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Standardizing Success and Troubleshooting in EUS-Guided Gastroenterostomy

An International Technical Review (With Videos)

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Abstract: EUS-guided gastroenterostomy (EUS-GE) is rapidly emerging as a pivotal procedure in the management of gastric outlet obstruction due to its advantages over historical comparators such as surgical gastroenterostomy and endoscopic placement of gastroduodenal stents. The ability to create a stable surgical-range connection between 2 lumens, distant from the tumor, with the minimally invasive nature of an endoscopic procedure, offers high clinical efficacy, acceptable safety, and low recurrence rates. However, widespread adoption is impeded by the steep learning curve and lack of standardized methodologies. Like other interventional EUS procedures, EUS-GE utilizes lumen apposing metal stents.

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Unlike drainage procedures, the target in EUS-GE is a mobile structure with a virtual resting caliber that needs to be distended to create the connection, making misdeployment a significant drawback. This comprehensive illustrated technical review dissects the general and specific technical principles of EUS-GE covering the equipment, scene, settings, and endoscopic signs of correct and incorrect placement. It provides a deeper insight into the wireless simplified EUS-GE technique, the EUS-guided double-balloon-occluded gastrojejunostomy bypass, and the direct technique. Through pragmatic tips, expert advice, and elucidative step-by-step videos, a systematic roadmap for mastering this intricate procedure is presented. By addressing common challenges and providing troubleshooting strategies, this review aims to demystify EUS-GE, equipping practitioners with the tools to achieve reproducible and optimal outcomes.

Key Words: malignant gastric outlet obstruction, endoscopic ultrasound-guided gastroenterostomy, EUS-guided anastomoses, therapeutic echoendoscopy

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Endoscopic ultrasound-guided gastroenterostomy (EUS-GE) involves the placement of a lumen-apposing metal stent (LAMS) to create a communication between the gastric lumen and the small bowel (typically the jejunum), under EUS guidance. This procedure bypasses the site of obstruction and relieves gastric outlet obstruction (GOO) symptoms due to either malignant or benign conditions, enabling early resumption of oral intake.

EUS-GE offers a safe, effective, and minimally invasive therapeutic option as supported by a growing body of literature. However, it remains a technically demanding procedure. The lack of standardization and the potential for significant adverse events (AEs) have limited its widespread adoption compared with standard approaches such as enteral stenting (ES) or surgical gastroenterostomy (S-GE).[1]

A steep learning curve is one of the main perceived limitations to broader implementation,[2] calling for structured training programs. Various EUS-GE techniques have been described, with notable variations among centers and operators. To facilitate wider adoption of EUS-GE, ensuring reproducibility and standardization is essential. This technical review brings together global experts to share insights and promote standardization of EUS-GE.

MATERIALS AND METHODS

This review was developed through a collaborative effort. Internationally recognized experts in EUS-GE were invited to contribute based on their publication history. Selection was guided by scientific merit and global standing in the field.

Following individual contributions, the manuscript underwent a comprehensive and collective review, to reach a shared consensus on the final version, incorporating diverse perspective from all participants.

The authors utilize different EUS imaging orientations. Most images in this publication adhere to the convention of displaying the cranial end or "near point" of the transducer on the left side of the ultrasound screen, mirroring the standard longitudinal view used in transabdominal ultrasound.[3] However, some contributors prefer the opposite orientation: notably, some images feature a right-sided orientation, which is explicitly noted in the figure legends in such instances.

The authors also acknowledge that EUS-GE using electrocautery-enhanced lumen-apposing metal stents is currently based on off-label device use. Nonetheless, formal registrational studies are ongoing.

TABLE 1. Flowchart of Technical Steps for EUS-Guided Gastroenterostomy, Including Available LAMS Sizes for this Indication, Contraindications, and Reported Adverse Events.

Flowchart of technical steps to perform an EUS-GE (using WEST or EPASS technique)

- Guidewire advancement across the duodenal stenosis
- Placement of the orojejunal tube
- EUS-guided identification of the target small bowel loop
- Controlled loop distention through saline
- Creation of the best operative window
  - The shortest possible interluminal distance (preferably <5 mm)
  - The larger possible operative space (ideally 4 cm for a 20 mm LAMS)
  - Oblique loop course aligned with the scope's operative channel
- Advancement of an electrocautery-enhanced LAMS using pure-cutting current
- LAMS release
- Optional confirmation of correct LAMS placement

LAMS size options for EUS-GE

- HOT AXIOS Stent 20 mm (Boston Scientific, Marlborough, MA)
- HOT AXIOS Stent 15 mm (Boston Scientific)
- Niti-S SPAXUS Stent 16 mm (Taewoong, Seoul, South Korea)

EUS-GE contraindications

- Severe malignant ascites
- Extensive peritoneal carcinomatosis
- Gastric linitis plastica
- Specific morphologic factors:
  - Excessive interluminal distance
  - Inability to maintain distention of the target enteral loop diameter >2.5 cm
  - Interposition of enteral/colonic loops or blood vessels
- General contraindications to interventional procedures
  - Severe, uncorrectable coagulopathy
  - Severe systemic comorbidities precluding anesthesia

EUS-GE adverse events

- LAMS misdeployment
- Bleeding
- Cholangitis
- Abdominal pain
- Aspiration pneumonia
- Tissue reactions on the jejunal or gastric side
- LAMS obstruction

Each item is discussed in the corresponding section of the manuscript.

EPASS indicates EUS-guided double-balloon-occluded gastrojejunostomy bypass; EUS-GE, EUS-guided gastroenterostomy; LAMS, lumen-apposing metal stent; WEST, wireless simplified EUS-GE technique.

EUS-GUIDED GASTROENTEROSTOMY: SUMMARY OF BEST AVAILABLE EVIDENCE

The concept of EUS-GE was first introduced by Fritscher-Ravens et al in 2002.[4] However, it was not until the advent of LAMS in 2012[5] that this procedure began to gain traction in clinical practice, marking a significant paradigm shift in the management of GOO.

EUS-GE with LAMS in expert centers ensures $>95\%$ technical and clinical success rates[6,7] with fewer AEs than S-GE (OR: 0.34; 95% CI: 0.20-0.58) and less symptoms recurrence than ES (OR: 0.17; 95% CI: 0.10-0.30).[8] Consequently, EUS-GE is being increasingly preferred over traditional approaches when expertise is available.

In surgically fit patients, S-GE has traditionally been the standard treatment for GOO, offering sustained symptomatic relief but associated with a significant morbidity (up to 41% of AE).[9] In a recent large multicenter retrospective study, Canakis et al[10] reported significantly shorter resumption of oral intake (1.4 vs. 4.1 d, $P<0.001$), a shorter hospital stay (5.3 vs. 8.5 d, $P<0.001$) and a lower AEs rate (4.9% vs. 12.5%, $P=0.02$) for EUS-GE compared with S-GE. There was no significant difference in mortality rates, and both techniques showed comparable technical (97.9% vs. 100%) and clinical (94.1% vs. 94.3%) success rates. Several randomized controlled trials (RCTs) are currently ongoing to assess efficacy and clinical outcomes.[11–14]

For patients who are poor surgical candidates or have a limited life expectancy, ES remains a widely accepted alternative.[15,16] However, several retrospective studies,[8,17–21] comparing EUS-GE versus ES reported a significantly higher clinical success rate (91% vs. 71%) and lower stent dysfunction rate (1% vs. 26%). In a prospective matched comparison, Vanella et al[7] reported a higher clinical success rate (100% vs. 75.0%, $P=0.006$), faster resumption of oral intake (2 vs. 3 d, $P=0.03$), fewer recurrences (3.7% vs. 33.3%, $P=0.02$), and a trend toward a shorter time to chemotherapy (median: 17 vs. 24 d, $P=0.055$) for patients treated with EUS-GE versus ES.

The recent international multicentric RCT (DRA-GOO) by Teoh et al[22] compared the outcomes of EUS-GE versus ES in unresectable patients with malignant GOO. This study demonstrated a lower median number of reinterventions with EUS-GE within 6 months (4% vs. 29%, RR: 0.15, 95% CI: 0.04-0.61). In addition, the EUS-GE group had a significantly shorter hospital stay [median: 4.0 (3.0-7.0) d vs. 6.0 (3.3-11.8) d; $P=0.013$] and better Gastric Outlet Obstruction Scoring System (GOOSS)[23] 1 month after the procedure (median: 2.41 vs. 1.91, $P=0.012$). However, there was no statistically significant difference between the EUS-GE and ES groups in terms of AEs, 30-day mortality, technical success, clinical success, or quality-of-life scores.

BETTER ESCAPE: EUS-GE CONTRAINDICATIONS

As EUS-GE relies on the ability to safely visualize and access the target enteral loop through the stomach, caution should be exercised in the presence of the following factors (Table 1):

- Severe malignant ascites: presence of intra-abdominal fluid per se is not an absolute contraindication[24,25]; however, massive ascites (Fig. 1) can affect the stability of the loop to be transversed by the LAMS, increasing the risk of stent misdeployment. Moreover, ascites heightens the risk of postprocedural infections which might hence require prolonged antibiotics courses.[26–28] The presence of ascites also prolongs the healing of the serosa-to-serosa apposing anastomosis created by the stent, thereby extending the risk of ascites contamination.
- Extensive peritoneal carcinomatosis: massive ascites is often associated with extensive peritoneal carcinomatosis. While carcinomatosis itself is not an absolute contraindication,[29] it suggests a reduced life expectancy and might be associated with additional downstream bowel stenoses. Therefore, thorough imaging review is recommended. It should also be considered that extensive carcinomatosis might complicate any backup surgery in case of AEs. Moreover, carcinomatosis can lead to edematous thickening of the gastric and enteral loops, affecting the distance between lumens.
- Gastric linitis plastica: neoplastic thickening of the gastric walls (Fig. 2), as seen in cases of neoplastic involvement, can be a contraindication to the procedure.[1] The thickening may result in an excessive distance between gastric and enteral lumen, surpassing the length of the LAMS saddle and hindering the electrocautery-enhanced advancement of the catheter, potentially leading to an increased AEs rate, such as bleeding.
- Other morphologic factors: total distance exceeding 1 to 1.5 cm between the 2 lumens, inability to adequately maintain distension of the target enteral loop to a minimum diameter of 2.5 cm, presence of interposed enteral or colonic loops (Fig. 3), and presence of interposed blood vessels are morphologic limiting factors (discussed later).[28]

Other factors representing potential contraindications to any interventional procedure are severe, uncorrectable coagulopathy and bleeding disorders and severe systemic comorbidities precluding the safe administration of anesthesia.

TECHNICAL DETAILS

Setting the Scene: Room, Radiation, and Sedation

The patient should be positioned either supine or prone to facilitate the use of fluoroscopy to assess the luminal anatomy. However, some practitioners prefer a left lateral semiprone position, for better pooling of fluid.

The stomach should be empty and clean throughout the procedure, either through prior placement of a nasogastric tube or intraprocedural endoscopic clearance.

Fluoroscopy should be available when performing EUS-GE, as it assists in critical steps of the procedure (such as tube placement across a stricture) and is essential to diagnose and treat intraprocedural AEs.[28,30]

Adequate sedation, usually involving anesthesiology support, is required for EUS-GE due to the increased aspiration risk[28] associated with enteral fluid instillation. Tracheal intubation is used in most expert centers. However, propofol sedation without intubation is also considered safe when precautions are taken to ensure an empty stomach and to limit the volume of fluid injected into the gastrointestinal tract throughout the procedure.[28]

The Equipment

Regardless of the technique used (see later), a catheter for fluid infusion of the jejunum should be available.

Once the jejunal tube is in place, it is recommended to use saline for infusion instead of water, as an excessive amount of the latter can lead to clinically significant electrolyte imbalances, particularly dilution hyponatremia. The use of contrast and dye (eg, indigo carmine) is at the discretion of the endoscopist.

However, uncontrolled infusion of contrast mixed with saline can alter the interpretation of the fluoroscopy image. Conversely, limited use of dye can aid in delineating enteral anatomy and providing confirmation of correct LAMS placement (see the "contrast bypass confirmation" sign later)).

