-guided gastroenterostomy has emerged as an alternative to these established therapies. We aim to analyze the technical aspects of endoscopic ultrasonography-guided gastroenterostomy, review its clinical outcomes and propose a treatment algorithm for patients with malignant GOO.

INTRODUCTION

Gastric outlet obstruction (GOO) is a clinical syndrome characterized by symptoms of luminal obstruction secondary to a variety of disorders (Table 1). The obstruction can be present at the level of distal stomach, pylorus or duodenum. Typical symptoms include postprandial vomiting, epigastric abdominal pain, bloating or abdominal discomfort, early satiety and weight loss[1,2].

Management of GOO, particularly in the setting of malignancy, has involved surgical GJ, endoscopic placement of luminal self-expanding metal stents (SEMS), and more recently, EUS-GJ. For benign GOO, endoscopic balloon dilation (EBD) is commonly the first-step prior to more invasive interventions. Irrespective of the etiology, the ultimate goal of therapy is the resumption or improvement in oral intake, which can be graded using the gastric outlet obstruction scoring system (GOOSS) (Table 2)[3].

Surgical GJ has been the traditional preferred treatment for GOO. This can be performed *via* either an open or laparoscopic approach, and with or without concomitant biliary bypass[4]. The main limitation with surgery is the well-recognized high rates of morbidity (39%-54%) and mortality (6%-31%)[5-10]. Noteworthy, many patients are poor surgical candidates due to advanced underlying malignant disease, poor nutritional status and short life expectancy[8-10].

Endoscopic placement of luminal uncovered SEMS is an established alternative treatment option for GOO, with reported technical and clinical success of 90%-100% and 70%-100%, respectively[1,11,12]. When compared to surgery, SEMS allows for faster resumption of oral intake, shorter hospital stay and fewer adverse events[13-15]. However, stent patency is an issue, as many patients (20%-30%) may experience symptom recurrence due to stent obstruction from food contents or tissue ingrowth after 6 mo[16,17]. It should be noted that many patients with malignant GOO can present or subsequently develop biliary obstruction. In these cases, many experts prefer routine placement of a biliary stent prior to duodenal stenting; however, this may not be feasible depending on the degree of luminal obstruction. Conversely, placement of a duodenal uncovered SEMS first can potentially compromise access to the ampulla of Vater as biliary stenting through the mesh of the SEMS can be technically challenging. Importantly, in certain circumstances, de novo biliary obstruction can develop secondary to the placement of the duodenal SEMS across the papilla. In most cases duodenal stent placement with overlap of the ampulla is often unavoidable in patients whose GOO is at, or near, the biliary orifice. In select cases of short malignant strictures without direct involvement of the ampulla, placement of a lumen-apposing metal stent (LAMS) as opposed to a conventional SEMS, has been reported as a potentially strategy to treat the GOO without overlapping a biliary stent and thereby facilitating future re-intervention if indicated[18]. Irrespectively, the concomitant management of GOO and biliary obstruction with "double" luminal and biliary stenting can be challenging and percutaneous transhepatic biliary drainage may be required. As such, luminal stenting is predominantly indicated for patients with short life expectancy (< 3 mo) in whom re-intervention is less likely[4,17,19]. Conversely, along the same lines, SEMS is not a good long-term plan for management of GOO with a benign cause. Fortunately, benign GOO is less commonly encountered

Table 1 Etiology of gastric outlet obstruction[1,2]	
Malignant causes	**Benign causes**
Pancreatic cancer	Peptic ulcer
Gastric cancer	Hypertrophic pyloric obstruction
Cholangiocarcinoma	Gastric polyp
Gallbladder cancer	Caustic ingestion
Duodenal cancer	Iatrogenic
Ampullary cancer	Gastric/duodenal tuberculosis
Other[1]	Prepyloric web

[1]Non-Hodgkin's lymphoma, intraabdominal small cell sarcoma; metastatic and/or primary tumors of the lung, breast, ovary, kidney, urinary tract or colon; and tumor around the head of the pancreas

Table 2 Gastric outlet obstruction scoring system[3]	
Level of oral intake	**Score**
No oral intake	0
Liquids only	1
Soft solids	2
Low residue or full diet	3

nowadays with high rates of Helicobacter pylori eradication and the prevalent use of proton pump inhibitors[20,21]. While EBD is an effective first-line treatment for benign GOO, patients requiring multiple sessions have a worse prognosis and often will need surgery for definitive management[22-24].

EUS-GJ

EUS-GJ has recently emerged as an alternative minimally invasive technique for the management of both benign and malignant GOO. The procedure is based on the concept of endosonographically identifying jejunum distal to the site of the obstruction followed by the creation a gastro-jejunal (GJ) anastomosis. Technical feasibility and increasing adoption of this procedure have been facilitated by the advent of different types of dedicated bi-flanged LAMS, including those with electrocautery-enhanced delivery systems[25,26]. Theoretically, endoscopic creation of a GJ bypass may avoid potential adverse events associated with surgery, yet still offer a functional anastomosis through the newly created tract. Moreover, the fully-covered LAMS should potentially prevent tissue ingrowth as compared to uncovered luminal SEMS while still imparting lumen apposition and reduced risk of migration *via* its dumbbell shape. However, it should be emphasized that EUS-GJ is still a technically complex procedure. In the following section, we further elaborate on the technical aspects of EUS-GJ, with a particular focus on the different approaches to locate and access the jejunum endosonographically.

