15 Gastric Outlet Obstruction: Antroduodenal Stenting, Venting PEG, EUS Guided Gastrojejunostomy

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Introduction

Malignant gastric outlet obstruction (mGOO) is a feared late complication of pancreatic cancer. From various studies, it is estimated that between 5 and 25% of patients with pancreatic cancer will ultimately develop mGOO [1, 2]. The onset of mGOO portends a poor prognosis, with historical series demonstrating a median survival of 3–4 months [3, 4]. The presentation of mGOO is often indolent, however can range from acute to subclinical. A diagnosis can be made based on clinical, endoscopic, and/or radiographic findings. Although mGOO traditionally required surgical management, a modern, multidisciplinary approach involving minimally invasive endoscopic techniques is increasingly used. Here, we present an overview of the pathophysiology, diagnosis, and management of patients with mGOO.

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Pathophysiology

Malignant GOO can occur at various levels depending on the location of the primary pancreatic cancer (Table 15.1). mGOO occurring at the duodenal bulb and duodenal sweep occurs from cancers at the head of the pancreas. mGOO occurring at the periampullary second portion of the duodenum arises from cancers at the pancreatic uncinate process or periampullary portion of the pancreas. mGOO occurring in the distal duodenum typically arises from cancers at the body or tail of the pancreas or from bulky mesenteric lymphadenopathy. mGOO occurs at these vari-

Table 15.1 Pathophysiology of malignant gastric outlet obstruction

Location[a]	Etiology
Gastric outlet (antrum, pylorus)	Gastric cancer
First portion of duodenum (bulb, sweep)	Cancer of the head of the pancreas Cholangiocarcinoma
Second portion of duodenum (periampullary)	Cancer of the uncinate process of the pancreas Ampullary cancer
Third/fourth portion of duodenum	Cancer of the body or tail of the pancreas Bulky metastatic lymphadenopathy
Gastrojejunal anastomosis (post-Whipple)	Benign: tissue edema, anastomotic strictures Malignant: local recurrence

[a] Of note, duodenal cancer and metastatic cancer can present with obstruction at any of the levels noted above

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ous locations from a combination of direct invasion of the pancreatic cancer into the duodenal wall and local edema of the duodenal wall due to mass effect from the adjacent malignancy.

In patients who have undergone either traditional or pylorus-preserving Whipple pancreaticoduodenectomy, gastric outlet obstruction can be either benign or malignant and tends to occur at the gastrojejunal anastomosis. Benign obstruction can arise due to strictures or localized tissue edema at the gastrojejunal anastomosis. Malignant obstruction is often due to local recurrence of pancreatic cancer.

Diagnosis

mGOO typically presents with the insidious onset of nausea, vomiting, anorexia, early satiety, and abdominal pain [5]. The emesis can often include undigested food products and can be malodorous. When prompted, patients routinely offer a history of worsening reflux symptoms and vomiting foodstuffs that are several days old. Owing to its insidious nature, patients rarely report significant drops in appetite and early satiety; although this is often observed by the patients' close relatives or loved ones. The presence of bile within the emesis can often result in a dark appearance that can be mistaken for coffee ground emesis and foregut bleeding.

mGOO is generally diagnosed radiographically with cross-sectional abdominal imaging such as computed tomography (CT), which may demonstrate a markedly distended stomach [6]. Occasionally, mGOO is diagnosed endoscopically, either during evaluation of nausea/vomiting or coffee ground emesis, or incidentally during attempted endosonography (EUS) and/or endoscopic retrograde cholangiopancreatography (ERCP) (Fig. 15.1).

Patients with mGOO experience severely decreased quality of life due to symptoms such as nausea, vomiting, abdominal pain, and nutritional deficiencies which are often exacerbated by the effects of the primary pancreatic malignancy. The nutritional deficiencies that accompany mGOO likely contribute to the poor prognosis of pancreatic cancer once mGOO has developed. However, given the proportion of patients with subclinical symptoms, the incidence of undiagnosed mGOO in pancreatic cancer is likely underestimated as patients and relatives may attribute the symptoms to that of systemic chemotherapy or to progressive decline from the primary pancreatic cancer.

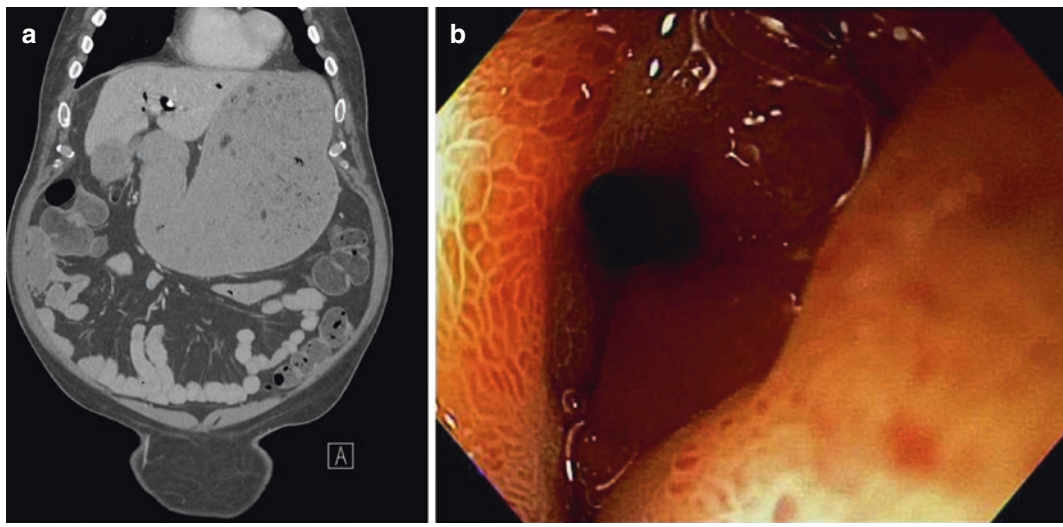

Fig. 15.1 Malignant gastric outlet obstruction. (**a**) Radiographic appearance of a typical patient with gastric outlet obstruction due to pancreatic malignancy, as seen on coronal views on computed tomography. (**b**) Endoscopic appearance of a severe duodenal stricture due to adjacent malignancy at the head of the pancreas

Principles of Management

The principles of management for mGOO can be separated into three categories—maintaining luminal patency, luminal bypass, and decompression. Enteral stent placement using a self-expanding metal stent (SEMS) is commonly performed to maintain luminal patency. Luminal bypass has traditionally been achieved surgically, with either open or laparoscopic gastrojejunostomy. More recently, EUS-guided gastroenterostomy (EUS-GE) has emerged as a minimally invasive alternative to achieve luminal bypass. Finally, in patients where luminal patency cannot be maintained and bypass is not an option, gastric decompression with placement of a venting gastrostomy tube can be performed as a last resort for palliation of mGOO.

Patients presenting with mGOO should be clinically optimized prior to proceeding with any procedure. The stomach should be fully decompressed using a large diameter nasogastric tube. During this time, intravenous fluids should be given to counteract the effects of volume depletion, and electrolyte abnormalities should be identified and corrected. In our practice, endoscopic procedures in the management of mGOO are performed under general endotracheal anesthesia, often with a rapid-sequence intubation, due to the risks of aspiration in the setting of obstruction. Parenteral antibiotics should be administered for patients undergoing surgical gastrojejunostomy, EUS-guided gastroenterostomy, and venting gastrostomy tube placement.

Surgical Gastrojejunostomy

Prior to the advent of enteral stent placement, the management of mGOO was limited to either surgical gastrojejunostomy or palliative venting gastrostomy. Today, laparoscopic surgical gastrojejunostomy remains an attractive option for patients who present with mGOO who have good performance status and a reasonable life expectancy [7, 8].