Unlike other therapeutic EUS procedures, the use of electrocautery-enhanced LAMS is mandatory for EUS-GE.[28]

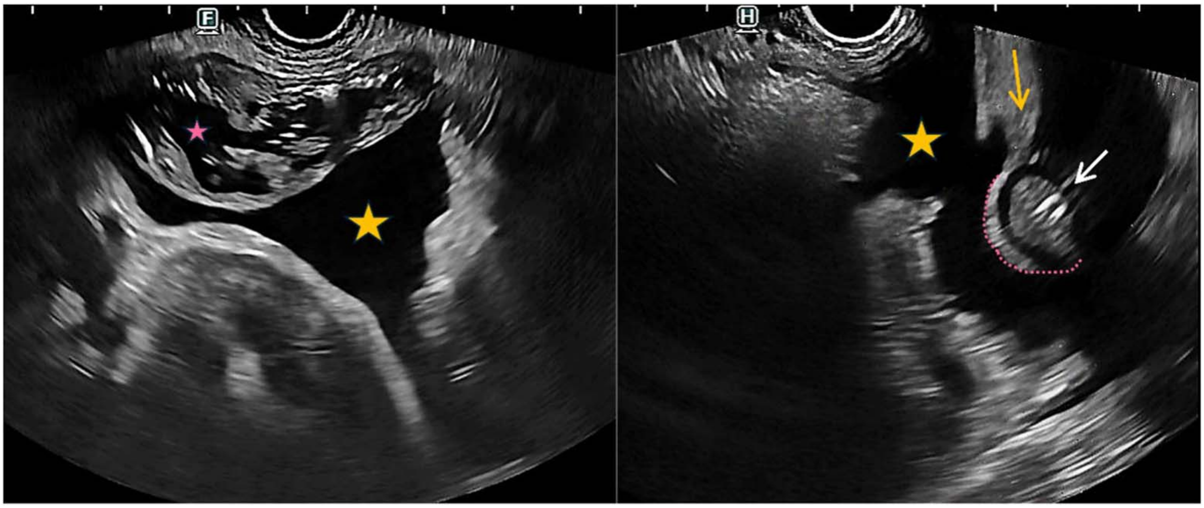

FIGURE 1. EUS appearance of jejunal loops (pink star on the left and pink dotted line on the right) surrounded by a large volume of ascitic fluid (yellow star). On the right, the loop, with its stretched mesentery (yellow arrow), and containing the orojejunal tube (white arrow) fluctuates inside a large volume of ascites without apposing to the gastric wall.

A LAMS diameter of 15 mm or more is usually suggested; however, to be compared with surgical anastomoses, a 20 mm LAMS is preferred[28,31] since comparative data suggest a better complete diet tolerance and a reduced reintervention rate when using 20 mm (vs. 15 mm) LAMS.[32,33]

General Principles

Successful completion of an EUS-GE depends on several crucial steps (Table 1).

These can be divided into: (1) EUS-guided identification of the target small bowel loop; (2) adequate loop distention; and (3) stabilization of the loop for LAMS insertion. Ideally, the technique should be as simple as possible, with the fewest number of devices and exchanges.[1]

One Loop or that Loop

Most experts prefer to target the duodenojejunal transition at Treitz ligament for EUS-GE. This area is typically close to the posterior wall of the stomach and it is rather fixed, with limited mobility, reducing the risk of losing ultrasound coupling during LAMS insertion. However, EUS-GE anastomoses are sometimes deployed toward the fourth portion of duodenum or in the jejunum just beyond the Treitz ligament. Despite offering technical convenience, this location might not provide the best clinical outcome, particularly in patients with pancreatic cancer, as disease progression can pose a considerable risk of food retention in the duodenum and potentially lead to anastomosis malfunction.

Moreover, if surgical revision is needed, accessing the area of Treitz ligament can be more challenging, complicating the revision and repair of any potential tissue or organ

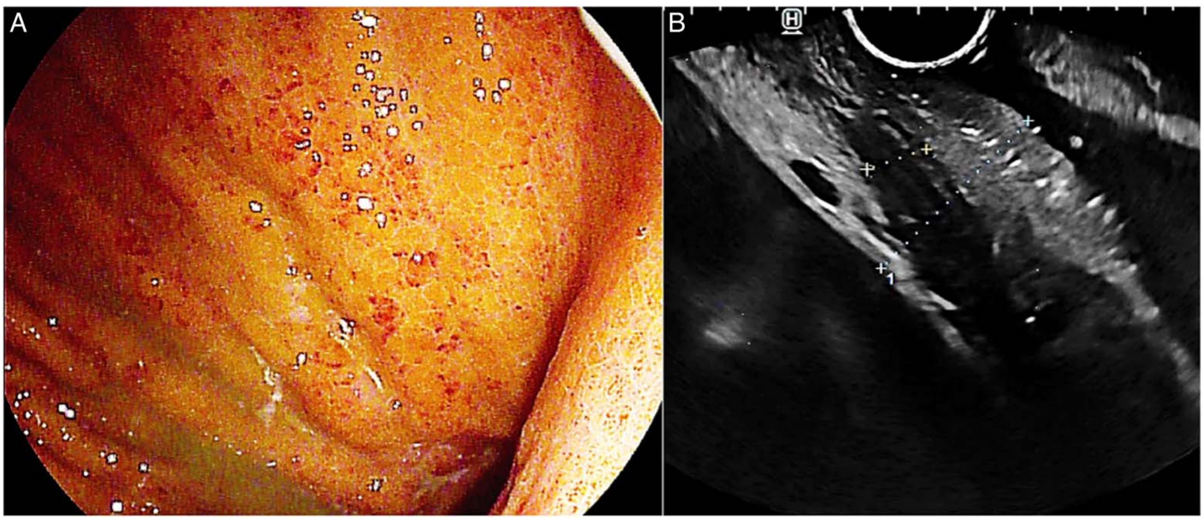

FIGURE 2. Endoscopic (A) and EUS (B) appearance of a diffuse neoplastic infiltration of the gastric wall in a context of linitis plastica. On the EUS image, the black (hypoechoic) layer (smaller dotted line) represents a significantly thickened muscularis propria, while the longer dotted line represents the total thickness of the gastric wall, exceeding 1.5 cm (normal values below 3 to 5 mm).

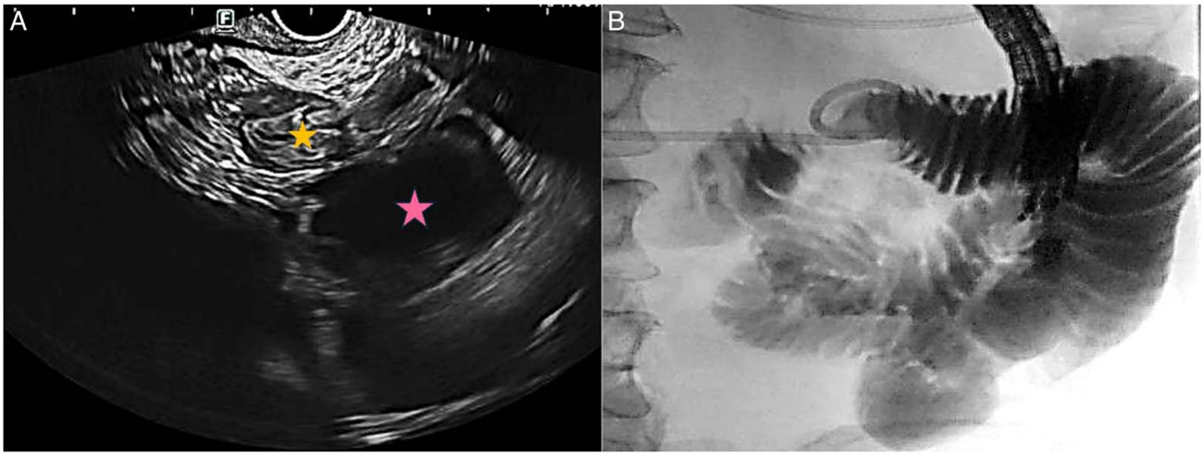

FIGURE 3. Enteral loop interpositions. A, EUS appearance of an interposed bowel loop (yellow star) between the gastric wall and the target jejunal loop (pink star) despite. B, Adequate distension of the jejunal loops, as demonstrated by the radiologic appearance of convoluted contrast-filled small bowel loops.

damage. Finally, the commonly held belief that the Treitz ligament is a stable and constant anatomic landmark is unsubstantiated, as anatomic and pathologic studies define 4 different types of Treitz ligament, each with varying extents and relationships to the duodenojejunal junction.[34]

Therefore, the endoscopist should target a location slightly distal (between 5 and 15 cm) to the Treitz angle toward the jejunal side (Fig. 5), thus potentially providing anastomosis that last longer and result in better clinical outcomes.

Furthermore, this location might even allow the use of the EUS-GE LAMS to access the papilla if subsequent ERCP is needed, for instance to revise a previously placed biliary self-expanding metal stent (SEMS).[35] However, if a second downstream stenosis is suspected, a more distal EUS-GE should be considered, even beyond the 15 cm threshold, provided that local expertise and suitable accessories are available.

All these considerations are not just speculative, as any technique, especially balloon-assisted ones allow endoscopists to target precisely confined area.

A direct comparison of EUS-GE placed at the Treitz ligament versus more distal locations is pending evaluation by prospective studies and RCTs.

Tricks for Crossing the Stenosis With a wire

"Assisted" EUS-GE techniques rely on passing a guidewire through the stenosis. The guidewire position helps define the duodenal anatomy, including potential malrotations. In nonwire-guided EUS-GE, direct needle puncture of the presumed target small bowel might result in a long-bypassed limb or even an unintentional gastrocolonic anastomosis.

A long (450 cm) hybrid guidewire is advanced deep into the jejunum, either directly or preferably through a soft cannula (such as a ball tip or a double-lumen cannula) or a sphincterotome, using either a forward or side-viewing endoscope. Occasionally, a duodenoscope may provide better visualization and cannulation of angulated strictures at the junction between the second and third jejunal portions.

In extreme circumstances, a cap-assisted forward-viewing endoscope (sometimes a pediatric colonoscope in case of distal stenoses; Fig. 4) or a hydrophilic angled wire may be used to negotiate the tight stricture.

Gentle manipulation is crucial to avoid excessive trauma to the tumor, as bleeding can obscure vision and complicate further manipulation.

The use of a double-lumen cannula facilitates simultaneous contrast injection to delineate the stricture. In some cases, bending a sphincterotome or inflating a large Fogarty balloon inside the lumen can help prevent the guidewire from looping in the duodenal folds. Balloon occluded contrast injection (using 20 mm extraction balloons) can aid in visualizing the viable tract through the stenosis.

Clinical Relevance of the Orojejunal Tube

An orojejunal tube (OJT) should typically target the first jejunal loop. Depending on the technique used, the first jejunal loop will contain either the pigtail of the catheter (Fig. 5A) or the space between the 2 balloons of a double-balloon catheter (Fig. 5B).

The OJT aids in (1) ensuring the correct identification of the target; (2) stabilizing the position of the loop in relation to the stomach wall; (3) ensuring controlled distention of the bowel loop before LAMS placement to mitigate the risk of stent misdeployment and to prevent placement in an incorrect location [such as proximal to the stenosis or too distally up to a type IV misdeployment[36] (ie, gastrocolostomy)].