TECHNICAL ASPECTS OF ENDOSCOPIC GASTROJEJUNOSTOMY

EUS-GJ is commonly performed with either a curvilinear standard or forward-viewing echoendoscope. The aim is to obtain adequate sonographic visualization of the jejunum from the stomach followed by creation of the GJ anastomosis *via* placement of the LAMS. There are currently 4 different types of LAMS available worldwide as outlined in Table 3. Although there are some slight variations among the different stents in terms of length and diameter, they all share one thing in common: The presence of wide flanges at the end of the stent. These flanges are key in imparting

Table 3 Types of lumen-apposing metal stents[27-29]

Stent	Flange diameter (mm)	Length (mm)	Lumen diameter (mm)	Electrocautery enhanced option	Material
AXIOS[TM] (Boston Scientific Corp., Marlborough, MA, United States)	21, 24, 29	10	10, 15, 20	Yes	Silicone-covered, nitinol-braided stent
NAGI[TM] (Taewoong Medical Co., Ltd., Goyang, South Korea)	20	10, 20, 30	10, 12, 14, 16	No	Silicone-covered, Nitinol stent
Niti-S Spaxus[TM] stent (Taewoong Medical Co., Ltd.)	23, 25, 31	20	8, 10, 16	Yes	Silicone-covered, Nitinol stent
HANARO[TM] stent (M.I.Tech, Pyeongtaek, South Korea)	22 - 28	10, 30	10, 12, 14, 16	No	Silicone-covered, Nitinol stent

lumen apposition, as they are designed to evenly distribute pressure across the fistulous tract thus providing anchorage and reducing the risk of migration. Furthermore, these LAMS are fully covered thereby preventing leakage across the anastomosis and reducing the risk of tissue ingrowth.

Most studies reporting outcomes on EUS-GJ have utilized the AXIOS[TM] stent (Boston Scientific Corp., Marlborough, MA, United States)[27,34,39]. The stent is delivered through a dedicated 10.5 French catheter-based system that is Luer-locked onto the echoendoscope channel inlet port. Stent deployment is then performed *via* the independent stepwise release of each flange under endoscopic and endosonographic visualization. While fluoroscopy is not mandatory, we strongly recommend its use when performing EUS-GJ as it provides an additional imaging modality for safety measure. In recent years, an electrocautery-enhanced delivery systems were developed (Hot Axios stent and delivery system, Boston Scientific Corp, Marlborough, MA, United States) and Hot-Spaxus (Taewoong Medical Co., Ltd.). In this system, the stent is delivered through a system with an electrocautery disk at the distal tip. The electrocautery tip allows passage of the delivery system without requiring mechanical force and tract dilation. This approach potentially minimizes the risk of adverse events and failure rate by reducing the number of steps and devices exchanges required during a procedure. We find this of particular importance during EUS-GJ, as steps such as wire advancement and tract dilation can potentially cause inadvertent movement of the target jejunal loop away from the stomach during the procedure. In fact, identifying the target jejunal loop and maintaining its relative position in close apposition to the stomach remains the main technical hurdle for EUS-GJ. Several approaches have been introduced on how to identify and access the jejunal loop. These techniques can be broadly divided into a direct unassisted and assisted approaches (Figure 1)[25,26].

DIRECT UNASSISTED EUS-GJ

From the stomach, the echoendoscope is used to identify a loop of small bowel immediately adjacent to the gastric body that will be safe for access (Figure 1A). The challenge with EUS-GJ is to obtain adequate visualization of the intestinal loop under EUS, as this is often under distended or distorted by the presence of intraluminal air [19,25,26,31]. Noteworthy, in cases when overactive peristalsis is an issue, administration of anti-peristaltic drugs such as glucagon or butylscopolamine can be considered[32]. Injection of approximately 500 mL of fluid (commonly performed with saline admixed with dye) in the duodenal lumen can help distend and localize the desired targeted loop. Contrast medium can be added to the fluid in order to help identify and confirm the location of the targeted loop under fluoroscopy. Fluid administration can be achieved *via* several different techniques. One method is to puncture the target loop with the EUS needle followed by administration of fluid *via* the needle itself. This approach poses several challenges. For one, this method does not obviate the initial challenge of adequately visualizing the loop for EUS needle puncture. Secondly, fluid infusion through the relatively small caliber needle can be cumbersome and often times ineffective.