Open surgical gastrojejunostomy is traditionally performed using an upper midline or subcostal incision, and laparoscopic gastrojejunostomy is typically performed using several small incisions, to accommodate multiple 5-mm ports and one 12-mm port for the laparoscopic stapler [9, 10]. The greater omentum is dissected off the greater curvature of the stomach to expose the inferior and posterior surface of the stomach. A suitable loop of proximal jejunum is identified and brought to the stomach. An enterotomy is made into the loop of jejunum, followed by a gastrotomy along the posterior and most dependent portion of the stomach. A side-to-side antecolic or retrocolic gastrojejunostomy is then created using a surgical stapler, and the enterotomy closed either with the stapler or with sutures. If tumor ingrowth or extrinsic compression of the common bile duct is noted at the time of gastrojejunostomy, a "double bypass" with choledochojejunostomy or hepaticojejunostomy can be additionally performed.

Several modifications of laparoscopic gastrojejunostomy have been described. In a partial stomach-partitioning gastrojejunostomy, the stomach is partitioned vertically, allowing enteric contents to favorably empty inferiorly across the gastrojejunostomy rather than towards the native gastric outlet [11]. Another variation is known as the modified Devine exclusion with vertical stomach reconstruction [12]. In this technique, the stomach is vertically transected, then the proximal portion of the stomach is stretched and then resected horizontally with a stapler, akin to a wedge resection of the dependent portion of the stomach. A loop of jejunum is then brought up and anastomosed in a horizontal side-to-side fashion.

Surgical gastrojejunostomy has historically been the gold standard for the management of mGOO. However, surgery carries considerable risks of morbidity and mortality. Morbidity typically includes delayed gastric emptying and postoperative ileus; however, there are also less common but serious adverse events such as anastomotic leakage. Prior to widespread use of enteral stents, large surgical series showed that palliative gastrojejunostomy carried surgical morbidity and mortality rates of 39% and 31%, respectively, with median survival of 4 months

[13]. Variables associated with shorter survival rates included advanced disease stage and Karnofsky performance status score less than 80. Re-intervention was necessary in 16.6%, and 20% of patients were never able to tolerate a normal diet. These findings were reflected in several additional surgical series, which reported delayed gastric emptying and postoperative ileus to occur in up to 58% of patients [4, 14], and median procedure-related hospital stay ranging from 14 to 24 days [15, 16]. Given that surgical risks were found to be higher particularly among patients with poor performance status or limited life expectancy, more contemporary studies revisiting this issue have concluded that surgical gastrojejunostomy should be reserved for patients with good performance status and reasonable life expectancy [17, 18].

Table 15.2 Commercially available endoscopic stents in the USA

Company	Stent[a]	Available sizes
Boston Scientific	WallFlex (SEMS) and WallFlex-Soft (SEMS)	22 mm × 6 cm 22 mm × 9 cm 22 mm × 12 cm
Boston Scientific	AXIOS (LAMS)	10 mm × 10 mm 15 mm × 10 mm 20 mm × 10 mm
Cook Medical	Evolution (SEMS)	22 mm × 6 cm 22 mm × 9 cm 22 mm × 12 cm
Olympus America	Hanarostent (SEMS)	22 mm × 6 cm 22 mm × 9 cm 22 mm × 12 cm

[a] *LAMS* lumen-apposing metal stent, *SEMS* self-expanding metal stent

Enteral Stent Placement

Enteral stent placement refers to the endoscopic placement of a self-expanding metal stent (SEMS) across the point of luminal obstruction. SEMS is typically made of nickel-titanium (Nitinol) alloy and is designed to be constrained on a delivery catheter, then expand to their desired shape once the stent has been deployed. Although SEMS can be either covered or uncovered, current commercially available duodenal SEMS in the USA is universally uncovered (WallFlex [Boston Scientific, Marlborough, MA], Evolution [Cook Medical, Bloomington, IN], and Hanarostent [Olympus America, Center Valley, PA]) (Table 15.2).

Technique

Enteral stent placement is performed under fluoroscopic guidance and using a therapeutic gastroscope capable of handling the large diameter stent delivery catheters (Fig. 15.2). The area of stenosis is first examined endoscopically; typically, if a therapeutic endoscope is able to readily traverse across the stenosis, this implies that enteral stent placement should be avoided due to the risk of stent migration and subsequent bowel obstruction and/or perforation. Nevertheless, relative luminal narrowing, with or without focally compromised motility, can produce significant symptoms and the patient may still benefit from bypassing this area or from decompression. However, if the lumen is widely patent alternative diagnoses such as delayed gastric emptying should be considered.

While there are subtle variations in technique, we typically approach the stenosis using standard ERCP catheters such as sphincterotomes, cannulas, or balloon-extraction catheters, preloaded with a 0.035 inch semi-stiff guidewire. The guidewire is used to gently probe the stenosis under fluoroscopic guidance and identify the true lumen, taking care to avoid creating false tracts. The catheter is used to follow the guidewire, and contrast is injected to both confirm correct guidewire position and to delineate the length of the stenosis. After the stenosis has been properly measured, the catheter is exchanged over the guidewire for the stent delivery catheter containing an appropriately sized uncovered metal duodenal stent. The stent is then deployed under direct endoscopic and fluoroscopic guidance across the stenosis. After stent position is