In addition, upon LAMS release, the OJT also assists in checking the proper placement of the LAMS by allowing the "contrast bypass confirmation" (see "Reading the Sign" section).[37]

The Best Operative Window

LAMS placement in EUS-GE relies on electrocautery-guided advancement through both the gastric and jejunal walls, requiring an adequate operative space in the jejunum for distal flange deployment. Given these points, the optimal operative window should feature the shortest possible interluminal distance (preferably < 5 mm) and an ideal operative space of 4 cm for a 20 mm LAMS (Fig. 6A). This is best obtained with an oblique loop course, ideally aligned with the scope's operative channel direction. Conversely, an unsuitable window is characterized by a transverse loop

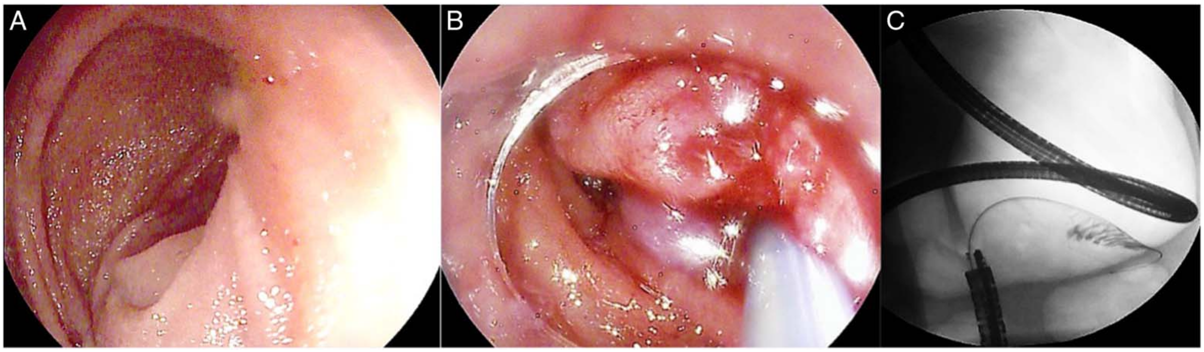

FIGURE 4. Use of a pediatric colonoscope to overcome a tight distal malignant duodenal stenosis at the Treitz ligament. A, Endoscopic appearance of the duodenal angulation upstream from the stenosis, preventing guidewire advancement. B–C, Negotiation of the stenosis using a cap and a catheter, enabling the injection of contrast media to radiologically visualize the stenotic tract.

direction, excessive interluminal distance, and interposition of vessels, thick connective tissue (omentum), or other visceral structures such as collapsed loops (Fig. 6B).

Power Settings

Among all EUS-guided procedures performed using LAMS, EUS-GE is by far the most technically challenging and hazardous, since the small bowel is a nonadherent, highly mobile target with a narrow lumen collapsing with peristalsis and containing air. Leakage of bowel contents into the peritoneal space can have disastrous consequences; it is therefore critical to pay meticulous attention to the electrocautery setup and settings.

First, the grounding pad should be checked for proper adherence and placed as close to the abdomen as possible. Next, use of pure-cutting current with high effect and power is essential. Using the VIO 300 D (ERBE, Tübingen, Germany), setting up the effect (up to 7) and wattage (up to 120) may be necessary. Using the VIO 3, the generator will automatically use as much or little power as needed, dependent upon wall thickness, pad placement and technique. Most widespread adopted setting is Autocut with effect 6.

Before applying current, it is crucial to extend the sheath adequately to observe the orientation and trajectory. Excessive pressure should be avoided both before (eg, tenting) and during current activation to ensure the highest current density at the tissue contact point, thereby minimizing resistance. Applying pressure increases the tissue surface area and requires more power for transection. Instead of applying excessive force it is preferable to gently advance the catheter across the wall, relying on energy rather than mechanical pressure. Generally, 1 to 2 seconds of electrocautery are expected to be used for a successful penetration.

Tricks for LAMS Release

Each flange of the LAMS should be deployed sequentially, allowing for adjustments in position as needed. Incremental distal flange deployment (ie, starting distal flange release, then unlocking and pushing the catheter further, and subsequently resuming flange deployment, sometimes repeating this process multiple times before full deployment) may prove beneficial in situations where

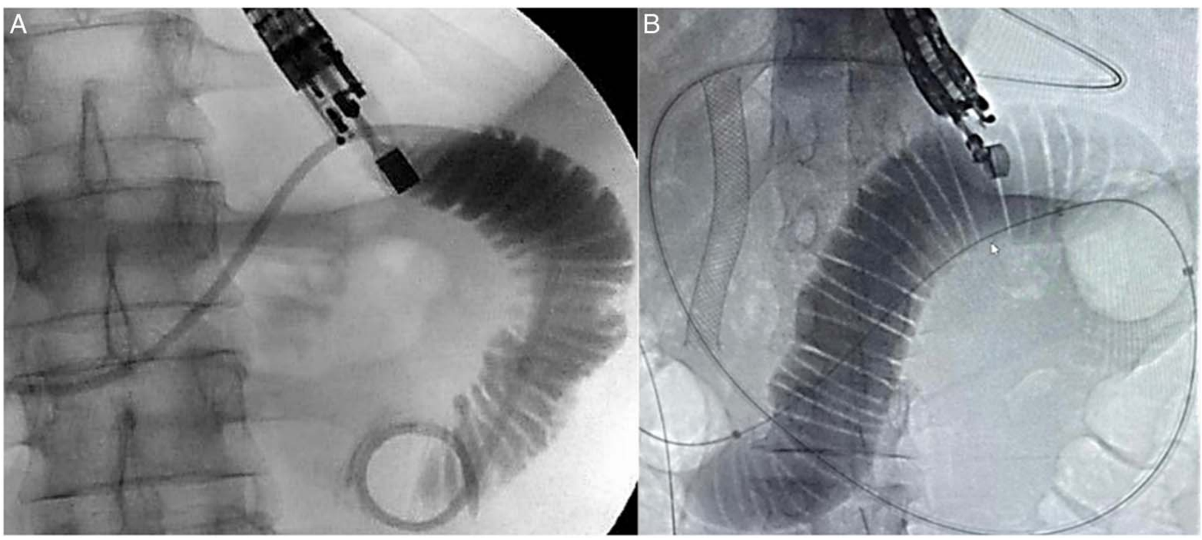

FIGURE 5. Radiologic identification of the target small bowel loop filled with contrast media. A, Jejunal loop containing the pigtail-tip of the OJT during a Wireless EUS-GE Simplified Technique (WEST, see section 5.e). B, Jejunal loop distended between the 2 balloons of an EUS-guided double-balloon-occluded gastrojejunostomy bypass (EPASS, see section 5.f).

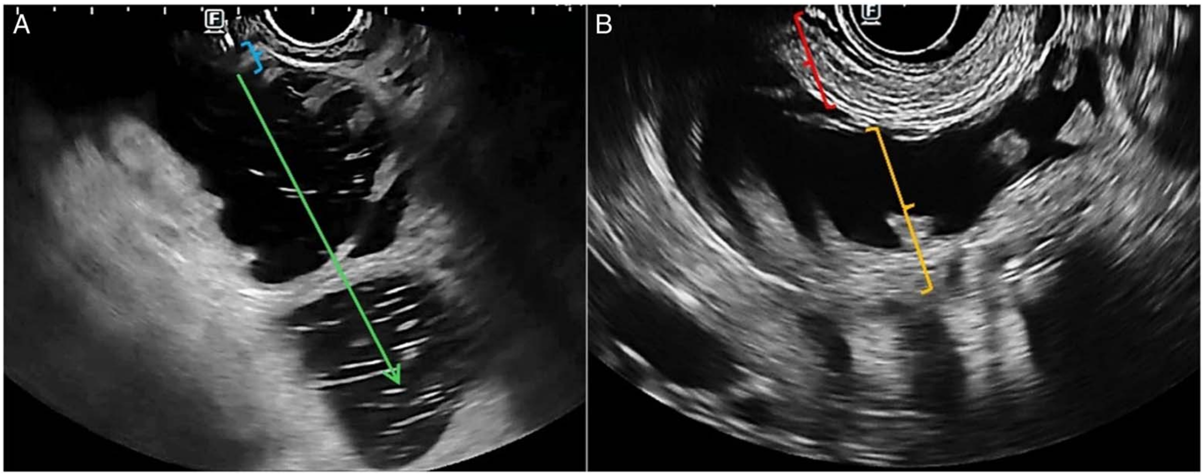

FIGURE 6. EUS operative windows. A, Ideal appearance of the target jejunal loop, with adequate operative space (> 4 cm) for LAMS deployment (green arrow) and short (< 5 mm) interluminal distance (blue bracket). B, Inappropriate window for EUS-GE showing a loop with an excessively transverse course, an insufficient caliber for safe LAMS deployment (yellow bracket), and excessive interluminal distance to be transversed (red bracket).

landing space is limited and deep catheter advancement is challenging.

When the target cavity lacks sufficient space for distal flange deployment, the "push technique" can be used. This technique involves first advancing a guidewire into the cavity through the catheter, fixing the delivery sheath with the elevator, and then advancing the inner catheter over the guidewire beyond the sheath to deliver the distal flange (Video 1, Supplemental Digital Content 1, http://links.lww.com/JCG/B269). The use of a guidewire can facilitate further passage of the catheter system when space is limited. As the outer catheter is retracted to expose the flanges, the innermost catheter component remains unconstrained and highly flexible, conforming to the target space's margins, thus allowing for further advancement without displacing the target.

To appose the 2 lumens, after deploying the distal flange, the catheter is retracted pulling the flange toward the stomach wall until the shape of the flange changes and the inner catheter deviates toward one side of the flange (Fig. 10A).

At this stage the release of the proximal flange can be performed under endoscopic guidance. However, most experts prefer the intrachannel release technique[37]: with the scope tip adherent to the wall and the catheter locked, the proximal flange is fully deployed inside the operative channel of the scope. The endoscope tip is then slightly retracted from the stomach wall, using tip deflection and rotation, and eventual minimal scope withdrawal, and finally the catheter is pushed to let the proximal flange out of the scope.

If the distal flange does not fully open, the position of the elevator should be checked to ensure it is completely open. Then, inserting a guidewire into the bowel can help retain access, followed by manipulating the sheath with to-and-fro movements to facilitate complete opening. If this approach fails, continue slowly withdrawing the sheath, as intended for proximal flange release.

Reading the Signs

To confirm proper LAMS advancement and placement, the endoscopist can rely on the observation of specific

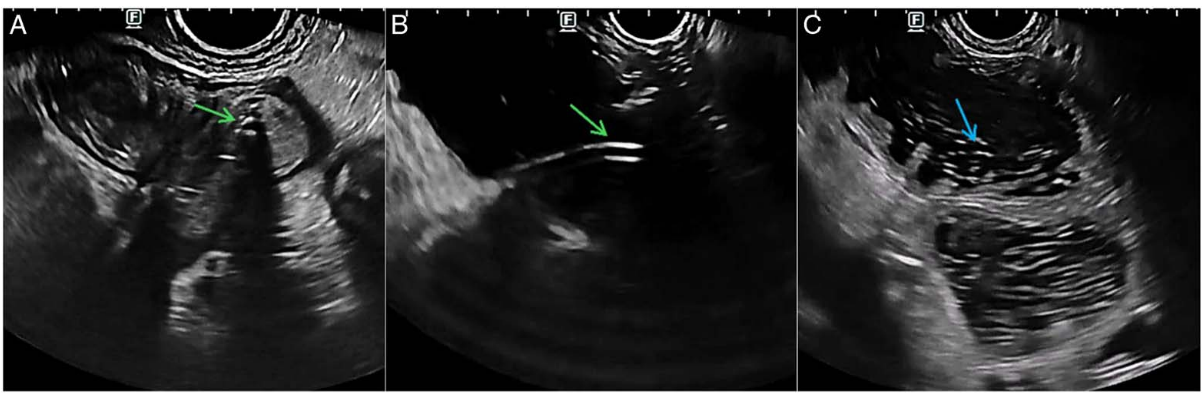

FIGURE 7. Endosonographic identification of the target jejunal loop. A–B, Visualization of the OJT tip inside the bowel loop lumen (green arrows) before (A) and after (B) fluid injection. C, Fluid turbulence within the bowel loop caused by saline injection through the OJT (blue arrow).

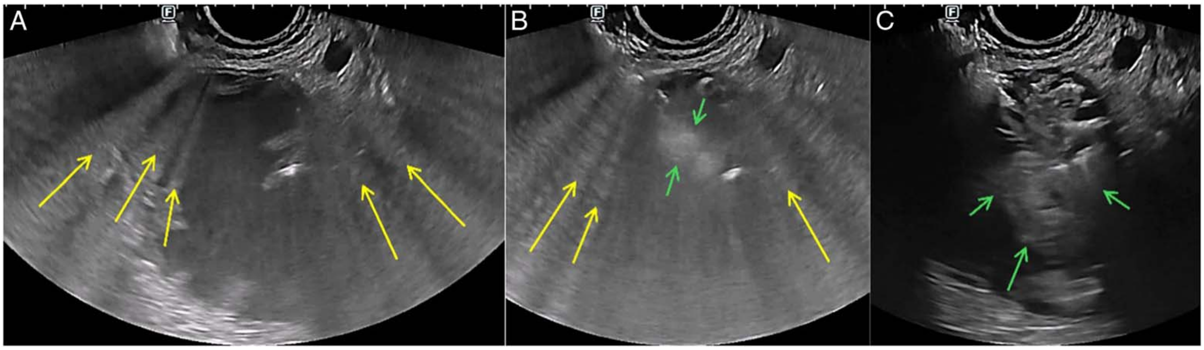

FIGURE 8. A–B, Application of current through the electrocautery-enhanced LAMS causes the appearance of image artifacts (yellow arrows). B–C, "Boiling water effect": the perturbation of water molecules inside the intestinal loop lumen as they interact with the electricity passing through the electrocautery tip should be visible (green arrows) starting during current application (B) and progressing after the cessation of current application (C).

endosonographic, endoscopic, and radiologic signs. When performing a EUS-GE, it is crucial to ensure that the distended loop under observation is the intended target. While there may be no doubt about identifying the target enteral loop when using a double-balloon catheter, the correct loop can also be recognized by endosonographic visualization of the OJT catheter itself, even inside a nondistended loop (Figs. 7A, B) or by observing a fluid turbulence within the bowel loop following saline injection through the OJT (Fig. 7C).