Conversely, a standard or ultra-thin endoscope could be used to directly infuse fluid. Using the smaller caliber endoscope may have the added benefit of traversing the GOO and permitting administration of fluid directly into the distal unobstructed target small bowel. Following distention of the small bowel with fluid, the endoscope is quickly exchanged for the echoendoscope in preparation for LAMS placement. The
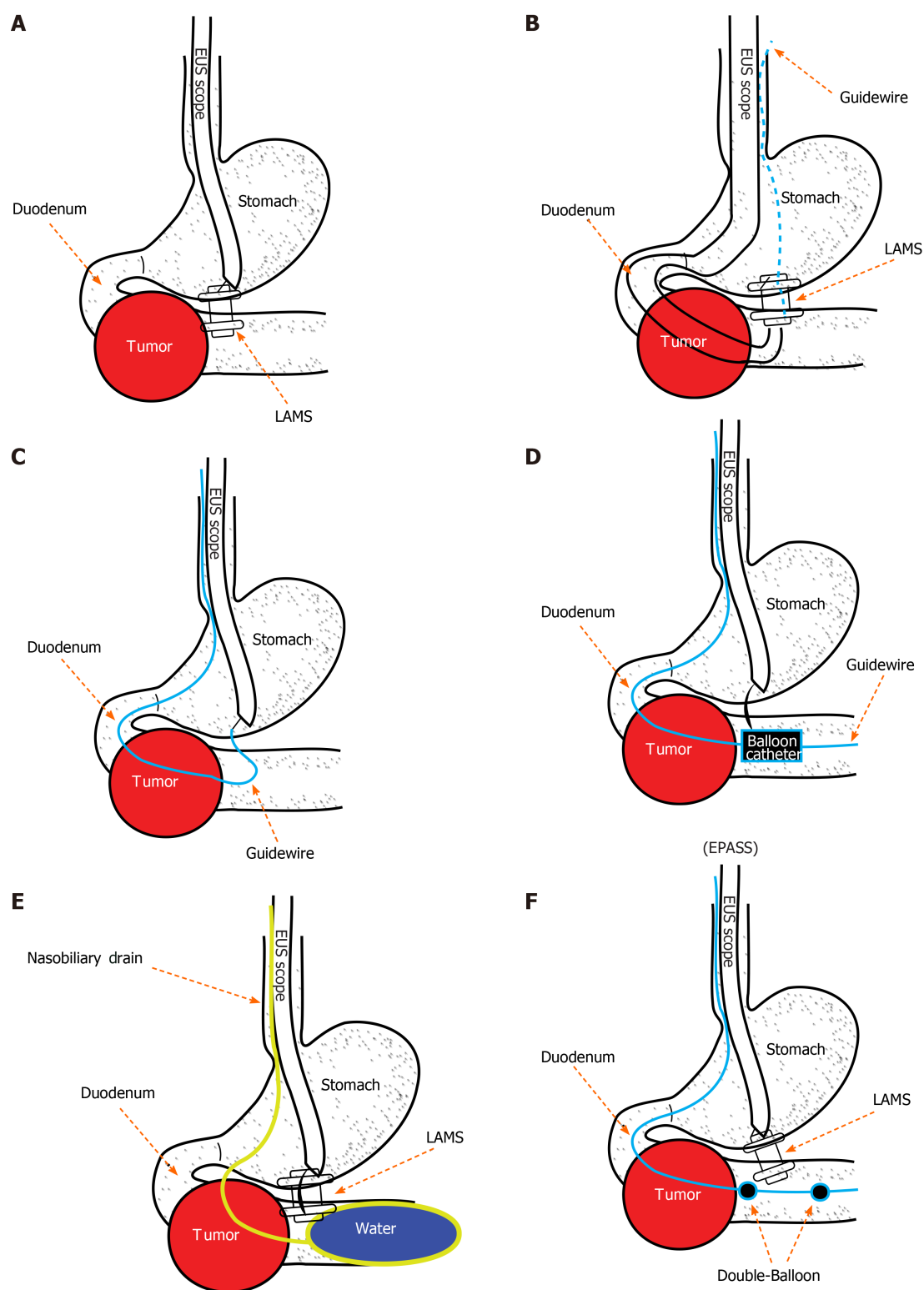
Figure 1 Schematic representation of different endoscopic ultrasound-gastrojejunostomy techniques. A: Direct technique; B: Retrograde technique; C: Rendezvous technique; D: Balloon-assisted technique; E: Nasobiliary-assisted technique; F: Endoscopic ultrasound-guided double balloon-occluded gastrojejunostomy bypass. LAMS: Lumen apposing metal stent.

main disadvantage of this approach is that fluid administered initially can rapidly migrate downstream away from the desired loop by the time EUS is being performed. Some advocate using the echoendoscope for water infusion, which may shorten the time between this step and LAMS placement. However, the echoendoscope is often too large to bypass the site of GOO and thereby only a small amount of fluid administered will accumulate distally, particularly in the setting of severe luminal obstruction.

Once the target jejunal limb is adequately identified under EUS, needle puncture can be safely performed using the 19-gauge fine needle followed by placement of either a 0.025 or 0.035-inch guidewire into the downstream jejunum for access management. With the wire in place, the needle tract can then be dilated to allow insertion of the LAMS delivery system for stent deployment. Alternatively, direct access can also be performed with the electrocautery-enhanced LAMS. This latter approach eliminates the need for needle puncture or tract dilation. Furthermore, direct free-hand access without the guidewire prevents inadvertently pushing the targeted loop away from the gastric body, which can occur when attempting to advance the guidewire into the downstream intestine. As such, we favor the use of the electrocautery-enhanced LAMS in our institution as it enables a one-step approach for the puncturing of the target loop, anastomosis dilation and deployment of the stent.