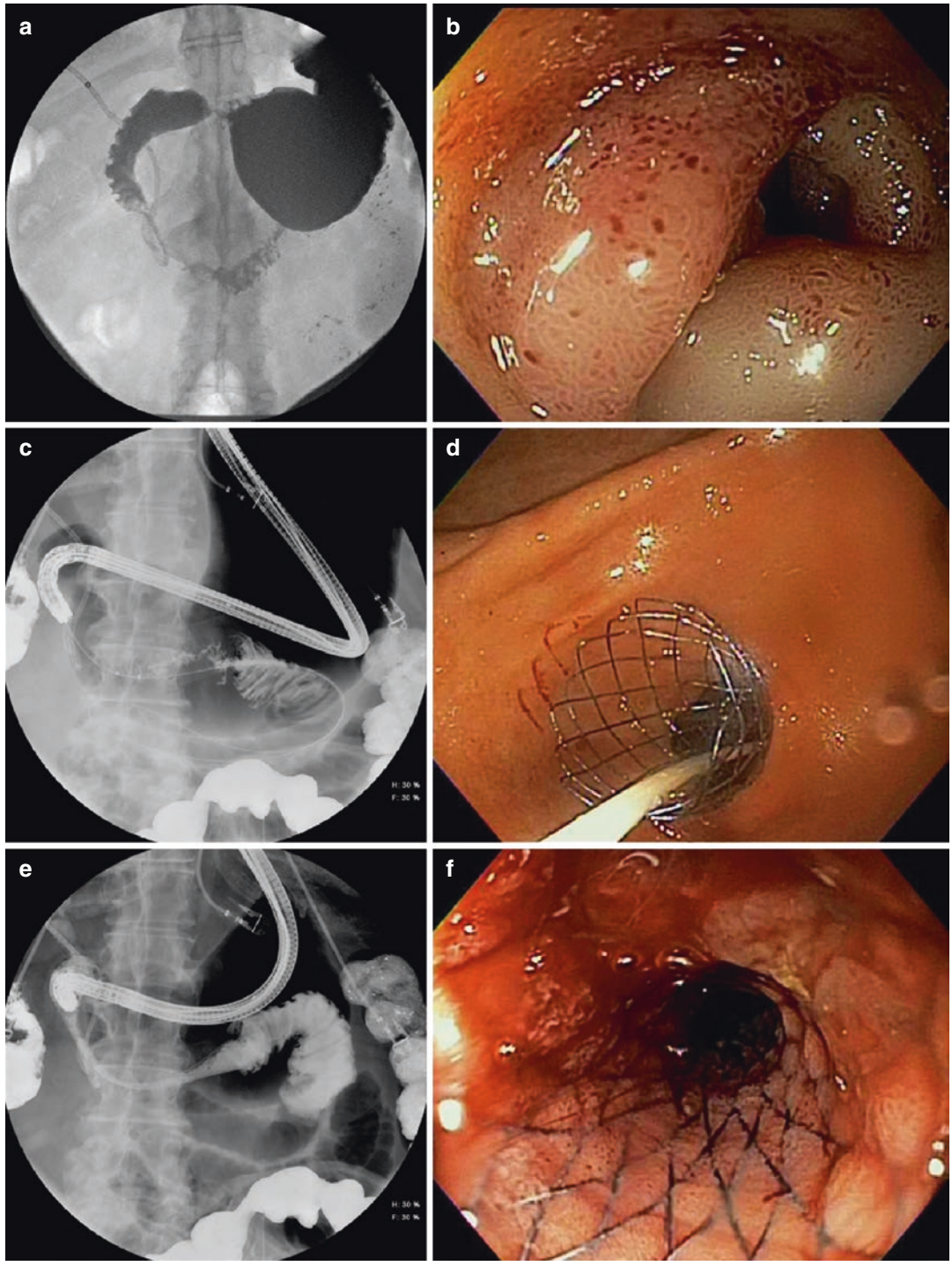

Fig. 15.2 Enteral stent placement. (**a**) Upper gastrointestinal series showing gastric outlet obstruction at the second portion of the duodenum due to pancreatic malignancy. (**b**) Endoscopic view of severe duodenal stricture in the second portion of the duodenum. (**c**) Fluoroscopic and (**d**) endoscopic views of stent deployment. (**e**) Fluoroscopic view of completed enteral stent deployment with contrast passage across the enteral stent into the distal duodenum. (**f**) Endoscopic view of completed enteral stent deployment

confirmed fluoroscopically, contrast can be injected across the stent to confirm luminal patency.

Outpatients who undergo enteral stenting can typically be discharged home following the procedure. Routine endoscopic follow-up is not typically necessary for patients who undergo enteral stent placement.

Outcomes and Efficacy

Endoscopic placement of a self-expanding metal stent was first described in 1992 [19]. The procedure rapidly became the standard procedure worldwide for patients with mGOO who are not otherwise candidates for surgical resection or surgical bypass, with multiple large systematic reviews, prospective studies, and randomized controlled trials to support its use [5, 7, 20–24].

Generally speaking, existing studies evaluating SEMS placement are limited by heterogeneous patient populations with various malignancies and treated with a large assortment of commercially available stents. A large systematic review of 32 studies demonstrated the technical success and clinical success of SEMS placement in patients with mGOO [20]. The mean survival time was 12 weeks (range, 1–184 weeks), technical success was 97% (range, 91–100%), and clinical success was 89% (range, 63–95%). Mean time to resumption of oral intake after SEMS placement was 4 days. Ultimately, 48% of patients were able to resume a full solid diet, 39% were able to tolerate soft solids, and 13% were unable to be advanced beyond full liquids. As such, we routinely warn patients undergoing enteral stent placement to expect limitations in oral intake, specifically avoiding high-fiber foods that may result in stent occlusion.

Despite their heterogeneity, studies evaluating SEMS placement in patients with mGOO uniformly show a large discrepancy between higher technical success rates and substantially lower clinical success rates which further decreases over time [22, 25–27]. The lower initial clinical success rate is believed to be attributed to a number of factors, which include gastrointestinal dysmotility (potentially from neural involvement by tumor), additional obstruction from peritoneal carcinomatosis, and generalized deconditioning and anorexia from underlying advanced malignancy. The continued decrease in clinical success rates over the long term is attributed to the inevitable development of stent-related complications such as tumor ingrowth and/or food impaction. Although enteral stent placement has been shown to improve obstructive symptoms, improvement in quality of life or performance status has not been consistently demonstrated [24, 28].

Adverse Events

Severe complications such as bleeding and perforation are rare and estimated to occur in approximately 1% of cases [5]. However, non-severe complications are common with enteral stent placement, estimated to occur in at least 25% of cases [5, 20]. These non-severe complications include stent malfunction, pain, and less commonly ampullary obstruction resulting in biliary obstruction, cholangitis, and/or pancreatitis.

Stent malfunction is the most common complication of enteral stent placement, occurring in at least 17% of cases and increasing with time [2, 5, 18]. Stents can malfunction due to tumor ingrowth, food impaction, or stent migration. Tumor ingrowth and recurrent mGOO are estimated to occur in the majority of patients who survive longer than 6 months after enteral stent placement and may require the insertion of additional stents (Fig. 15.3) [29]. Food impactions may require endoscopy for clearance. Stent migrations are uncommon in the USA where only uncovered duodenal SEMS are commercially available; however, worldwide, where both covered and uncovered SEMS are available, stent migration within 8 weeks of placement has been reported to be significantly more common with covered SEMS (up to 28%) [30]. Although migrated stents can be repositioned or removed when recognized early, completely migrated stents may cause downstream intestinal obstruction and/or perforation requiring emergency surgical intervention [31].