To confirm the electrocautery-enhanced advancement of the LAMS inside the jejunal loop, the tip of the catheter should produce the so-called boiling water effect (Fig. 8C). This effect, characterized by fluid perturbation inside the loop occurs when the tip of the cautery-enhanced catheter contacts the fluid, causing movement of the water particles due to the electric current.

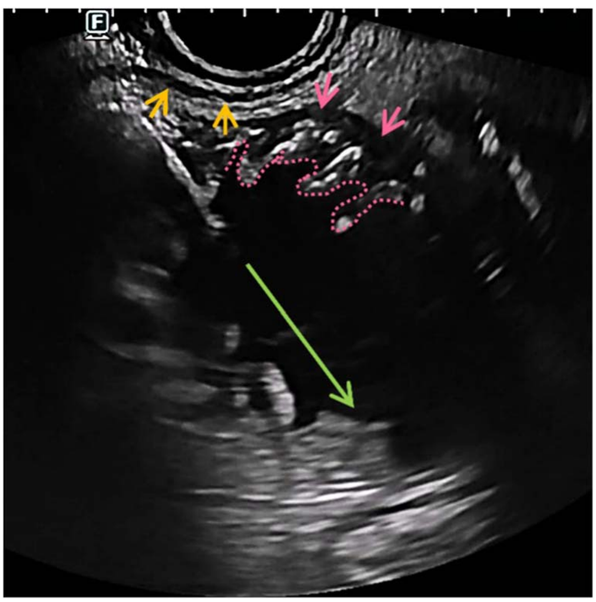

FIGURE 9. Advancement of the LAMS catheter inside the target loop along the longitudinal axis (green arrow) should not perturbate the stable apposition of the gastric (yellow arrows) and jejunal (pink arrows and dashed line) walls.

As some authors refer to the "cloud effect" or "smoke sign" to describe the visual changes caused by current application, the "boiling water effect" should not be confused with EUS image artifacts produced by cautery itself (Fig. 8A). The boiling water effect should appear behind the image artifacts and continue spreading after the cessation of current application (Fig. 8C).

At this point, the catheter can be advanced as deep as possible, striving to maintain acoustic coupling. If the visibility of the distal end of the catheter is lost while advancing it deeper, it is still important to ensure that the jejunal wall remains attached to the gastric wall upon catheter insertion (Fig. 9).

After releasing the distal flange, the catheter is retracted to appose the gastric and jejunal walls until the inner catheter deviates toward one flange side (Fig. 10A). At this stage, the LAMS should be visible inside the loop, clearly surrounded by fluid and the jejunal walls (Fig. 10B). If this is not observed, a type I to II misdeployment is likely (Fig. 10C).[36,38]

If blue dye was used for jejunal inflation, a "blue stream" of dyed fluid flowing through the LAMS after release of the proximal flange suggests proper stent positioning (Fig. 11). In case of doubt, proceed to the following sign.

Upon LAMS release, an additional sign of correct placement is the "contrast bypass confirmation." This involves injecting contrast through the OJT and then following its passage through the LAMS into the stomach by applying aspiration through the echoendoscope (Fig. 12A). Conversely, in case of misdeployment, the contrast cannot be aspirated (Fig. 12B). In this eventuality, the OJT also helps excluding clinically significant contrast leaks from an eventual jejunal enterotomy, allowing for the removal of the misplaced LAMS and the performance of a new EUS-GE.[38]

Procedure Step-by-Step: The Wireless Simplified Technique (WEST)

The Wireless EUS-GE Simplified Technique or "WEST" involves free-hand LAMS insertion using an OJT to inflate the jejunum.[28,39–42] The advantages of this technique lie in its standardized approach, which eliminates the need for additional guidewires or finder needles, and involves the following steps (Video 2, Supplemental Digital Content 2, http://links.lww.com/JCG/B270).

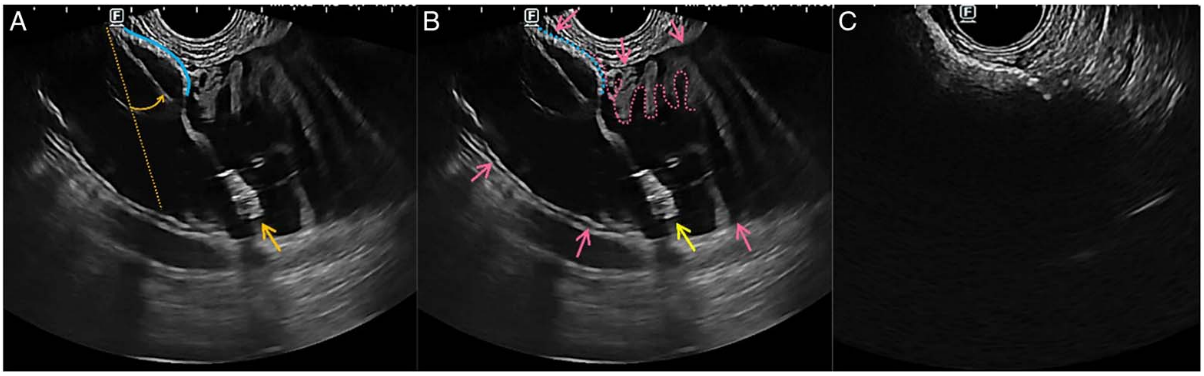

FIGURE 10. EUS signs of correct (or incorrect) distal flange placement. A, Catheter deviation (yellow arrows) toward the flange side (blue line) upon retraction of the catheter, following distal flange release. B, When the catheter is retracted to appose the 2 walls, the LAMS flange (blue line) and catheter tip (yellow arrow) should be visible inside the loop, defined by the jejunal walls (pink arrows) and folds (pink dashed line). C, EUS view of the distal LAMS flange, not surrounded by fluid, and with no visibility of the jejunal walls or catheter tip inside the jejunal loop is suggestive of stent misdeployment.

Orojejunal Tube Placement

Using mostly a forward-viewing scope, a guidewire is placed across the stricture. A standard catheter or a sphincterotome aids in successfully manipulating the guidewire toward the desired location and contrast injection can be used to confirm adequate positioning. A 7, 8.5, or 10 Fr OJT is then usually inserted over the guidewire and placed after the Treitz ligament. Subsequently, the endoscope is extracted under fluoroscopic guidance, ensuring the OJT remains in place and avoiding excessive intragastric looping.

FIGURE 11. Endoscopic vision of the "blue stream" of dyed fluid flowing through the LAMS, from the jejunal loop to the gastric lumen, confirming correct stent positioning.

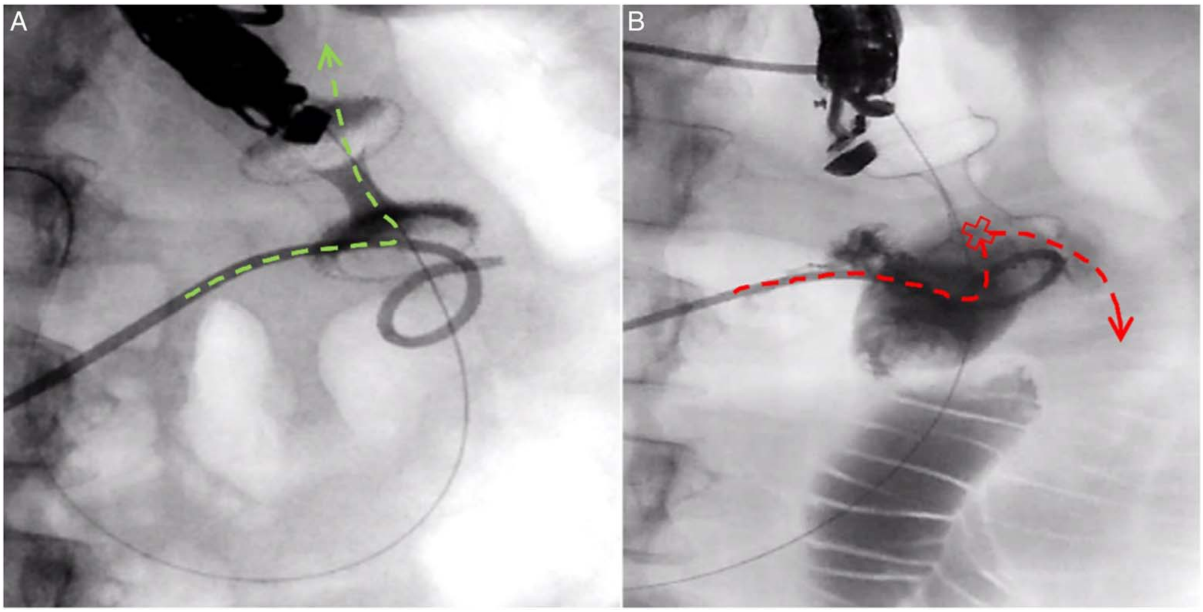

FIGURE 12. Using the OJT to assess correct LAMS placement. A, Injection of contrast media through the OJT results in correct aspiration through the LAMS into the stomach (green dotted arrow) in case of appropriate LAMS placement (contrast bypass confirmation). B, In case of misdeployment, contrast injected through the OJT cannot be aspirated into the stomach through the LAMS (red dotted arrow) and flows downstream; in this eventuality, contrast injection also helps excluding clinically significant contrast leaks from the jejunum.

Saline Instillation

Saline instillation can begin either as soon as the scope is extracted or after EUS identification of the OJT inside the jejunal loop (Fig. 7A), to prevent overinflation of the small intestine. Administering antispasmodics, such as hyoscine butyl bromide/butyl scopolamine or glucagon, helps preventing downstream fluid dispersion and distend the target loop.[1] Generally, 300 to 500 mL of saline is required to achieve adequate enteral distension, though exceptionally higher volumes may be necessary.

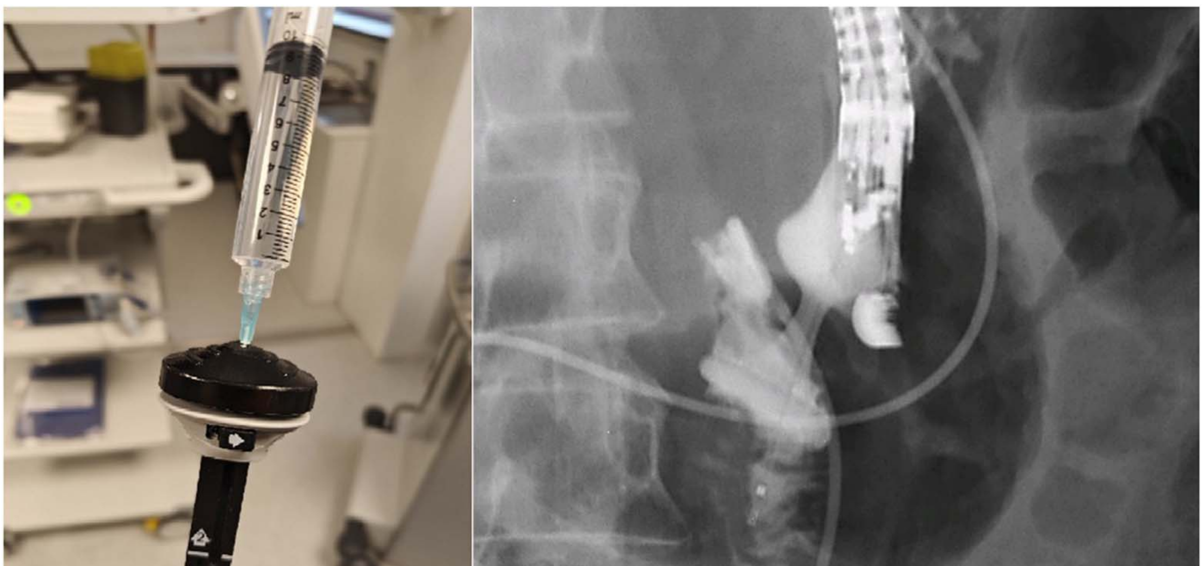

FIGURE 13. Contrast injection through the small operative channel of the LAMS catheter through an intramuscular syringe allows injection of contrast at the tip of the device to confirm correct stent positioning.