A retrograde technique has also been described as a variant of the direct unassisted approach. With this technique, the echoendoscope is advanced beyond the GOO and the LAMS is deployed in retrograde fashion (from the jejunum into the stomach) (Figure 1B). An advantage of this method is the relative stable location of the stomach as a target for puncturing. However, this technique is seldomly performed in clinical practice, primarily due to the difficulty of advancing the echoendoscope across the GOO, which can be associated with a higher risk of iatrogenic perforation.

DEVICE-ASSISTED EUS-GJ

With the "assisted" EUS-GJ methods, an additional device (*i.e.*, ultraslim endoscope, balloon catheter, nasobiliary drain) is often used to help identify the target loop of bowel (Figure 1)[19,25,26,31].

Ultra-slim endoscope device assisted technique

With this technique, the ultraslim endoscope is maneuvered across the GOO for direct visualization of the unobstructed distal small bowel. Fluid can then be directly administered through the endoscope to distend the target loop of bowel. The echoendoscope is then inserted and advanced into the stomach alongside the ultraslim endoscope. There are several advantages with this technique. For one, the concomitant continuous infusion of fluid *via* the endoscope allows for stable visualization of the target loop *via* the echoendoscope in the stomach. Secondly, following EUS needle puncture, wire advancement through the EUS needle can be directly visualized and pulled through the ultra-slim endoscope. This allows for additional tension and traction during LAMS placement (rendezvous technique) (Figure 1C). Alternatively, the guidewire advanced into the intestine *via* the EUS needle can be pulled out of the mouth and a therapeutic endoscope advanced in antegrade fashion across the GOO to the puncture site. Once in position, the LAMS could be deployed in retrograde fashion (from the jejunum to the stomach) using the therapeutic endoscope. This method is a variant of the retrograde technique described earlier. Similarly, this is infrequently performed given the difficulty of maneuvering the therapeutic endoscope across the GOO. There are also some drawbacks with the use of an ultra-slim endoscope that are worth noting. For one, this approach requires the complex set-up of two separate endoscopic processors for the simultaneous operation of the ultra-slim and echoendoscope, which may not be readily available in every endoscopy unit. Furthermore, insertion and maneuvering of the echoendoscope alongside the ultra-slim endoscope can sometimes be challenging, not to mention that two operators are often required to control each scope. Given these issues, we tend to favor the use of other device-assisted strategies for EUS-GJ.

Balloon device assisted technique

With this technique, a 0.025- or 0.035-inch guidewire is first pushed across the GOO and coiled in the small intestine distal to the obstruction under endoscopic and/or fluoroscopic guidance. Once this is achieved, the balloon catheter is advanced over the wire across the GOO and then inflated with contrast medium (Figure 1D). The inflated balloon helps stabilize the desired loop of bowel distal to the obstruction and also serves as a target for EUS-guided needle puncture. In fact, successful puncturing of the balloon ascertains the position of the tip of the needle within the desired loop of bowel. Stent placement can then proceed as previously described. Alternatively, following puncture of the inflated balloon with the EUS needle, the guidewire can be advanced then captured (*i.e.*, extraction balloon) and retrieved across the GOO to provide additional tension for stent placement.

Nasobiliary drain assisted technique

Similar to the balloon device assisted technique, a guidewire is first pushed across the GOO and coiled in the small intestine distal to the obstruction. Once the guidewire is in the desired location, the endoscope is withdrawn from the mouth of the patient and the nasobiliary drain advanced only under fluoroscopic guidance (Figure 1E). Alternatively, placement of the nasobiliary drain can be performed with the assistance of either a therapeutic endoscope or ERCP scope. The larger caliber channel of these scopes allows insertion of the nasobiliary drain through the scope channel and across the GOO. Contrast can then be injected through the nasobiliary drain to confirm its location in relationship to the desired loop of bowel. Drain positioning can then be adjusted by pushing or pulling it through the indwelling endoscope. Once in position, the endoscope and wire can be withdrawn from the patient leaving the nasobiliary drain in place with the tip positioned beyond the GOO. It is in our opinion that this strategy provides a more reliable method for securing drain placement (Figure 2). The nasobiliary drain can then be connected to a foot-pedal activated irrigation pump for fluid infusion during EUS-GJ. The main advantage of using an irrigation pump is that it enables us to infuse large quantities of fluid continuously distal to the obstruction, providing a more reliable target loop for EUS-guided access. Of note, there is variability in clinical practice on whether the lumen of the newly deployed transluminal LAMS should be dilated during the same session. We do not routinely dilate the lumen of the LAMS following EUS-GJ to avoid inadvertent stent dislodgement; albeit current data on this issue remains limited.