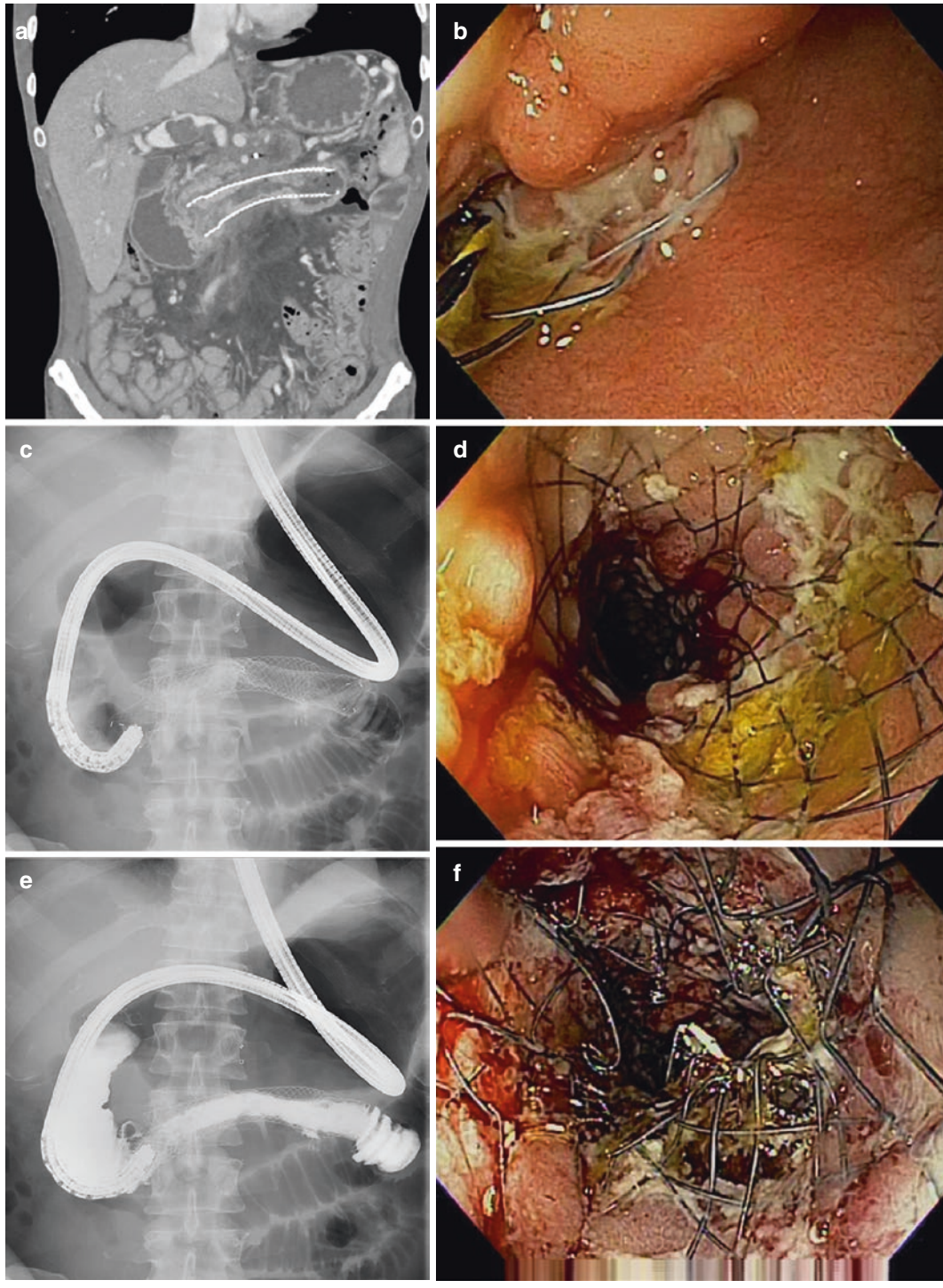

Fig. 15.3 Management of enteral stent malfunction due to tissue ingrowth. (**a**) Radiographic appearance of existing enteral stent with visible tissue ingrowth in a patient with pancreatic malignancy. (**b**) Endoscopic view of malfunctioned existing enteral stent with severe tissue ingrowth. (**c**) Fluoroscopic and (**d**) endoscopic views of stent deployment. (**e**) Fluoroscopic view of completed enteral stent deployment with contrast passage across the enteral stent into the distal duodenum. (**f**) Endoscopic view of overlapping enteral stents

Pain after enteral stent placement is most often due to expansion of the SEMS. As the SEMS takes approximately 48–72 h to fully expand, pain usually improves slowly over that interval. However, acute pancreatitis has uncommonly been reported to occur due to occlusion of the ampullary orifice by the duodenal SEMS [32].

Occlusion of the ampullary orifice by the duodenal SEMS may also result in biliary obstruction and/or cholangitis. Therefore, ERCP with biliary SEMS placement should be considered prior to duodenal SEMS placement in patients with mGOO who also have known or impending biliary obstruction [5]. Despite this, patients who have biliary SEMS who subsequently undergo duodenal stent placement have also been described to be at increased risk for biliary stent dysfunction; in a large series of patients with biliary stents, 52% of patients who underwent duodenal stent placement experienced biliary stent dysfunction [33].

Enteral Stents Versus Surgical Gastrojejunostomy

There has been considerable debate with regard to comparing enteral stents versus surgical gastrojejunostomy for the management of mGOO, with three randomized controlled trials [21–23], a large Cochrane review [7], and multiple additional systematic reviews and meta-analyses [18, 34]. Overall, they suggest that surgical gastrojejunostomy is superior to enteral stent placement and should be preferred in patients with acceptable life expectancy and good performance status.

Among the three randomized controlled trials, one showed improvement in quality of life with enteral stent but not with surgical bypass [23], whereas another did not show a difference between the two groups [22]. All three trials showed comparable rates of technical success and mortality, but longer hospital stay with surgery. Enteral stent placement was associated with more rapid improvement in symptoms [21, 22]. However, the largest randomized study with longest follow-up showed that late complications such as need for re-intervention were more common with enteral stent placement than surgical gastrojejunostomy, leading the authors to conclude that surgical gastrojejunostomy is preferable for patients with life expectancy of 2 months or longer [22]. These findings were subsequently confirmed in a Cochrane systematic review [7]. By pooling the data from the three randomized controlled trials, comprising 84 patients including 41 patients randomized to surgical palliation and 43 patients randomized to enteral stents, the authors concluded that enteral stent placement has the benefit of quicker resumption of oral intake and reduced inpatient hospital stay, however with higher recurrence rate and increased need for re-intervention.

Multiple meta-analyses have additionally compared surgical bypass with enteral stent placement. Recently, Mintziras et al. in 2019 reported a large systematic review and meta-analysis which included 27 studies and 2354 patients, of which 55.5% underwent enteral stent placement and 44.5% underwent surgical gastrojejunostomy [18]. The authors found that postoperative mortality and major complications were similar in the two groups. Surgical gastrojejunostomy was associated with significantly longer survival than enteral stent placement, with a mean difference of 43 days. Although the mean time to oral intake and length of hospital stay favored the enteral stent group, the frequency of re-interventions was nearly three times higher in the enteral stent group. It is worth noting, however, that existing studies have significant heterogeneity with regard to baseline patient clinical status, which may in turn influence reported clinical outcomes.

From a cost-effectiveness standpoint, studies have shown that enteral stenting is more cost-effective than surgical gastrojejunostomy [35, 36]. A decision-analysis study comparing surgical gastrojejunostomy and endoscopic stenting showed that over a 1-month period, enteral stent placement was the most cost-effective strategy with the lowest rate of complications and the highest success rate [37]. Therefore, although

surgical gastrojejunostomy is more durable, enteral stent placement is more appropriate for patients with either a short life expectancy or poor performance status.

EUS-Guided Gastroenterostomy

Recently, EUS-guided gastroenterostomy (EUS-GE) with placement of an electrocautery-enhanced lumen-apposing metal stent (LAMS) has emerged as a novel alternative procedure that may offer long lasting patency with fewer incidence of stent failure. Currently, the only commercially available LAMS in the USA is the AXIOS stent (Boston Scientific), although worldwide several additional options are available (Spaxus [Taewoong Medical, Gyeonggi-do, South Korea] and Nagi [Taewoong Medical]) (Table 15.2).

Technique

EUS-GE is typically performed under fluoroscopic guidance and using a linear-array therapeutic echoendoscope in order to handle the large diameter of the LAMS delivery catheter (Fig. 15.4). There are multiple different variations in EUS-GE technique, of which we will describe the most common approaches [38].

We have typically utilized a "freehand" or "direct" anterograde EUS-GE technique. In this approach, a standard ERCP cannula preloaded with a 0.035 inch semi-stiff guidewire is guided across the obstruction into the distal duodenum/proximal jejunum, followed by injection of approximately 600 mL of sterile water mixed with iodinated contrast and methylene blue. The patient is also administered 0.5–1 mg of glucagon to reduce intestinal peristalsis. In other variants of the technique a naso-jejunal tube is used to instill fluid throughout the procedure. The echoendoscope is then positioned along the greater curvature of the gastric body. From this location, the distended loop of small bowel can be identified both endosonographically and fluoroscopically. An electrocautery-enhanced LAMS is deployed in a "freehand" fashion into the jejunum under endosonographic and fluoroscopic guidance, thus establishing the gastroenterostomy. Following successful deployment, correct stent positioning is confirmed endoscopically and fluoroscopically. We then typically dilate the LAMS with a standard dilation balloon, and inject contrast across the LAMS both to confirm luminal patency and to rule out contrast extravasation which would imply intraprocedural perforation.

Occasionally, the linear echoendoscope may be able to traverse across the malignant obstruction. When that occurs, a direct "retrograde" EUS-GE approach can be considered. With this approach, the linear echoendoscope is in the distal duodenum, and the LAMS is deployed in retrograde fashion into the stomach (i.e. EUS-enterogastrostomy or EUS-EG). While this situation is uncommon, this approach is less technically demanding as the stomach is a larger and more stable target for electrocautery-enhanced LAMS puncture than the small bowel.