EUS Identification and Optimization of Scope Positioning

The EUS scope is inserted beside the OJT, carefully avoiding its dislocation. Fluoroscopic guidance of the scope tip toward the Treitz and the OJ often aids in quickly finding a suitable bowel loop in the optimal position. Once an adequately dilated target is obtained on EUS, enteric loop orientation and trajectory distance should be optimized.

A longitudinal loop orientation is generally preferred (Fig. 6A), while tangential or oblique angles should be avoided whenever possible, aiming for the shortest distance without intervening structures. If no safe trajectory can be identified, changing the patient's position to a left lateral position may help. In rare cases of malignant GOO where LAMS insertion is deemed unfeasible or unsafe, ES should be considered a viable option.

LAMS Insertion

After successful small bowel access using pure-cutting current, the LAMS is deployed in a stepwise manner as previously described.

Confirmation of Adequate Positioning

Following LAMS release, efforts should be made to ascertain adequate positioning. This can be achieved by visualizing both flanges inside the target structure on EUS, by confirming adequate flange opening on fluoroscopy or by through-the-LAMS visual confirmation of the presence of small bowel mucosa. Contrast can also be injected to rule out any leakage, using either the OJT or by injecting contrast through the delivery device using an intramuscular needle or a small intravenous cannula (Fig. 13).

Once adequate LAMS positioning is confirmed, the OJT is extracted under fluoroscopic control.

Procedure Step-by-Step: EUS-Guided Double-Balloon-Occluded Gastrojejunostomy Bypass (EPASS)

The EPASS technique (Fig. 14) is a device-assisted method used for performing EUS-GE (Video 3, Supplemental Digital Content 3, http://links.lww.com/JCG/B271).

Orojejunal Tube Placement

The EPASS technique involves the peroral insertion of a double-balloon occluder beyond the stricture to occlude a segment of proximal small bowel near the stomach, allowing for targeting under EUS guidance.[22,43]

Initially, a gastroscope is inserted to the site of obstruction. A guidewire is then navigated through the stenosis and advanced deeply into the proximal jejunum.

After removing the gastroscope, a double-balloon occluder [open-tip type 16F ileus tube, 16DBR-3000T0 (800-001-1889), Tokyo Medical University type; Create Medic Co. Ltd, Yokohama, Japan] is introduced over the guidewire and advanced beyond the duodenal-jejunal flexure using an overtube (ST-SB1S, Olympus Medical, Japan).[43] The 2 balloons of the occluder, positioned ~20 cm apart around the Treitz angle, are inflated with 30 to 40 mL of normal saline and contrast.

Small Bowel Inflation

Following balloons inflation, the occluded proximal small bowel segment is distended with a mixture of normal saline, contrast, and indigo carmine, totaling around 350 to 400 mL, injected through the dedicated channel of the occluder. The overtube is then pulled out.

Identification of the Target Loop

Subsequently, a linear echoendoscope is inserted into the stomach, and a distended loop of small bowel located posterior to the body of the stomach is identified. Direct puncture of the target small bowel is performed using the cautery-enhanced delivery system of a LAMS. Finally, the LAMS is deployed in the usual manner between the stomach and the small bowel.

A Novel Through the Scope Exchangeable Dual Balloon Catheter

Recently, a through the scope exchangeable dual balloon catheter (TTS-DUBX; Naja, Chess Medical, Canada) has been developed.[44] The TTS-DUBX has two 50 mm balloons set 12 cm apart for bowel occlusion and distension. Its 10 Fr diameter allows for through-the-scope insertion while its detachable proximal hub allows for through-the-scope exchange (Fig. 15). Ultimately, the aim of this proprietary catheter is to optimize bowel distension to facilitate LAMS deployment while being inserted and exchanged in a similar efficient manner as with the OJT approach. The TTS-DUBX has obtained FDA clearance as an enteroclysis catheter and is pending commercialization.

When Stenosis is Not Crossable—The Direct Puncture Technique

In rare cases, duodenal obstruction may be too tight to allow wire access and catheter placement into the downstream bowel (Fig. 16A). This adds complexity to the procedure, as it prevents bowel filling and distention of the target lumen.

However, bowel distension can still be achieved using the direct puncture technique (Video 4, Supplemental Digital Content 4, http://links.lww.com/JCG/B272). In this approach, the loop is punctured with a 19G needle, and fluid is instilled through the needle to distend the lumen (Fig. 16B) aided by the use of antiperistaltic drugs.[45]

Although this technique does not achieve the same degree of distension as catheter-assisted methods, it is valuable when catheter advancement into the bowel is not feasible or when the small bowel is inaccessible due to previous surgery or radiation therapy. It can increase the technical success of EUS-GE and may represent the only endoscopic alternative, as placement of ES inherently requires crossing the stenosis.

Once the small bowel loop is adequately distended, the needle is removed, and the LAMS is quickly advanced. The LAMS should be ready for advancement through as soon as the needle is removed to ensure deployment before the luminal fluid dissipates.

In some cases, endoscopists may prefer to perform over-the-wire LAMS placement (Fig. 16C).

To Dilate or Not

There is considerable debate regarding the role of LAMS dilation following an uneventful EUS-GE. Some operators routinely perform LAMS dilation (Fig. 17), arguing that it stabilizes the final position of the LAMS, potentially reducing the risk of migration, fluid leakage, bleeding from the fistula margins, and potentially enabling faster resumption of oral intake.[7]

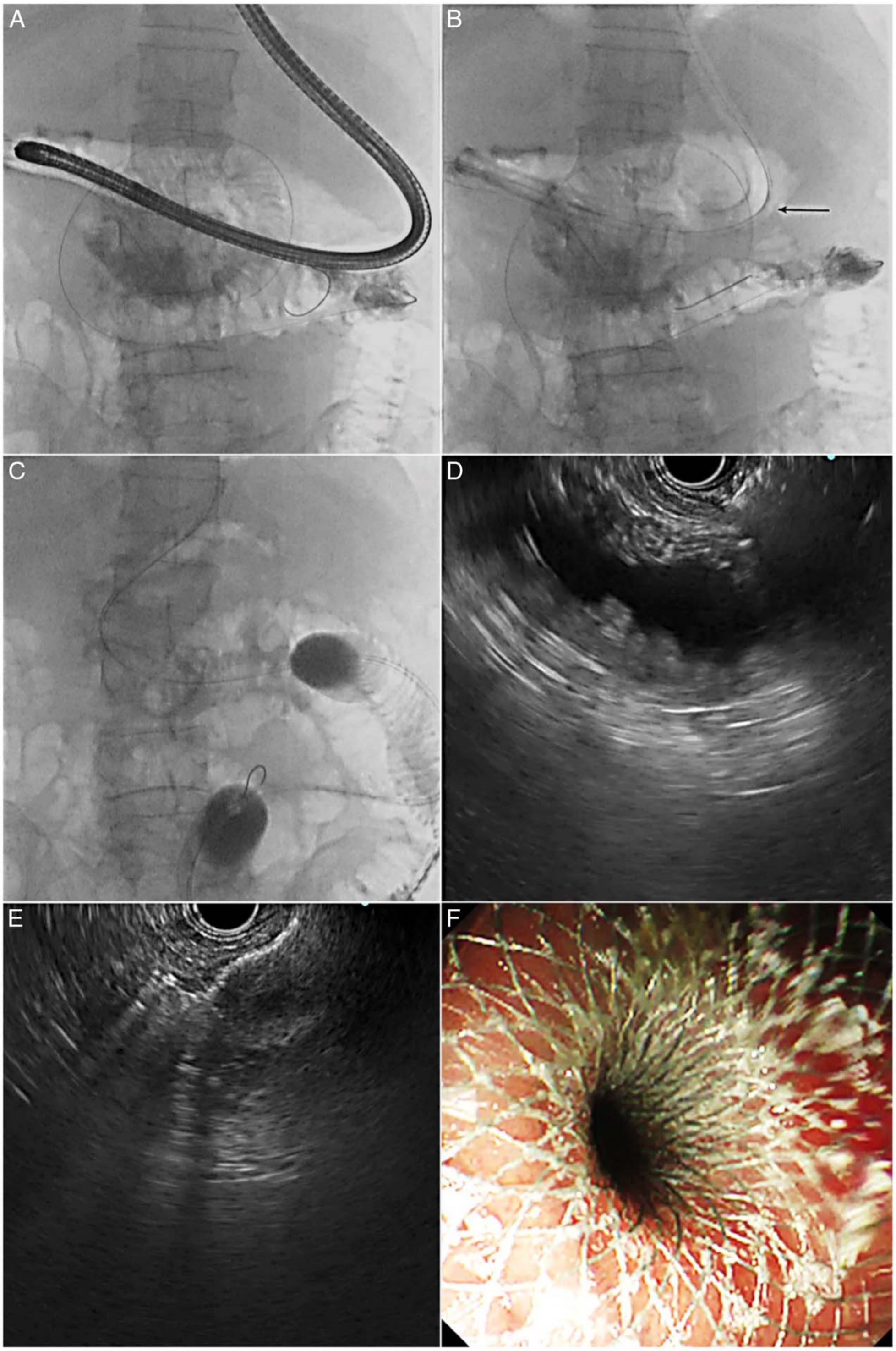

FIGURE 14. EPASS technique. A, Insertion of a gastroscope to the site of obstruction and navigation of the stenosis with a guidewire, which is inserted deeply into the proximal jejunum. B, Removal of the gastroscope leaving an overtube in place, through which an over-the-guidewire double-balloon occluder is advanced beyond the duodenal-jejunal flexure, avoiding gastric looping. C, Inflation of the 2 balloons of the occluder with saline and contrast and distension of the interposed bowel segment with a mixture of saline, contrast, and indigo carmine. D, EUS image of the distended small bowel loop. E, Direct puncture of the target loop using a cautery-enhanced LAMS and subsequent release of the distal flange. F, Intragastric release of the proximal flange of the LAMS. Please note that in image D and E the transducer's "near point" is on the right side of the screen, contrary to the other images in this publication.

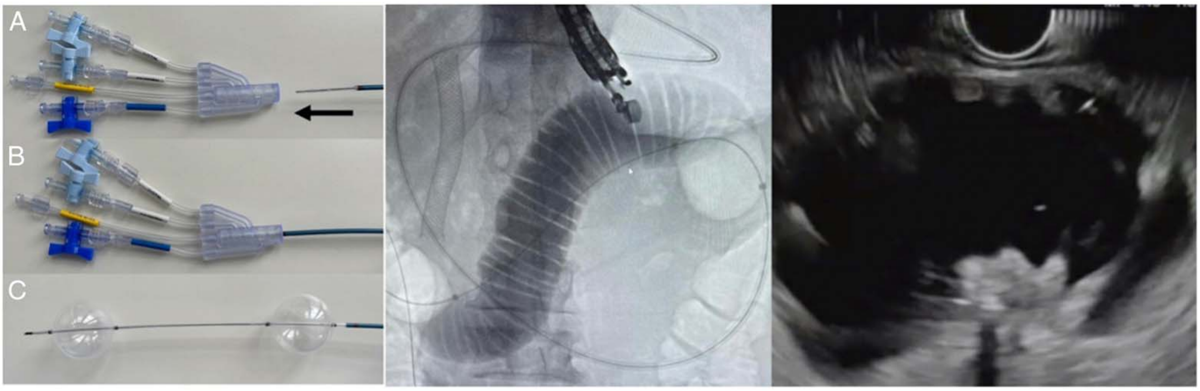

FIGURE 15. Through-the-scope exchangeable dual balloon catheter. A, The main difference of this device is that the "working hub" can be detached from the tube. This allows through-the-scope advancement of the catheter, detachment of the hub to allow extraction of the scope while maintaining the catheter in the jejunum, and ultimately reattachment of the working hub which has 3 different ports for inflation of the 2 balloons and injection of fluids between them. B, Radiologic appearance of a jejunal loop isolated between the 2 balloons and distended by saline mixed with contrast media. C, EUS view of the distended jejunal loop.