ENDOSCOPIC ULTRASONOGRAPHY-GUIDED DOUBLE BALLOON-OCCLUDED GASTROJEJUNOSTOMY BYPASS

Recently, the novel endoscopic ultrasonography-guided double balloon-occluded gastrojejunostomy bypass (EPASS)[30] was introduced as an alternate technique for EUS-GJ. This procedure uses a unique double-balloon enteric tube (Tokyo Medical University type; Create Medic Co., Ltd, Yokohama, Japan). With this technique, a 0.025- or 0.035-inch guidewire is placed across the GOO followed by advancement of the device to the area of interest. The tube consists of two balloons, which are then inflated with contrast and fluid for both localization and for anchoring in the desired location. The segment of small bowel between the two balloons is then filled and distended with fluid to facilitate subsequent EUS-guided LAMS placement (Figure 1F).

OUTCOMES OF EUS-GJ

Since the introduction of EUS-GJ, there have been several case series, retrospective and prospective cohort studies evaluating outcomes associated with this technique[27,30, 34-40]. The reported technical success from these studies, defined as adequate positioning and deployment of the stent, has been high, ranging between 86.7% to 100 % and irrespective of the technique used[33]. Similarly, clinical success, when defined as the patient's ability to tolerate oral intake or improvement in the GOOSS of ≥ 1 point[27], has been reported to range between 80% to 100%[33]. Commonly reported adverse events (0-26%) have included stent misdeployment, peritonitis, bleeding, hemo- and pneumoperitoneum, peritonitis, abdominal pain and leakage[33].

McCarty *et al*[34] recently performed a systematic review and meta-analysis evaluating the efficacy and safety of EUS-GJ for both benign and malignant GOO. The authors included four retrospective and one prospective study in their analysis (*n* = 199 patients). The characteristics of these studies are summarized in Table 4. The overall mean procedure time for all techniques (assisted and unassisted EUS-GJ) was 43.5±20 minutes, with nearly all patients (*n* = 198; 99.5%) having a 15 mm x 10 mm LAMS (AXIOS, Boston Scientific Corp, Marlborough, MA, United States) placed. Overall, the pooled technical and clinical success rates were 92.9 (95%CI: 88.3-95.8; I^2 = 0.00%) and 90.1% (95%CI: 84.6-93.4; I^2 = 0.00%), respectively. In all, the adverse event rate for EUS-GJ was 10.6% (95%CI: 6.7-16.3; I^2 = 27.2), with serious events occurring in 5.6% (95%CI: 2.9-10.7; I^2 = 1.7%).

Two studies have evaluated predictors of technical success. In their multicenter retrospective study, Tyberg *et al*[35] found that presence or absence of previous intervention, altered anatomy, and the use of LAMS with or without cautery did not affect technical outcomes. On the other hand, a separate study by Wannhoff *et al*[27]

Table 4 Outcomes of endoscopic ultrasonography-guided gastroenterostomy using a lumen-apposing self-expandable metal stent in benign and malignant gastric outlet obstruction[27,30,35-40]

	Itoi *et al* [30]	Tyberg *et al* [35]	Chen *et al*[36]		Kerdsirichairat *et al*[38]	Ge *et al*[37]	Jovani *et al* [39]	Wannhoff *et al*[27]	James *et al* [40]
Type of study	Single-center, Prospective	International, Retrospective	Multicenter, Retrospective		Single-center, Retrospective	Single-center, Retrospective	Single-center, Retrospective	Single-center, Retrospective	Single-center, Retrospective
Number of patients (*n*)	20	26	74		57	22	73	35	22
Number of malignant obstructions	20	17	49		48	22	64	33	0
Number of benign obstructions	0	9	25		9	0	9	2	22
EUS-GJ technique, *n*	EPASS *n* = 20	Direct *n* = 3, Balloon-assisted *n* = 13, Nasobiliary *n* = 3, Ultraslim scope *n* = 5, NOTES *n* = 2	Direct *n* =52	Balloon-assisted *n* = 22	Direct *n* = 57	Direct *n* = 24	Direct *n* = 73	Direct *n* = 22, Nasobiliary *n* = 10, other = 3	Direct *n* = 9, Orojejunal = 5, Balloon-assisted = 8
Technical success (%)	90	92	94.2	90.9	92.9	100	93	80	95.4
Clinical success (%)	NA	85	92.3	90.9	89.5	95.8	97	74.3	NA
Adverse events (%)	10	11.5	5.8	9.1	3.5	20.8	7.4	14.3	19
Recurrence/need for Reintervention (%)	NA	3.8	5.8	18.2	15.1	8	15	NA	23.8

EUS-GJ: Endoscopic ultrasound guided gastrojejunostomy; EPASS: Endoscopic ultrasonography-guided double balloon-occluded gastrojejunostomy bypass; NOTES: Natural orifice transluminal endoscopic surgery; NA: Not applicable.

showed that the presence of moderate or severe ascites was a predictor of failure, with a lower technical success of 42.9% as compared to EUS-GJ in patients with mild or no ascites (89.3%; $P = 0.018$). However, on multivariate analysis, only distance between the lumina was identified as a predictor of technical success, with an optimal distance identified at 19 mm.