With the "freehand" technique, we do not routinely access the target jejunum first under EUS, nor do we first place a guidewire across the proposed gastroenterostomy tract. This avoids the dangerous situation in which the small bowel is paradoxically pushed away from the stomach by the guidewire, which increases the risk of subsequent LAMS misdeployment and perforation.

An alternative EUS-GE technique is known as the "balloon-assisted" technique. Using this technique, a dilating balloon is passed over a guidewire into the small bowel, which is then inflated with a mixture of contrast and saline while positioned in the duodenum and/or jejunum. The fluid-filled balloon is identified under EUS with the echoendoscope in the stomach. The balloon is then punctured under EUS guidance using a 19-gauge fine needle aspiration (FNA) needle. The bursting of the balloon indicates correct positioning of the needle tip within the small bowel lumen. At that point, a second guidewire is

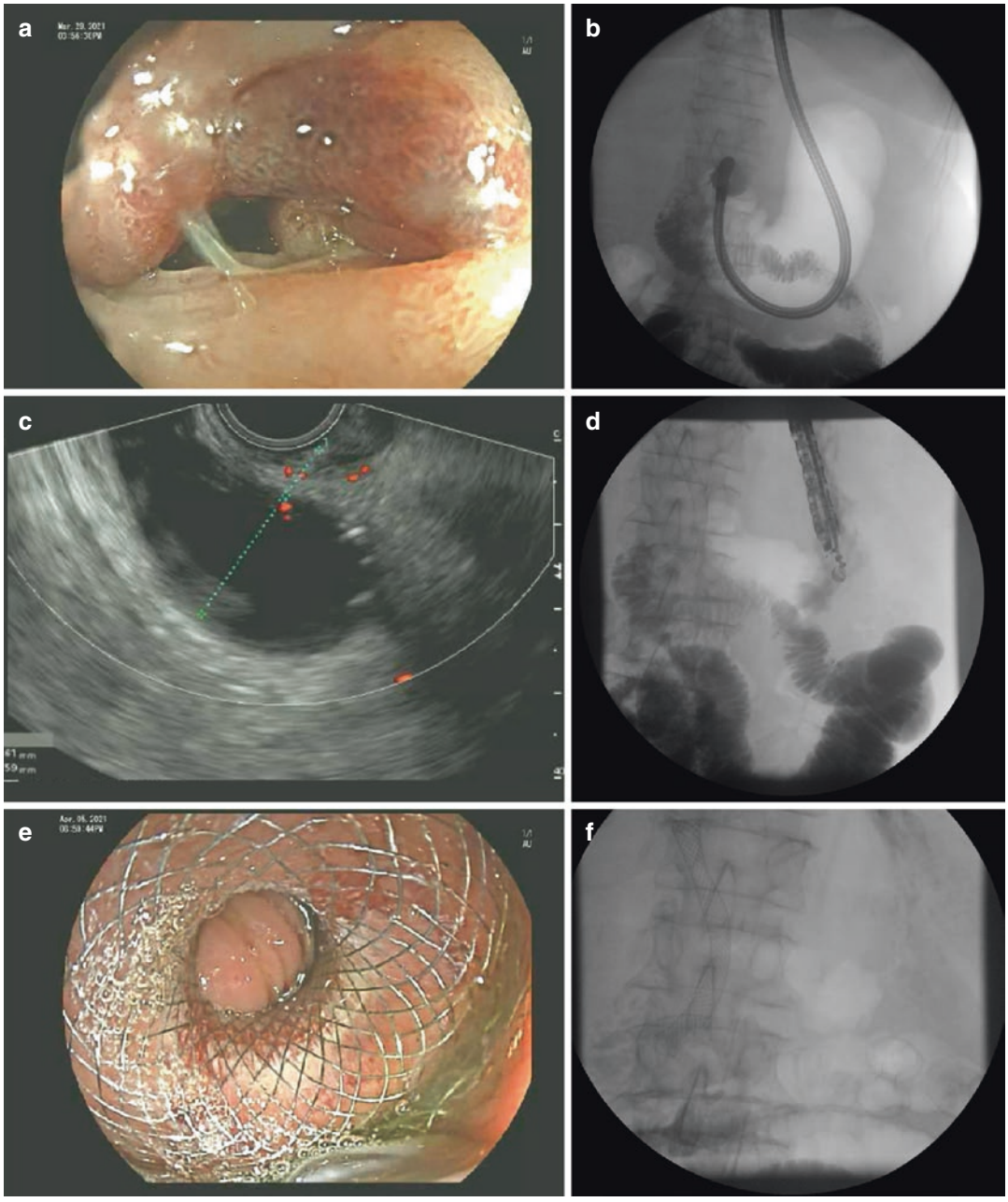

Fig. 15.4 EUS-guided gastroenterostomy (EUS-GE). (**a**) Endoscopic and (**b**) fluoroscopic views of guidewire passage across a severe duodenal stricture in the second portion of the duodenum. (**c**) Endosonographic and (**d**) fluoroscopic views of LAMS deployment. (**e**) Endoscopic and (**f**) fluoroscopic views of completed EUS-GE

advanced across the FNA needle and advanced into the jejunum, and a LAMS is subsequently deployed over the guidewire, thus creating the gastroenterostomy. In a different variation of this technique known as the rendezvous EUS-GE method, the puncturing guidewire can be trapped in the dilating balloon and then pulled back through the duodenal obstruction and out of the mouth, and a LAMS is subsequently deployed over the guidewire.

In Japan, a novel double balloon device (EUS-guided balloon-occluded gastrojejunostomy bypass; EPASS) was developed by Itoi et al. specifically to facilitate EUS-GE [39–41]. The device is not commercially available in the USA. The device consists of two balloons, connected by an enteric tube. Using this technique, a 0.089 inch guidewire is first passed as far into the small bowel as possible under standard endoscopy. The endoscope is exchanged over the guidewire, and subsequently the double balloon enteral tube is advanced over a guidewire into the small bowel. The two balloons are positioned in the duodenum and jejunum in an area adjacent to the stomach and then inflated using saline and contrast in order to anchor the small bowel. A mixture of saline and contrast is then injected into the intervening small bowel between the two balloons via the enteric tube, thus distending and stabilizing the segment of small bowel lumen. Subsequently, the echoendoscope is introduced and freehand EUS-GE is performed using an electrocautery-enhanced LAMS to create the gastroenterostomy.

EUS-GE can be combined with EUS-guided biliary drainage to allow for same session double endoscopic bypass for combined malignant gastric outlet obstruction and biliary obstruction [42, 43].

We routinely hospitalize all patients who undergo EUS-GE for observation following the procedure and prescribe a 7-day course of broad-spectrum antibiotics. For those EUS-GE patients who survive beyond 6 months, we consider repeat endoscopy to exchange the LAMS given concern regarding breakdown of the plastic coating within the metal stent, which can subsequently result in tissue ingrowth and eventual stent obstruction.

Outcomes and Efficacy

Since the early EUS-GE work using LAMS starting in 2012, multiple studies have evaluated the outcomes and efficacy of EUS-GE in the setting of mGOO, as well as comparing EUS-GE versus surgical gastrojejunostomy and versus enteral stent placement [39, 44, 45]. However, the literature has generally been sparse with regard to EUS-GE and the procedure has yet to achieve widespread adoption for multiple reasons including its technical difficulty, procedural risks, and lack of standardization.