However, this additional maneuver carries a theoretical risk of LAMS misplacement[7] and increases procedural costs.

Conversely, nondilated stents have much wider flanges and might therefore favor better serosa-to-serosa apposition, allowing anastomosis healing within 72 hours if free fluid is absent.

Despite these considerations, there is insufficient evidence supporting either strategy.[1] Comparative studies of spontaneous gradual dilation versus intraprocedural dilation are needed to support one strategy over the other.

Postprocedural Care

Available literature recommends early refeeding following EUS-GE.[7,21,40]

Most experts suggest that a low residue diet can be started within 24 hours from an uneventful procedure,[7,10,46] or even on the same day. However, a liquid diet might be cautiously preferred at day 0 if a reintervention is necessary (eg, to manage a postprocedural bleeding).

Due to the large volume of fluid injected in the small bowel during the procedure and the long fasting period usually preceding the intervention (which may cause constipation), an "optimized protocol" for postprocedural care has been described including: (1) administering a prokinetic drug on the evening of the procedure and (2) maintaining regular bowel movements, possibly with enemas or laxatives, to reduce the risk of postprocedural vomiting and facilitate early refeeding.[7]

LEARNING CURVE

Only 2 studies have assessed the learning curve for EUS-GE.[47,48]

Jovani et al[48] indicated that 25 cases were required to achieve proficiency and 40 cases to reach mastery for a single operator experienced in interventional EUS. This was assessed based on procedural time and analyzed using cumulative sum (CUSUM) analysis. The results were further corroborated by moving average graphs and sequential time-block analysis. Interestingly, all complications occurred during the first 39 cases, further strengthening the conclusion.

Tyberg et al[47] reported that 7 procedures were needed for efficiency. However, while both studies used procedural time and CUSUM analysis, the latter study had a significant variability in indications and endoscopic techniques, as well as different procedural time targets, which may account for the discrepancy in results.

Some authors have argued that use of procedural time is a suboptimal metric to assess the learning curve,[49,50]

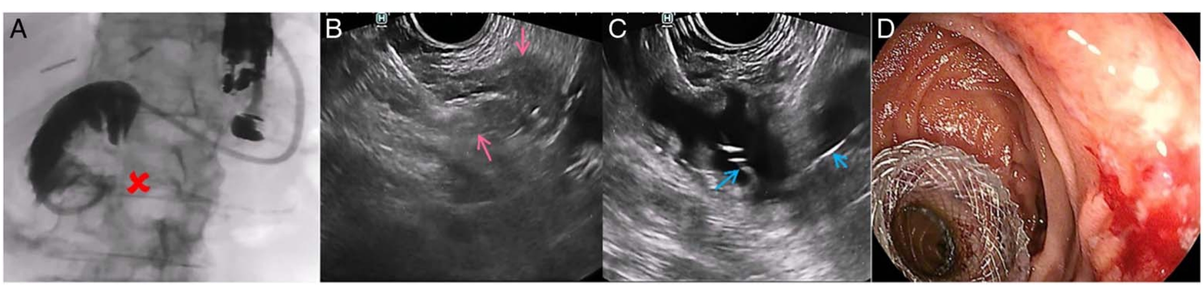

FIGURE 16. Direct puncture technique. A, In a patient with postsurgical anatomy, an OJT was placed across a first stricture, but was unable to pass a second tight stricture (red cross). B, A jejunal loop was therefore searched with an echoendoscope through the stomach and puncture with a 19 G needle; the target small bowel loop (pink arrows) is being distended through direct injection of saline through the needle (visible as hyperechoic turbulence inside the loop). C, A guidewire is advanced through the needle and can be visible inside the distended loop (blue arrows). D, LAMS successfully released between 2 postanastomotic jejunal loops to bypass a jejunal stricture.

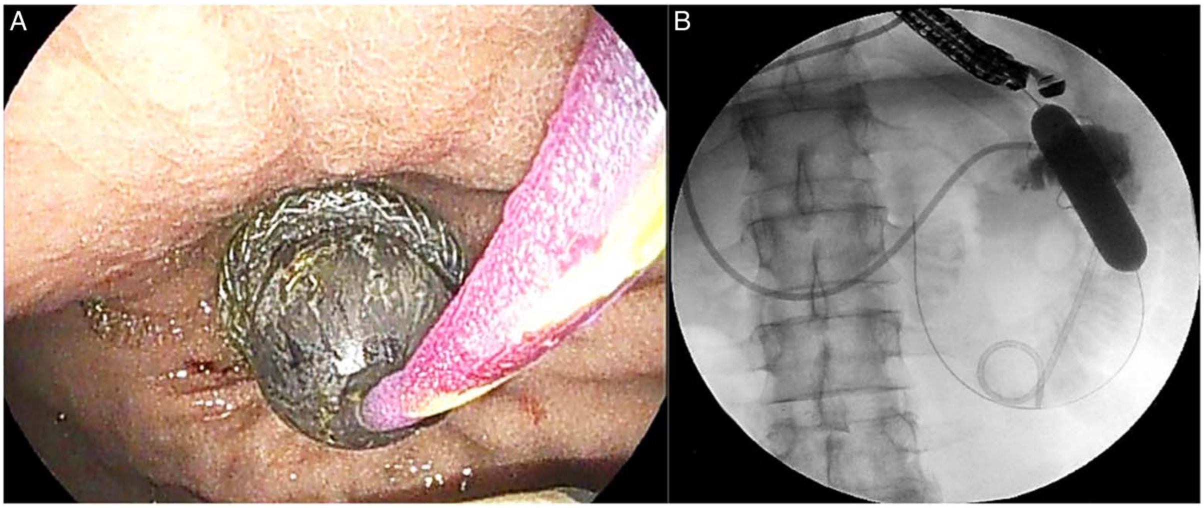

FIGURE 17. Endoscopic (A) and radiologic (B) vision of LAMS dilatation using a pneumatic balloon.

proposing that outcomes such as AEs could be more informative.[50–52] However, a very large number of patients is needed for such a study,[51] likely achievable only through multicentric, international collaborations. In their absence, procedural time remains a good metric to define proficiency/mastery and, while imperfect, it provides adequate guidance for subspecialty training programs and quality assurance.[53]

TROUBLESHOOTING COMMON ISSUES

Misdeployments

Stent misdeployment occurs when a flange of the LAMS is released in an incorrect location. It represents the most common cause of technical failure and AEs in EUS-GE. The incidence of misdeployment is around 10%,[33,36,42,54] and might depend on the operator's experience[36,48] and chosen technique.[42]

Signs suggestive of misdeployment, which should be promptly recognized, either on fluoroscopy or endoscopy, include pneumoperitoneum, extraluminal contrast leakage, absence of the "blue stream" sign upon release of the proximal flange (if dye was used), inability to visualize the small bowel lumen, or visualization of the peritoneum following stent deployment (Fig. 18).[28]

Classification

A retrospective study, including 467 patients from 16 tertiary proposed a classification based on the location of the proximal and distal flanges.[36] Misdeployments were classified into 4 types:

- Type I: deployment of the distal flange in the peritoneum and the proximal in the stomach, without evidence of enterotomy (ie, small bowel injury); (prevalence: 60%).
- Type II: deployment of the distal flange in the peritoneum and the proximal flange in the stomach, with enterotomy (prevalence: 30%).
- Type III: deployment of distal flange in the small bowel and the proximal flange in the peritoneum (prevalence: < 5%).
- Type IV: deployment of the distal flange in the colon and the proximal flange in the stomach, creating a gastro-colonic anastomosis (prevalence: < 5%).

Beyond this classification, an additional event (potentially referred to in the future as type V misdeployment) involves advancing the LAMS over both walls of a jejunal loop, resulting in the transfixation of the loop.

This might occur if the target loop in not properly distended or if the catheter is advanced with too much force while the image is distorted by the application of current. In such cases, the distal flange might end up deployed in the peritoneum, outside the loop.[55] Another possibility is

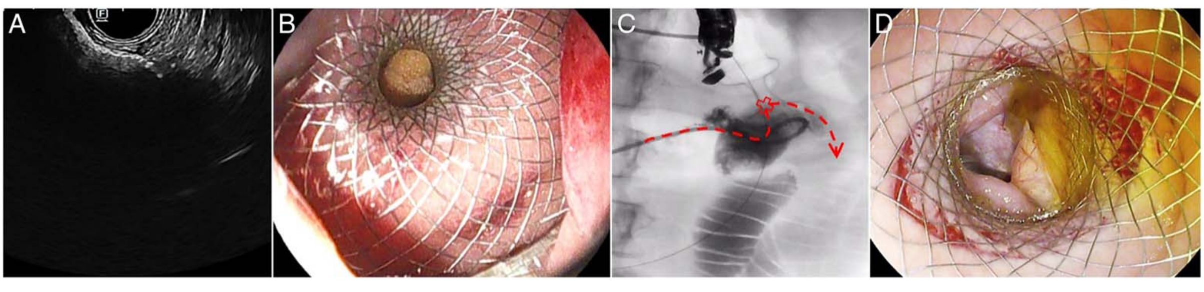

FIGURE 18. Signs of misdeployment with erroneous release of the distal flange of the LAMS inside the peritoneal cavity. A–C, Refer to the same case. A, Absence of the visualization of fluid and the jejunal walls surrounding the LAMS. B, Visualization of the peritoneum through the LAMS. C, Absence of the "contrast bypass confirmation." D, Visualization of the target jejunal loop inside the peritoneal cavity through a dilated LAMS.

transfixation of a collapsed and virtual loop intervening between the stomach and the target loop. This event may be more subtle and challenging to recognize during the procedure, potentially resulting in a delayed dislocation of the LAMS.

Possible Solutions

In most cases, misdeployment is a minor AE, as it can be successfully managed conservatively or endoscopically in nearly 90% of cases,[36] especially when recognized and treated intraoperatively. In the aforementioned study,[36] surgical management was required in 10% of patients with misdeployment (1.1% of the overall sample).[29]

However, particularly in fragile patients, misdeployment can lead to severe AEs, necessitating surgery, admission to the intensive care unit, or even resulting in death, despite attempts at endoscopic salvage.[28,56]

Type I misdeployments can usually be managed by stent removal, endoscopic closure of the created gastrostomy, and possibly redoing the EUS-GE (see video at reference[38]) thus avoiding surgery.

However, it is not always possible to clearly assess the presence of an enterotomy, and therefore distinguish between type I and type II misdeployments.

Injecting contrast through the OJT can help identify significant leaks from the jejunum,[38] but close monitoring and evaluation by a multidisciplinary team is still essential due to the risk of late or unrecognized perforation caused by thermal injury during stent deployment. If perforation occurs, the injury would be reclassified as type II.

For type II misdeployments, challenging endoscopic salvage techniques have been reported but a careful evaluation is required regarding their feasibility at centers with less expertise or resources.

Endoscopic management depends on whether a guidewire was preloaded and inserted into the jejunum before misdeployment.

If so, good options to consider include bridging with a through-the scope fully covered esophageal SEMS or inserting a second LAMS through the misdeployed LAMS into the target small bowel.[28,36]

However, as most experts suggest free-hand stent deployment, the guidewire is not routinely placed in the jejunum before misdeployment. In such cases, a Natural Orifice Transluminal Endoscopic Surgery (NOTES) approach with through-the-LAMS peritoneoscopy to reconnect the injured jejunum to the stomach has been described (Fig. 19; Video 5, Supplemental Digital Content 5, http://links.lww.com/JCG/B273).[57]

However, this NOTES salvage approach is more challenging with a standard upper endoscope[58] than with a double-channel upper endoscope[57] and locating the earlier enterotomy site may not be always possible. In addition, NOTES salvage of stent misdeployment should only be attempted if expertise and equipment are available. Otherwise, a surgical approach should be considered the primary option.