EUS-GJ OUTCOMES COMPARED TO OTHER TECHNIQUES FOR THE MANAGEMENT OF GOO

EUS-GJ is a relatively novel technique with limited comparative data between this procedure and other traditional surgical and endoscopic approaches for GOO. There have been two recent studies comparing EUS-GJ with surgical bypass (Table 5)[41,42]. Khashab *et al*[41] compared open gastrojejunostomy and EUS–GJ in patients with malignant GOO. While technical success was lower with EUS-GJ (86.7%) compared to surgery (100%) ($P = 0.009$), there was no difference in clinical success (87% *vs* 90%) between the two groups ($P = 0.18$). Furthermore, there was no difference in terms of recurrence of GOO (EUS-GJ 3% *vs* surgery 14%; $P = 0.08$) or adverse event rate (EUS-GJ 16% *vs* surgery 25%; $P = 0.3$) between the two groups. The authors concluded that their results demonstrated that EUS-GJ is a less invasive alternative to surgery with similar efficacy and safety outcomes. Likewise, Perez-Miranda *et al*[42] reported the results of their multicenter retrospective comparative study on EUS-GJ *vs* laparoscopic surgical gastrojejunostomy for the management of benign and malignant GOO (Table 5). There was no significant difference in technical success between EUS-GJ (88%) and surgery (100%) ($P = 0.11$). Conversely, the rate of adverse events was significantly lower with EUS-GJ as compared to laparoscopic surgical bypass (12% *vs*

Table 5 Outcomes of endoscopic ultrasonography-guided gastroenterostomy using a lumen-apposing self-expandable metal stent as compared to surgery[41,42]

	Khashab *et al*[41]		Perez-Miranda *et al*[42]	
Type of study	Multicenter, retrospective		Multicenter, retrospective	
Group	EUS-GJ	Surgery	EUS-GJ	Laparoscopic GJ
Number of patients, *n* (%)	30/93 (32.3)	63/93 (67.7)	25/54 (46.3)	29/54 (53.7)
Technique	Direct; EPASS; Balloon-assisted	Open GJ2	Direct Assisted	Laparoscopic GJ
Technical success (%)	87	100	88	100
Clinical success (%)	87	90	84	90
Adverse events (%)	16	25	12	41
Recurrence/need for Reintervention (%)	3	14	NA	NA

EUS-GJ: Endoscopic ultrasound guided gastrojejunostomy; GJ: Gastrojejunostomy; EPASS: Endoscopic ultrasonography-guided double balloon-occluded gastrojejunostomy bypass; NA: Not applicable.

Table 6 Outcomes of endoscopic ultrasonography-guided gastroenterostomy using a lumen-apposing self-expandable metal stent as compared to duodenal stenting[37,43]

	Chen *et al*[43]		Ge *et al*[37]	
Type of study	Multicenter, retrospective		Single center, retrospective	
Group	EUS-GJ	Duodenal stenting	EUS-GJ	Duodenal stenting
Number of patients, *n* (%)	30 (36.5)	52 (63.4)	22 (22)	78 (78)
Technique	Direct; EPASS; Balloon-assisted	Uncovered Wallflex (Boston Scientific)	Direct Assisted	Uncovered WallFlex; Boston Scientific, or (Evolution; Cook Medical)
Technical success (%)	86.7	94.2	100	100
Clinical success (%)	83.3	67.3	95.8	76.3
Adverse events (%)	16.7	11.5	20.8	40.2
Recurrence/need for Reintervention (%)	4.0	28.6	8	32

EUS-GJ: Endoscopic ultrasound guided gastrojejunostomy; EPASS: Endoscopic ultrasonography-guided double balloon-occluded gastrojejunostomy bypass.

41%, $P = 0.04$). In terms of expected cost, the authors reported that EUS-GJ was significantly less costly than surgery ($4905.5 *vs* $14778.8; $P < 0.001$).