The safety and efficacy of EUS-GE were reported in a recent systematic review and meta-analysis by McCarty et al. [46]. A total of 5 large studies comprising of 199 patients were included in the analysis, which included four retrospective studies and one prospective study [25, 47–50]. Among the patients included, 78% were patients with mGOO, and the majority (67%) were performed using a direct EUS-GE method, followed by 18% performed using a balloon-assisted method and 10% performed using the EPASS device. Immediate technical success was achieved in 92.9%, with clinical success achieved in 90.1%. Serious adverse events occurred in 5.6% of cases, related to perforation, peritonitis, bleeding, and abdominal pain. The overall adverse event rate was reported to be 10.6%. Over a mean follow-up period of 4.3 months, the re-intervention rate was 11.4%.

Only one study thus far has directly compared the efficacy of various EUS-GE techniques and was reported by Chen et al. [48] The study included a total of 74 patients from seven centers (six from the USA, one from Europe), of which 52 underwent direct EUS-GE, and 22 underwent balloon-assisted EUS-GE. The study showed similar technical success (94.2% vs 90.9%), clinical success (92.3% vs 90.9%), and adverse events (5.8% vs 9.1%) between the direct and balloon-assisted groups. Postprocedure length of stay, need for re-intervention, and survival were similar between the two groups. However, mean procedure time was significantly shorter with the direct EUS-GE technique compared to the balloon-assisted technique (35.7 vs 89.9 min), leading the authors to suggest that this may be the preferred method for EUS-GE.

EUS-GE Versus Surgical Gastrojejunostomy

Several studies have compared EUS-GE versus surgical gastrojejunostomy for the management

of mGOO [51, 52]. Overall, they suggest that EUS-GE is a non-inferior and less invasive alternative to surgical gastrojejunostomy.

Khashab et al. reported a multicenter retrospective study comparing 30 patients who underwent EUS-GE versus 63 patients who underwent surgical gastrojejunostomy [51]. Technical success was significantly higher in the surgical gastrojejunostomy group compared with EUS-GE (100% vs 87%). However, there was no statistically significant difference in clinical success (90% vs 87%), adverse events (25% vs 16%), length of hospital stay (12 vs 11.6 days), rate of recurrence (14% vs 3%), or time to re-intervention (121 vs 88 days) between the surgical gastrojejunostomy and EUS-GE groups.

Similarly, Perez-Miranda et al. reported a multicenter retrospective study comparing 25 patients who underwent EUS-GE versus 29 patients who underwent laparoscopic gastrojejunostomy [52]. There was no statistically significant difference in technical success (100% vs 88%) or clinical success (90% vs 84%) between the surgical gastrojejunostomy and EUS-GE groups. However, surgical gastrojejunostomy was associated with increased procedure time (178 vs 77 min), higher adverse events (41% vs 12%), and higher estimated costs ($14,778.80 vs $4515.00) compared to EUS-GE.

EUS-GE Versus Enteral Stents

Several studies have compared EUS-GE versus enteral stenting for the management of mGOO [25, 53]. Overall, they suggest that EUS-GE may be offered for select patients with mGOO in centers with extensive experience in the procedure.

Chen et al. reported a multicenter retrospective study comparing 30 patients who underwent EUS-GE from 2013 to 2015 versus 52 patients who underwent enteral stent placement from 2008 to 2010. The study showed no statistically significant difference in technical success (86.7% vs 94.2%), clinical success (83.3% vs 67.3%), and adverse events (16.7% vs 11.5%) between the EUS-GE and enteral stent groups. However, symptom recurrence and need for re-intervention were significantly lower in the EUS-GE group compared to the enteral stent group (4.0% vs 28.6%), and on multivariable analysis, enteral stent placement was independently associated with need for re-intervention.

Recently, our group reported a more contemporary experience comparing the clinical outcomes and adverse events between EUS-GE and enteral stent placement in patients with mGOO [25]. In an effort to minimize heterogeneity among existing stents and techniques, we compared 22 patients who underwent EUS-GE specifically using the electrocautery-enhanced AXIOS LAMS, versus 78 patients who underwent enteral stent placement specifically using current generation enteral stents (Boston Scientific WallFlex or Cook Evolution). Among these patients, 50.0% had ascites, and 50.0% had evidence of peritoneal carcinomatosis on cross-sectional abdominal imaging. Technical success was achieved in 100% in both EUS-GE and enteral stent groups. However, initial clinical success was higher among patients undergoing EUS-GE compared to enteral stent placement (95.8% vs 76.3%, $p = 0.042$), with a trend towards lower number of adverse events (20.8% vs 40.2%, $p = 0.098$). Additionally, a lower rate of stent failure requiring repeat intervention was observed among patients undergoing EUS-GE compared to enteral stent placement (8.3% vs 32.0%, $p = 0.021$). Kaplan–Meier survival curve analysis furthermore demonstrated greater stent durability among patients who underwent EUS-GE ($p = 0.013$). The length of hospital stay was similar between the two procedures, with no reported incidences of postprocedure ileus.

As previously mentioned, a "double bypass" can be performed endoscopically, using a combination of EUS-GE and EUS-guided choledochoduodenostomy, to allow for same session endoscopic management of combined mGOO and malignant biliary obstruction. This was first demonstrated by our group and subsequently in a small case series [42, 43].

Adverse Events

LAMS misdeployment resulting in perforation is currently the most feared adverse event in EUS-GE and is the single adverse event that has most hindered the standardization of the technique and limited both its adoption and dissemination. Failed electrocautery-enhanced LAMS puncture and subsequent LAMS misdeployment can result in perforation of both the gastric and jejunal lumens. Even a minor slippage of the LAMS can result in pneumoperitoneum and peritonitis. While gastric perforation can typically be endoscopically closed without difficulty, the jejunal perforation is often not endoscopically accessible. As such, salvage of a failed EUS-GE can be an arduous task, sometimes requiring NOTES (natural orifice transluminal endoscopic surgery) rescue with direct endoscopic examination of the peritoneal cavity [54, 55]. An unsuccessful salvage results in either emergency surgery or can be fatal. Therefore, fear of LAMS misdeployment and perforation has limited EUS-GE to only select tertiary care centers, with limited training opportunities and an undefined learning curve.

The rate of LAMS misdeployment and/or perforation varies from the available studies, ranging from 6.8% reported by Chen et al. to up to 36% reported by Perez-Miranda et al. [52, 53] In our study, misdeployment resulting in perforation occurred in 8.3% of EUS-GE cases [25]. In the reported literature, most cases of misdeployment were salvaged endoscopically; however, occasionally surgical intervention was necessary.

Other adverse events related to EUS-GE include hemoperitoneum, LAMS migration, and LAMS tissue ingrowth. Hemoperitoneum is likely due to inadvertent puncture of extraluminal vessels during LAMS deployment and can be severe, requiring urgent angiography and embolization. LAMS migration has been uncommonly described. Finally, LAMS tissue ingrowth has been described among patients who survived greater than 6–9 months after initial LAMS placement. This is due to the eventual breakdown of the plastic covering within the LAMS, which results in the stent becoming uncovered. In our study, LAMS mesh erosion occurred in 4.2% of EUS-GE cases and was managed with stent replacement [25].

Venting Gastrostomy

Placement of a venting gastrostomy tube is indicated where all available surgical and endoscopic options have been exhausted. This technique is usually reserved as a "last resort," given that venting gastrostomy tube placement does not provide nutrition to the patient. Nutritional supplementation will be necessary with either separate jejunostomy placement, or initiation of total parenteral nutrition (TPN), the latter of which is controversial due to risks of infection and ethical questions regarding futility.