At the end of salvage maneuvers, fluoroscopic confirmation of the absence of contrast leak should be obtained from both the jejunal (through the OJT injection) and gastric side.

Needle decompression of the capnoperitoneum may be necessary, and systemic broad-spectrum antibiotics should be administered.[28]

For type III misdeployments, surgical management is recommended.

Type IV misdeployment (ie, gastrocolostomy) may be recognized intraprocedurally (Fig. 20) or as a late finding with postprandial diarrhea.

In most cases, this issue can be addressed endoscopically by removing the LAMS after allowing the fistula to mature for 3 weeks. Repair of the inadvertent gastrocolostomy can be performed with full-thickness endoscopic suturing,[28,36,59] and a new EUS-GE can be created.

Radiographic follow-up is recommended to document healing. Patients who fail endoscopic closure should be referred for surgical repair.

Regardless of the type of misdeployment and the success of endoscopic troubleshooting, engagement of surgeons is recommended in all patients, especially those with type II to IV misdeployments.

Other Adverse Events

Apart from misdeployment and perforation, other possible AEs include:

- Bleeding, luminal or extraluminal, can result from accidental injury to normal or abnormal vessels in the path of EUS-GE during deployment or cautery injury to the opposite jejunal wall, when the landing space for the stent is suboptimal.[60] These are usually mild or moderate events, often managed conservatively.[61,62] Most interposing bleeds

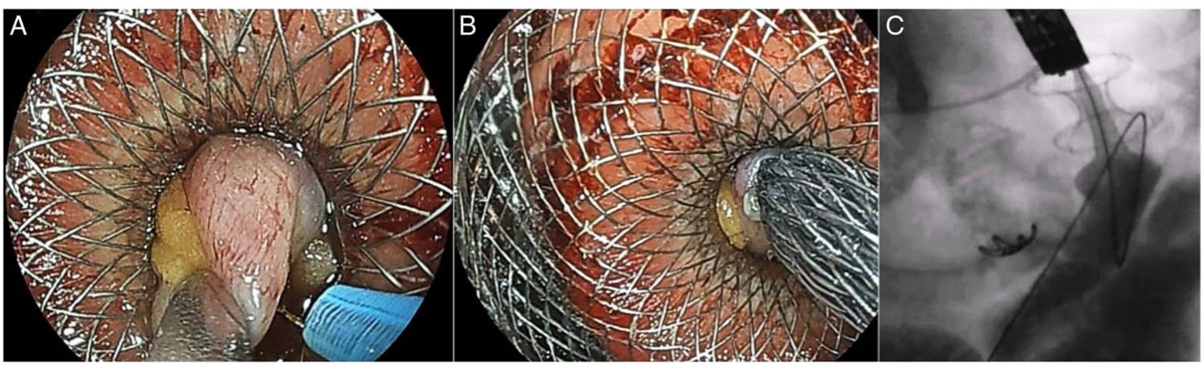

FIGURE 19. NOTES salvage procedure following a type II misdeployment. A, Through-the-LAMS peritoneoscopy, allowing to grasp the target jejunal loop with forceps and to perform an enterotomy using a precut knife. B, After loop cannulation with a guidewire, a new LAMS is advanced and released inside the misdeployed LAMS, stably reconnecting gastric and jejunal lumen. C, Radiologic confirmation of the correct LAMS-in-LAMS placement.

FIGURE 20. Type IV misdeployment (gastrocolonic anastomosis). A, EUS image showing a distended colonic loop interposition (yellow arrows) between the gastric lumen and the target jejunal loop (pink arrows). B, Endoscopic visualization of the colonic wall through the LAMS. C, Endoscope passing through the LAMS from the stomach to the transverse colon (yellow dashed line) instead of the jejunal lumen (pink dashed line).

are minor and stop due to the tamponade effect of expanding LAMS. Bleedings observed during the index procedure need to be identified and addressed though mechanical or thermal hemostasis, or simple epinephrine injection of the fistula either outside or through the meshes (Fig. 21).[1,7] Bleeding occurring on the jejunal side requires balloon dilation of the LAMS, evaluation with regular endoscope and eventually clipping.[60]

- Cholangitis has been anecdotally described following the procedure, likely related to high-volume backflow of instilled saline through a previously placed (and malfunctioning) biliary SEMS.[7,63]
- Postprocedural abdominal pain can be due to cautery induced injury of interposing omentum, even in an accurately placed LAMS. The subsequent inflammation causes peritonism which often subsides with analgesics and conservative measures.
- Aspiration pneumonia[1] is usually an anesthesia-related AE which can occur in the early phase of EUS-GE since the stomach remains atonic, especially in cases of chronic GOO, and particularly if the LAMS has not been dilated. For symptomatic patients, continuous nasogastric aspiration is advisable until gastric motility restarts.
- Long-term AEs might include tissue reactions (such as erosions, ulcerations, or granulation tissue) on the jejunal (Fig. 22A) or gastric (Fig. 22C) side of the LAMS, potentially contributing to stent dysfunction and GOO recurrence.[1,7] Stomal ulcers may occur due to the stent edge rubbing against the jejunal mucosa or gastric acid directly entering the jejunum. For those reasons, acid suppression is advisable and targeted EUS-guided vagus nerve ablation is speculated (as in surgery).

Although data on long-term indwelling are scarce, material integrity may cause late dysfunction of the stent in case of long-term placement (eg, in benign diseases). Therefore, a scheduled endoscopic check-up every 6 to 12 months might be recommended to verify the coating and position of the LAMS, allowing for prompt LAMS replacement or LAMS-in-LAMS insertion:

- Sustained blockage of LAMS can result from food bolus or foreign body impaction, and rarely tumor ingrowth (Fig. 22B), especially gastric malignancy, leading to recurrent GOO or upstream duodenum obstruction and afferent loop syndrome. The later can manifest with pain, cholangitis, or even pancreatitis and may require endoscopic reintervention and drainage of the afferent loop.

FUTURE PERSPECTIVE AND CONCLUSION

EUS-GE remains a promising endoscopic intervention that is still evolving. Reported technical and clinical outcomes to date are impressive, but practitioners face challenges in this area as well. No universally agreed upon or standardized technique exists for performing EUS-GE at this time, and there are significant differences in the approach to this procedure that are practiced in various centers around the world. Furthermore, the tools used to perform EUS-GE remain off-label at this time, that is, all of the devices used in this arena were devised for use in different contexts. It also appears likely that there is some degree of publication bias in the literature with regards to EUS-GE as positive outcomes or reports from larger centers are more likely to be submitted to journals while procedures with poor clinical outcomes or AEs are less likely to be

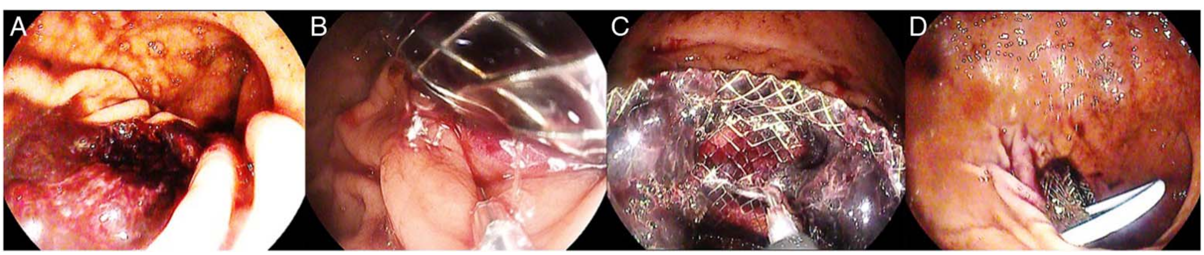

FIGURE 21. Endoscopic treatment of an active bleeding following EUS-GE. A, Clots and blood oozing from gastric side of the gastroenterostomy. B–C, Epinephrine injection in the margins of the fistula and through the mesh of the LAMS. D, Whitish appearance of the vasoconstricted mucosa after epinephrine injection; a coaxial double-pigtail plastic stent was placed to maintain patency of the LAMS in case of new clots.

FIGURE 22. Local tissue reactions. A, Mucosal erosions on the jejunal side of the LAMS. B, Tumor ingrowth through the LAMS mesh. C, Mucosal overgrowth over a long-term indwelling LAMS, contributing to a caliber reduction of the gastroenterostomy.

submitted to journals. AEs from EUS-GE are at an acceptable level, but the procedure carries intrinsic risks, hence the treating physicians should be aware of the challenges of creating intra-abdominal anastomoses and their management.

This paper has tried to bring on the table the technical expertise of world experts in this technique. However, future studies should aim to reach broader consensus on technical steps and compare different techniques, in an attempt to identify a standardized technical approach. Particular attention should be given to open technical questions, such as the need for LAMS dilation, the need for LAMS revision, the impact of the position of the LAMS on clinical outcomes, etc. Cost-effectiveness analyses, which currently suggest advantages over enteral stents and surgical gastrojejunostomy in terms of, respectively, reduced reinterventions and hospital stay/overall costs, require validation through multicenter, prospective studies across diverse health care settings. In parallel, standardized training protocols and competency benchmarks (eg, evidence-based procedural thresholds, curricula, and validated assessment tools) will be essential to ensure safe and reproducible implementation beyond expert centers. Future research should also investigate whether novel devices, such as the novel through-the-scope exchangeable double-balloon catheter, could facilitate easier distention, stabilization, identification and access of the target jejunal loop, thereby simplifying the learning curve and promoting wider adoption of the procedure. Finally, further randomized comparative evidence against surgical gastrojejunostomy and endoscopic stenting as well as real-life prospective clinical data should be promoted to confirm the potential advantages of the technique and discovering potential drawbacks in its large-scale application, before exploring further expansion in the realm of benign GOO, small bowel obstruction, metabolic interventions, etc.

REFERENCES

1. Van Der Merwe SW, Van Wanrooij RLJ, Bronswijk M, et al. Therapeutic endoscopic ultrasound: European Society of Gastrointestinal Endoscopy (ESGE) Guideline. *Endoscopy*. 2022;54:185–205.
2. De Ponthaud C, Bozkirli B, Rizzo GEM, et al. Management of malignant Gastric Outlet Obstruction (mGOO) due to pancreatic cancer in the era of EUS-Gastrojejunostomy: an international practice survey and case vignette study by Pancreas 2000 from the European Pancreatic Club. *Surg Endosc*. 2024;38: 3231–3240.
3. Dietrich C, Arcidiacono P, Braden B, et al. What should be known prior to performing EUS exams? (Part II). *Endosc Ultrasound*. 2019;8:360.
4. Fritscher-Ravens A, Mosse CA, Mills TN, et al. A through-the-scope device for suturing and tissue approximation under EUS control. *Gastrointest Endosc*. 2002;56:737–742.
5. Binmoeller KF, Shah JN. Endoscopic ultrasound-guided gastroenterostomy using novel tools designed for transluminal therapy: a porcine study. *Endoscopy*. 2012;44:499–503.
6. Jaruvongvanich V, Mahmoud T, Abu Dayyeh BK, et al. Endoscopic ultrasound-guided gastroenterostomy for the management of gastric outlet obstruction: a large comparative study with long-term follow-up. *Endosc Int Open*. 2023;11.
7. Vanella G, Dell'Anna G, Capurso G, et al. EUS-guided gastroenterostomy for management of malignant gastric outlet obstruction: a prospective cohort study with matched comparison with enteral stenting. *Gastrointest Endosc*. 2023;98: 337–347.
8. Miller C, Benchaya JA, Martel M, et al. EUS-guided gastroenterostomy vs. surgical gastrojejunostomy and enteral stenting for malignant gastric outlet obstruction: a meta-analysis. *Endosc Int Open*. 2023;11:E660–E672.
9. Perez-Miranda M, Tyberg A, Poletto D, et al. EUS-guided gastrojejunostomy versus laparoscopic gastrojejunostomy: an international collaborative study. *J Clin Gastroenterol*. 2017;51: 896–899.
10. Canakis A, Bomman S, Lee DU, et al. Benefits of EUS-guided gastroenterostomy over surgical gastrojejunostomy in the palliation of malignant gastric outlet obstruction: a large multicenter experience. *Gastrointest Endosc*. 2023;98:348–359.
11. ClinicalTrials.gov. Enteral anastomosis for the treatment of gastric outlet obstruction: a randomized controlled study comparing endoscopic versus surgical gastrojejunostomy. Accessed February 10, 2025. https://clinicaltrials.gov/study/NCT05561907?cond=gastric%20outlet%20obstruction&rank=3
12. ClinicalTrials.gov. EUS-guided versus laparoscopic gastrojejunostomy for malignant gastric outlet obstruction. Accessed February 10, 2025. https://clinicaltrials.gov/study/NCT05605327?cond=gastric%20outlet%20obstruction&rank=4
13. ClinicalTrials.gov. Endoscopic ultrasound-guided versus surgical gastroenterostomy for malignant gastric outlet obstruction. Accessed February 10, 2025. https://clinicaltrials.gov/study/NCT05564143?cond=gastric%20outlet%20obstruction&page=2&rank=14
14. ClinicalTrials.gov. Comparing endoscopic ultrasound vs surgical gastrojejunostomy for management of GOO. Accessed February 10, 2025. https://clinicaltrials.gov/study/NCT06128018?cond=gastric%20outlet%20obstruction&page=2&rank=16
15. Jue TL, Storm AC, Naveed M, et al. ASGE guideline on the role of endoscopy in the management of benign and malignant gastroduodenal obstruction. *Gastrointest Endosc*. 2021;93:309–322.
16. Ahmed O, Lee JH, Thompson CC, et al. AGA clinical practice update on the optimal management of the malignant