There have been two recent studies evaluating outcomes between EUS-GJ and luminal stenting for GOO (Table 6)[37,43]. In a multicenter retrospective study, Chen *et al*[43] compared EUS-GJ to endoscopic stenting for patients with malignant GOO. Overall, there was no statistically significant difference between the groups in terms of technical (EUS-GJ: 86.7% *vs* stenting: 94.2%, $P = 0.2$) or clinical success rates (EUS-GJ 83.3% *vs* stenting 67.3%, $P = 0.12$). While the occurrence of adverse events was also similar in both groups (16.7% *vs* 11.5%, $P = 0.5$), recurrence of GOO symptoms and the need for reintervention was significantly less after EUS-GJ (4.0%) when compared to patients who underwent luminal stenting (28.6%) ($P = 0.02$). Indeed, on multivariate analysis, luminal stenting was independently associated with the need for reintervention (odds ratio: 12.8; $P = 0.03$). These findings are similar to those reported by Ge *et al*[37], who demonstrated that the rate of re-intervention for recurrent GOO symptoms is significantly lower after EUS-GJ (8.3%) as compared to luminal stenting (32.0%) ($P = 0.021$). While both procedures were associated with a technical success of 100%, clinical success rate was higher in the EUS-GJ group than in the luminal stenting group (95.8% *vs* 76.3%, $P = 0.042$). Lastly, the luminal stenting group also trended towards increased adverse events (40.2% *vs* 20.8%; $P = 0.09$).
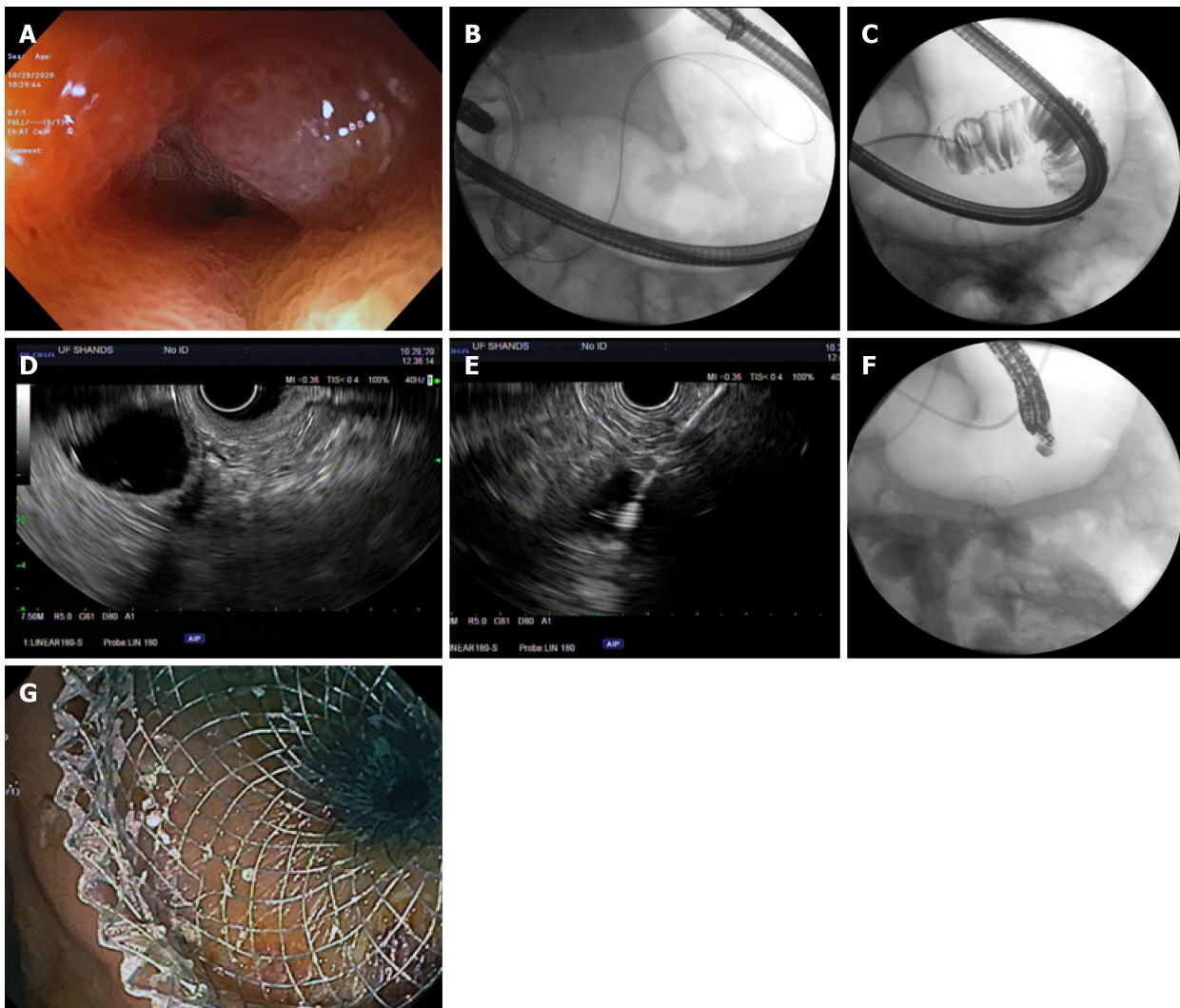
Figure 2 Endoscopic ultrasound-guided gastrojejunostomy using the nasobiliary drain assisted technique. A: Endoscopic view of the severe luminal obstruction in the proximal duodenum secondary to advanced pancreatic cancer; B: A percutaneous transhepatic biliary drain previously placed for jaundice can be identified on fluoroscopy. A therapeutic endoscope was used to advance and coil a 0.035" guidewire across the obstruction in the distal unobstructed bowel under fluoroscopic guidance; C: A nasobiliary catheter drain was then advanced through the channel of the scope over the guidewire across the obstruction. Contrast was injected under fluoroscopy to identify the target jejunal loop for endoscopic ultrasound (EUS)-guided gastrojejunostomy using; D: The target loop is distended with continuous infusion of fluid *via* the nasobiliary drain assisting with visualization under EUS; E: Successful EUS puncture of the target loop under EUS for lumen-apposing metal stent (LAMS) placement; F: Fluoroscopic image of the LAMS with adequate apposition of the gastric and jejunal lumen; G: Endoscopic view of the LAMS with confirmation of position by the visualization of the blue dyed water (methylene blue) infused through the nasobiliary drain.