Various endoscopic and radiographic techniques of gastrostomy tube placement have been described [56]. In the traditional "pull" technique, an upper endoscopy is first performed, and a suitable location is identified via transillumination or manual palpation in the left upper abdomen. A finder needle is placed into the stomach under endoscopic visualization, and a guidewire is passed percutaneously into the stomach. The guidewire is endoscopically grasped and pulled out through the patient's mouth. A skin incision is made at the guidewire entry site. The guidewire is then attached to a gastrostomy tube at the oral side, and the guidewire is pulled from the abdomen side, such that the tube traverses down the patient's mouth, esophagus, and proximal stomach before exiting via the abdominal skin incision. Typically, a large caliber gastrostomy tube (i.e. 24-French) is preferred for venting purposes to reduce the risk of the tube being clogged with solid gastric contents.

Following tube placement, patients experience immediate improvement in symptoms due to complete decompression of the stomach. However, patients typically are instructed to take predominantly a liquid diet, for fear of clogging the gastrostomy tube. Recently, a large caliber

aspiration tube (V-Tube, Aspire Bariatrics, King of Prussia, PA) has been approved for use in gastric decompression [57]. Originally developed for endoscopic bariatric therapy, the tube is 28-French in diameter, with a fenestrated intragastric portion that sits in the gastric fundus. The purpose of the device is to allow patients access to a regular diet with decreased risk of clogging.

The clinical efficacy of decompressive gastrostomy is well-documented, with approximately 90% rate of symptom relief and avoidance of nasogastric decompression [58, 59]. Adverse events related to gastrostomy include skin-site issues such as skin infection, overgrowth of granulation tissue, and leakage of gastric contents, and tube-related issues such as clogging, accidental dislodgement, and the "buried bumper syndrome." In a study comparing radiographic versus endoscopic gastrostomy, radiographic gastrostomy was noted to have higher 30-day complication rates than endoscopic gastrostomy (23% vs 11%), which included infection and inadvertent tube removal [60]. Ascites is traditionally considered a relative contraindication to gastrostomy tube placement; however, paracentesis prior to the procedure may facilitate successful placement with low adverse event rates [61].

Special Considerations

mGOO in the Post-Whipple Anatomy

The management of mGOO is more challenging in the post-Whipple patient due to the postsurgical anatomy, and options are limited in this setting, especially as mGOO often occurs in conjunction with delayed gastric emptying [62]. When mGOO arises at the level of the gastrojejunostomy, endoscopic options include either enteral stent placement (into alimentary +/− pancreaticobiliary limbs), or venting gastrostomy tube placement.

Delayed Gastric Emptying

Approximately 60% of patients with pancreatic cancer have evidence of delayed gastric emptying, without evidence of direct tumor invasion [63]. This is believed to be due to tumor infiltration into the nerve plexuses. The presenting symptoms may mimic those of mGOO, leading to progressive anorexia, nausea, and vomiting. The diagnosis can be made either on a gastric emptying study or as a diagnosis of exclusion when endoscopically ruling out mechanical obstruction. In these cases, enteral stent placement or gastrojejunostomy is ineffective in relieving symptoms and should be avoided.

Delayed gastric emptying in the setting of pancreatic cancer is often challenging to manage. Prokinetic agents such as metoclopramide may be beneficial [63]. However, patients with delayed gastric emptying will often require decompressive (venting) gastrostomy tube placement. A combined gastrostomy/jejunostomy tube can palliate both symptoms of delayed gastric emptying, as well as provide postpyloric enteral nutrition. However, combined tubes may fail due to reflux of the jejunostomy attachment back into the stomach, requiring endoscopic revision. As such, in our practice, a venting gastrostomy tube placement is often combined either with a separate jejunostomy tube placement (placed either percutaneously via interventional radiology, or surgically) or with initiation of total parenteral nutrition (TPN) in patients who cannot undergo jejunostomy tube placement.

Summary and Management Algorithm

Malignant GOO is both a distressing condition for the patient and a therapeutic challenge for the gastroenterologist and oncologist. Until recently, mGOO was treated either with surgical gastroenterostomy or enteral stent placement. Advancements in therapeutic EUS have allowed for the development of novel procedures such as EUS-GE, an endoscopic analogue to surgical gastroenterostomy, allowing for complete enteral bypass around the region of the malignancy without the substantial morbidity and mortality associated with surgical intervention in complex and often severely ill oncological patients. Table 15.3 summarizes the currently available treatment modalities.

Table 15.3 Comparison of treatment modalities in the management of malignant gastric outlet obstruction

Modality	Benefits	Risks
Surgical gastrojejunostomy	• Standard palliative surgical option • Longest durability, best option for patients with good performance status and reasonable life expectancy • May be combined with operative biliary bypass	• Most invasive • Delayed gastric emptying and postoperative ileus may occur in up to 58% of patients • Additional more serious risks include anastomotic leakage • Longest procedure-related hospital stay
Enteral stent placement (SEMS)	• Standard palliative endoscopic option • Least technically demanding, excellent technical success, and high initial clinical success • Stent malfunction can be managed with insertion of additional stents • Best option for patients with limited life expectancy or poor performance status	• Initial clinical success decreases over time, with stent malfunction and tissue in growth occurring in majority of patients beyond 6 months • Additional risks include pain, biliary obstruction, cholangitis, pancreatitis, stent migration, and perforation
EUS-guided gastroenterostomy (LAMS)	• Novel palliative endoscopic option • Endoscopic analogue to surgical gastrojejunostomy • May be considered as alternative to enteral stents in patients with reasonable life expectancy but poor surgical candidate • May be combined with EUS-guided biliary drainage	• Highly technically challenging, limited to centers of expertise • Yet to achieve widespread adoption due to procedural risks, technical difficulty, and lack of standardization • Most dreaded risk is stent misdeployment/perforation which may require surgical rescue • Additional risks include hemoperitoneum, stent migration, and tissue ingrowth
Venting gastrostomy	• Highly effective for gastric decompression	• Option of last resort, as venting gastrostomy does not allow nutrition • Risks include tube-related issues such as clogging and dislodgement, and skin-site issues such as infection and leakage

We typically advocate for the following management algorithm (Fig. 15.5). When mGOO is suspected based on either clinical history and/or cross-sectional abdominal imaging, nasogastric decompression is first performed to completely empty the stomach. During this time, consultation should be obtained with both the patient's primary medical and surgical oncologist. A frank discussion with the patient should involve the risks and benefits of surgical gastrojejunostomy, enteral stent placement, and novel strategies such as EUS-GE.

Typically, in a patient with otherwise good performance status and reasonable life expectancy, bypass with either surgical gastrojejunostomy or EUS-GE should be considered due to superior long-term durability as compared with enteral stent placement. Given its inherent risks, complex procedures such as EUS-GE should only be offered at select centers with expertise in the technique. Even in expert hands, EUS-GE has potentially serious risks of small bowel perforation and stent misdeployment, both of which can pose significant challenges to the endoscopist and which may require surgical rescue. Enteral stent placement should be reserved for cases where surgical gastrojejunostomy or EUS-GE is not possible.