alimentary tract obstruction: expert review. *Clin Gastroenterol Hepatol*. 2021;19:1780–1788.
17. Boghossian MB, Funari MP, De Moura DTH, et al. EUS-guided gastroenterostomy versus duodenal stent placement and surgical gastrojejunostomy for the palliation of malignant gastric outlet obstruction: a systematic review and meta-analysis. *Langenbecks Arch Surg*. 2021;406:1803–1817.
18. Chen YI, Itoi T, Baron TH, et al. EUS-guided gastroenterostomy is comparable to enteral stenting with fewer re-interventions in malignant gastric outlet obstruction. *Surg Endosc*. 2017;31:2946–2952.
19. Chandan S, Khan SR, Mohan BP, et al. EUS-guided gastroenterostomy versus enteral stenting for gastric outlet obstruction: systematic review and meta-analysis. *Endosc Int Open*. 2021;9:E496–E504.
20. Chan SM, Dhir V, Chan YYY, et al. Endoscopic ultrasound-guided balloon-occluded gastrojejunostomy bypass, duodenal stent or laparoscopic gastrojejunostomy for unresectable malignant gastric outlet obstruction. *Dig Endosc*. 2023;35: 512–519.
21. van Wanrooij RLJ, Vanella G, Bronswijk M, et al. Endoscopic ultrasound-guided gastroenterostomy versus duodenal stenting for malignant gastric outlet obstruction: an international, multicenter, propensity score-matched comparison. *Endoscopy*. 2022;54:1023–1031.
22. Teoh AYB, Lakhtakia S, Tarantino I, et al. Endoscopic ultrasonography-guided gastroenterostomy versus uncovered duodenal metal stenting for unresectable malignant gastric outlet obstruction (DRA-GOO): a multicentre randomised controlled trial. *Lancet Gastroenterol Hepatol*. 2024;9.
23. Adler DG, Baron TH. Endoscopic palliation of malignant gastric outlet obstruction using self-expanding metal stents: experience in 36 patients. *Am J Gastroenterol*. 2002;97.
24. Basha J, Lakhtakia S, Yarlagadda R, et al. Gastric outlet obstruction with ascites: EUS-guided gastro-enterostomy is feasible. *Endosc Int Open*. 2021;9:E1918–E1923.
25. Mahmoud T, Storm AC, Law RJ, et al. Efficacy and safety of endoscopic ultrasound-guided gastrojejunostomy in patients with malignant gastric outlet obstruction and ascites. *Endosc Int Open*. 2022;10:E670–E678.
26. Bronswijk M, van Wanrooij RLJ, Vanella G, et al. EUS-guided gastroenterostomy in patients with ascites: what lies beneath? *Endosc Int Open*. 2022;10:E294–E294.
27. Stefanovic S, Adler DG, Arlt A, et al. International consensus recommendations for safe use of LAMS for on- and off-label indications using a modified Delphi process. *Am J Gastroenterol*. 2024;119:671–681.
28. Van Wanrooij RLJ, Bronswijk M, Kunda R, et al. Therapeutic endoscopic ultrasound: European Society of Gastrointestinal Endoscopy (ESGE) Technical Review. *Endoscopy*. 2022;54: 310–332.
29. Abbas A, Dolan RD, Bazarbashi AN, et al. Endoscopic ultrasound-guided gastroenterostomy versus surgical gastrojejunostomy for the palliation of gastric outlet obstruction in patients with peritoneal carcinomatosis. *Endoscopy*. 2022;54: 671–679.
30. Vanella G, Dell'Anna G, Loria A, et al. Radiation exposure during modern therapeutic endoscopic ultrasound procedures and standard alternatives. *Endosc Int Open*. 2022;10: E1105–E1111.
31. Vanella G, Tamburrino D, Mandarino FV, et al. Diameter of surgical versus endoscopic ultrasound-guided gastrojejunostomy: that much wider after all is said and done? *Endoscopy*. 2022;54:E449–E451.
32. Vedantam S, Shah R, Bhalla S, et al. No difference in outcomes with 15 mm vs. 20 mm lumen-apposing metal stents for endoscopic ultrasound-guided gastroenterostomy for gastric outlet obstruction: a meta-analysis. *Clin Endosc*. 2023;56:298–307.
33. Bejjani M, Ghandour B, Subtil JC, et al. Clinical and technical outcomes of patients undergoing endoscopic ultrasound-guided gastroenterostomy using 20-mm vs15-mm lumen-apposing metal stents. *Endoscopy*. 2022;54.
34. Nassar S, Menias CO, Palmquist S, et al. Ligament of Treitz: anatomy, relevance of radiologic findings, and radiologic-pathologic correlation. *AJR Am J Roentgenol*. 2021;216: 927–934.
35. Brewer Gutierrez OI, Bukhari M, Chen YI, et al. Successful ERCP through an endoscopic ultrasound-guided gastrojejunostomy. *Endoscopy*. 2017;49:921–922.
36. Ghandour B, Bejjani M, Irani SS, et al. Classification, outcomes, and management of misdeployed stents during EUS-guided gastroenterostomy. *Gastrointest Endosc*. 2022;95:80–89.
37. Vanella G, Dell'Anna G, Bronswijk M, et al. Redo-endoscopic ultrasound-guided gastroenterostomy for the management of distal flange misdeployment: trust your orojejunal catheter. *Endoscopy*. 2022;54:E752–E754.
38. Anderloni A, Attili F, Carrara S, et al. Intra-channel stent release technique for fluoroless endoscopic ultrasound-guided lumen-apposing metal stent placement: changing the paradigm. *Endosc Int Open*. 2017;05:E25–E29.
39. Bronswijk M, Van Der Merwe S. Endoscopic ultrasound-guided gastroenterostomy: another knock-out for simplification. *Endoscopy*. 2023;55:1000–1001.
40. Bronswijk M, Vanella G, van Malenstein H, et al. Laparoscopic versus EUS-guided gastroenterostomy for gastric outlet obstruction: an international multicenter propensity score-matched comparison (with video). *Gastrointest Endosc*. 2021; 94:526–536.e2.
41. Bronswijk M, Vanella G, Petrone MC, et al. EUS-guided gastroenterostomy: Less is more! The wireless EUS-guided gastroenterostomy simplified technique. *VideoGIE*. 2020;5:442.
42. Monino L, Perez-Cuadrado-Robles E, Gonzalez JM, et al. Endoscopic ultrasound-guided gastroenterostomy with lumen-apposing metal stents: a retrospective multicentric comparison of wireless and over-the-wire techniques. *Endoscopy*. 2022;55.
43. Itoi T, Ishii K, Ikeuchi N, et al. Prospective evaluation of endoscopic ultrasonography-guided double-balloon-occluded gastrojejunostomy bypass (EPASS) for malignant gastric outlet obstruction. *Gut*. 2016;65:193–195.
44. Chen YI, Menard C, Khashab M, et al. EUS-guided gastroenterostomy using a novel through-the-scope exchangeable dual-balloon enteroclysis catheter: a potentially secure and scalable approach. *VideoGIE*. 2023;8:500–502.
45. Trieu JA, Baron TH. EUS-guided gastroenterostomy using direct needle-puncture technique. *VideoGIE*. 2024;9:164–168.
46. Irani S, Baron TH, Itoi T, et al. Endoscopic gastroenterostomy: techniques and review. *Curr Opin Gastroenterol*. 2017;33: 320–329.
47. Tyberg A, Kats D, Choi A, et al. Endoscopic ultrasound guided gastroenterostomy: what is the learning curve? *J Clin Gastroenterol*. 2021;55:691–693.
48. Jovani M, Ichkhanian Y, Parsa N, et al. Assessment of the learning curve for EUS-guided gastroenterostomy for a single operator. *Gastrointest Endosc*. 2021;93:1088–1093.
49. Perez-Miranda M. EUS-guided gastroenterostomy: closing knowledge gaps by evaluating learning curves. *Gastrointest Endosc*. 2021;93:1094–1096.
50. Elfanagely Y, Tse CS, Rich H, et al. Learning curves for EUS: single operators, endoscopy teams, and institutions. *Gastrointest Endosc*. 2021;93:989.
51. Liu Z, Zhang X, Zhang W, et al. Comprehensive evaluation of the learning curve for peroral endoscopic myotomy. *Clin Gastroenterol Hepatol*. 2018;16:1420–1426.
52. Modayil R, Stavropoulos SN. How many peroral endoscopic myotomy procedures are necessary for proficiency? *Clin Gastroenterol Hepatol*. 2018;16:1393–1397.
53. Jovani M, Khashab MA. Response. *Gastrointest Endosc*. 2021; 93:989–990.
54. Ge PS, Young JY, Dong W, et al. EUS-guided gastroenterostomy versus enteral stent placement for palliation of malignant gastric outlet obstruction. *Surg Endosc*. 2019;33: 3404–3411.
55. Martins BC, Ruas JN, Fiuza F, et al. Lessons learned from a salvage procedure for lumen-apposing metal stent

misplacement during EUS-guided gastrojejunal bypass. *VideoGIE*. 2020;5:464.

56. Kastelijn JB, Moons LMG, Garcia-Alonso FJ, et al. Patency of endoscopic ultrasound-guided gastroenterostomy in the treatment of malignant gastric outlet obstruction. *Endosc Int Open*. 2020;8:E1194–E1201.
57. Tyberg A, Saumoy M, Kahaleh M. Using NOTES to salvage a misdeployed lumen-apposing metal stent during an endoscopic ultrasound-guided gastroenterostomy. *Endoscopy*. 2017;49: 1007–1008.
58. Sanchez-Ocana R, Penas-Herrero I, Gil-Simon P, et al. Natural orifice transluminal endoscopic surgery salvage of direct EUS-guided gastrojejunostomy. *VideoGIE*. 2017;2:346.
59. Pham KDC, Havre RF. Endoscopic management of gastrocolic fistula after endoscopic ultrasound-guided gastrojejunostomy (EUS-GJ). *Endoscopy*. 2019;51:E169.
60. Chavan R, Ramchandani M, Nabi Z, et al. Luminal and extraluminal bleeding during EUS-guided double-balloon-occluded gastrojejunostomy bypass in benign gastric outlet obstruction with portal hypertension. *VideoGIE 2019*, 5:64–67.
61. McCarty TR, Garg R, Thompson CC, et al. Efficacy and safety of EUS-guided gastroenterostomy for benign and malignant gastric outlet obstruction: a systematic review and meta-analysis. *Endosc Int Open*. 2019;07:E1474–E1482.
62. Iqbal U, Khara HS, Hu Y, et al. EUS-guided gastroenterostomy for the management of gastric outlet obstruction: a systematic review and meta-analysis. *Endosc Ultrasound*. 2020; 9:16–23.
63. Garcia-Alonso FJ, Chavarria C, Subtil JC, et al. Prospective multicenter assessment of the impact of EUS-guided gastroenterostomy on patient quality of life in unresectable malignant gastric outlet obstruction. *Gastrointest Endosc*. 2023;98:28–35.