PROPOSED TREATMENT ALGORITHM FOR THE MANAGEMENT OF GOO

The current limited data suggests that EUS-GJ is both effective and safe for the management of malignant GOO and should be considered as an alternative to surgery or luminal stenting in select patients when performed at centers with adequate advanced endoscopy expertise (Figure 3). Endoscopic placement of a duodenal SEMS is a widely available procedure associated with a high technical success. Given that the main limitation of this approach is stent occlusion and need for re-intervention, SEMS may be the preferred treatment for patients with advanced disease and short-life expectancy. The current literature suggests that EUS-GJ may be an effective alternative for treating GOO symptoms in these patients with less need for re-interventions. Furthermore, as previously discussed, malignant GOO can present with concomitant biliary obstruction. Our preference is to attempt biliary access *via* ERCP prior to duodenal stenting if feasible. If biliary access cannot be attained *via* conventional ERCP, EUS-guided biliary access followed by duodenal stenting is an alternate option. In those patients with GOO who have not endorsed biliary obstruction, EUS-GJ offer two potential distinct advantages over duodenal stenting. For one, access through the native papilla is not hindered by an overlying SEMS. Secondly, retrograde access to the papilla for ERCP can be attempted *via* the EUS-GJ in those cases in which
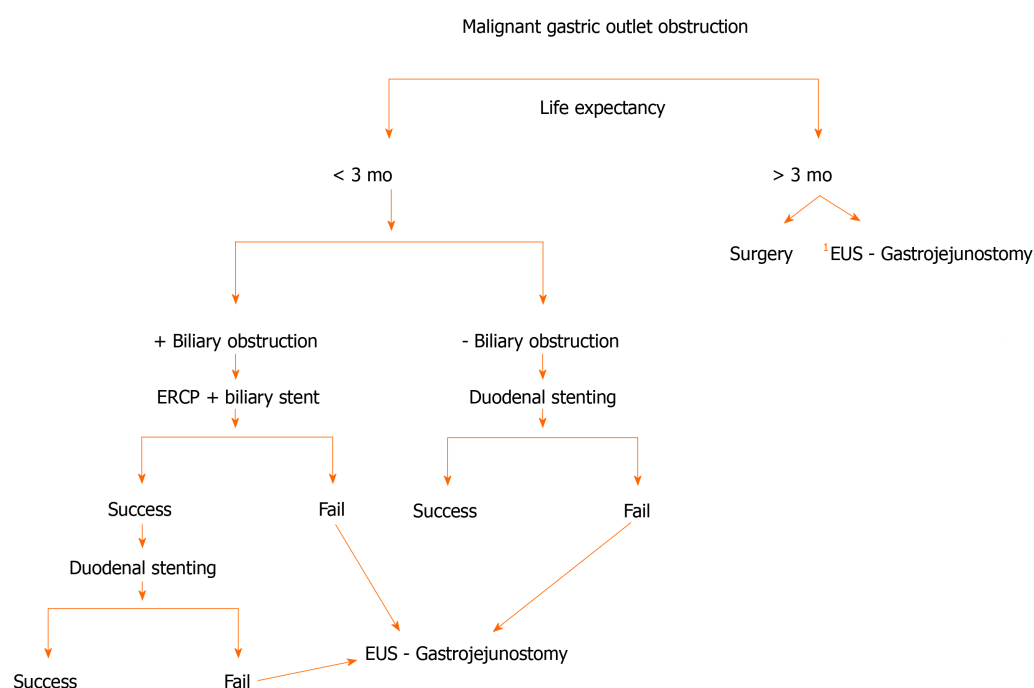
Figure 3 Approach to a patient with malignant gastric outlet obstruction syndrome. ERCP: Endoscopic retrograde cholangiopancreatography; EUS: Endoscopic ultrasound. [1]Currently possible only in highly specialized centers +avoid in perigastric varices, relative contraindication: massive ascites.

antegrade scope advancement is more challenging due to the GOO.

EUS-GJ can also be entertained as a salvage method if initial attempt at luminal stenting has failed, allowing the creation of a functional anastomosis away from the obstruction. While outcomes data on EUS-GJ are comparable to surgical bypass, the former has been shown to be more cost effective and may be a good alternative for patients who are not operative candidates. The potential role of EUS-GJ for the management of benign GOO remains less clear. While there have been studies on the efficacy and safety of EUS-GJ in these patients, durability of LAMS patency remains unanswered. Hence, definitive surgery should still be considered the mainstay for the management of patients with benign GOO not amenable to endoscopic dilation and/or luminal stenting[44]. However, we should emphasize that EUS-GJ is a technically complex procedure and its current use should be limited to highly specialized centers. Hence, the best treatment approach should always be individualized, based on multiple factors, including patient and disease characteristics, as well as availability of local resources and expertise.

CONCLUSION

EUS-GJ is emerging as a potential treatment option for GOO. When compared to luminal stenting, EUS-GJ may provide a longer lasting treatment for GOO. In the hands of experts, EUS-GJ appears to be similar in efficacy and safety when compared to surgery; yet it may be less costly. However, current data on EUS-GJ is scarce and limited to expert centers. Further improvements and standardization of the technique may facilitate its adoption in clinical practice. Lastly, large prospective randomized trials comparing EUS-GJ with surgery and luminal stenting are needed to better define its role in the management of these complex patients.

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