When a patient is not a candidate for surgical gastrojejunostomy due to poor performance status or has limited life expectancy, either EUS-GE or enteral stenting can be considered. EUS-GE is preferred to enteral stenting, in centers with this expertise, due to better symptom control and less need for re-intervention. We recommend enteral stent placement in patients where an acceptable window cannot be identified for EUS-GE due to distance between bowel walls, intervening vascu-

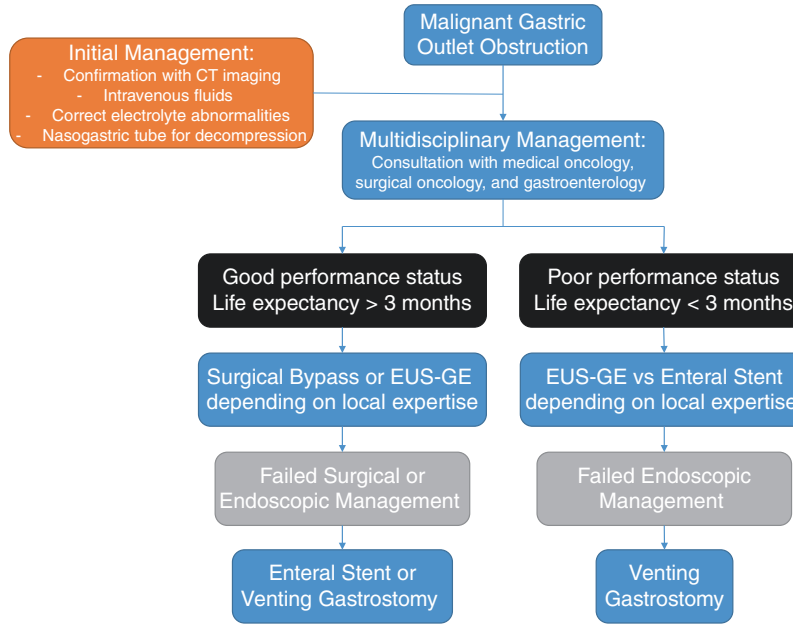

Fig. 15.5 Proposed management algorithm

lature, ascites, or other technical reasons. Venting gastrostomy is reserved only as a last resort when the patient has exhausted all surgical and endoscopic options.

Ultimately, the management of mGOO is multidisciplinary in nature. By approaching the condition in a collaborative fashion, an optimal treatment plan can be crafted and personalized based on the patient's immediate clinical situation and overall picture.

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References

1. Chandrasegaram MD, Eslick GD, Mansfield CO, et al. Endoscopic stenting versus operative gastrojejunostomy for malignant gastric outlet obstruction. Surg Endosc. 2012;26:323–9.
2. Oh SY, Edwards A, Mandelson M, et al. Survival and clinical outcome after endoscopic duodenal stent placement for malignant gastric outlet obstruction: comparison of pancreatic cancer and nonpancreatic cancer. Gastrointest Endosc. 2015;82:460–8.
3. Gudjonsson B. Cancer of the pancreas. 50 years of surgery. Cancer. 1987;60:2284–303.
4. Wong YT, Brams DM, Munson L, et al. Gastric outlet obstruction secondary to pancreatic cancer: surgical vs endoscopic palliation. Surg Endosc. 2002;16:310–2.
5. Fukami N, Anderson MA, et al. The role of endoscopy in gastroduodenal obstruction and gastroparesis. Gastrointest Endosc. 2011;74:13–21.
6. Maglinte DD, Howard TJ, Lillemoe KD, et al. Small-bowel obstruction: state-of-the-art imaging and its role in clinical management. Clin Gastroenterol Hepatol. 2008;6:130–9.
7. Upchurch E, Ragusa M, Cirocchi R. Stent placement versus surgical palliation for adults with malignant gastric outlet obstruction. Cochrane Database Syst Rev. 2018;5:CD012506.
8. Helyer L, Easson AM. Surgical approaches to malignant bowel obstruction. J Support Oncol. 2008;6:105–13.
9. Mittal A, Windsor J, Woodfield J, et al. Matched study of three methods for palliation of malignant pyloroduodenal obstruction. Br J Surg. 2004;91:205–9.
10. Al-Rashedy M, Dadibhai M, Shareif A, et al. Laparoscopic gastric bypass for gastric outlet obstruction is associated with smoother, faster recovery and shorter hospital stay compared with open surgery. J Hepato-Biliary-Pancreat Surg. 2005;12:474–8.
11. Lorusso D, Giliberti A, Bianco M, et al. Stomach-partitioning gastrojejunostomy is better than conventional gastrojejunostomy in palliative care of gastric outlet obstruction for gastric or pancreatic cancer: a meta-analysis. J Gastrointest Oncol. 2019;10:283–91.

12. Oida T, Mimatsu K, Kawasaki A, et al. Modified Devine exclusion with vertical stomach reconstruction for gastric outlet obstruction: a novel technique. J Gastrointest Surg. 2009;13:1226–32.
13. Medina-Franco H, Abarca-Perez L, Espana-Gomez N, et al. Morbidity-associated factors after gastrojejunostomy for malignant gastric outlet obstruction. Am Surg. 2007;73:871–5.
14. Watanapa P, Williamson RC. Surgical palliation for pancreatic cancer: developments during the past two decades. Br J Surg. 1992;79:8–20.
15. Yim HB, Jacobson BC, Saltzman JR, et al. Clinical outcome of the use of enteral stents for palliation of patients with malignant upper GI obstruction. Gastrointest Endosc. 2001;53:329–32.
16. Del Piano M, Ballare M, Montino F, et al. Endoscopy or surgery for malignant GI outlet obstruction? Gastrointest Endosc. 2005;61:421–6.
17. Jang S, Stevens T, Lopez R, et al. Superiority of gastrojejunostomy over endoscopic stenting for palliation of malignant gastric outlet obstruction. Clin Gastroenterol Hepatol. 2019;17:1295–302.
18. Mintziras I, Miligkos M, Wachter S, et al. Palliative surgical bypass is superior to palliative endoscopic stenting in patients with malignant gastric outlet obstruction: systematic review and meta-analysis. Surg Endosc. 2019;33:3153–64.
19. Topazian M, Ring E, Grendell J. Palliation of obstructing gastric cancer with steel mesh, self-expanding endoprostheses. Gastrointest Endosc. 1992;38:58–60.
20. Dormann A, Meisner S, Verin N, et al. Self-expanding metal stents for gastroduodenal malignancies: systematic review of their clinical effectiveness. Endoscopy. 2004;36:543–50.
21. Fiori E, Lamazza A, Volpino P, et al. Palliative management of malignant antro-pyloric strictures. Gastroenterostomy vs. endoscopic stenting. A randomized prospective trial. Anticancer Res. 2004;24:269–71.
22. Jeurnink SM, Steyerberg EW, van Hooft JE, et al. Surgical gastrojejunostomy or endoscopic stent placement for the palliation of malignant gastric outlet obstruction (SUSTENT study): a multicenter randomized trial. Gastrointest Endosc. 2010;71:490–9.
23. Mehta S, Hindmarsh A, Cheong E, et al. Prospective randomized trial of laparoscopic gastrojejunostomy versus duodenal stenting for malignant gastric outflow obstruction. Surg Endosc. 2006;20:239–42.
24. van Hooft JE, Uitdehaag MJ, Bruno MJ, et al. Efficacy and safety of the new WallFlex enteral stent in palliative treatment of malignant gastric outlet obstruction (DUOFLEX study): a prospective multicenter study. Gastrointest Endosc. 2009;69:1059–66.
25. 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;33:3404–11.
26. No JH, Kim SW, Lim CH, et al. Long-term outcome of palliative therapy for gastric outlet obstruction caused by unresectable gastric cancer in patients with good performance status: endoscopic stenting versus surgery. Gastrointest Endosc. 2013;78:55–62.
27. Gaidos JK, Draganov PV. Treatment of malignant gastric outlet obstruction with endoscopically placed self-expandable metal stents. World J Gastroenterol. 2009;15:4365–71.
28. Piesman M, Kozarek RA, Brandabur JJ, et al. Improved oral intake after palliative duodenal stenting for malignant obstruction: a prospective multicenter clinical trial. Am J Gastroenterol. 2009;104:2404–11.
29. Sasaki T, Isayama H, Nakai Y, et al. Clinical outcomes of secondary gastroduodenal self-expandable metallic stent placement by stent-in-stent technique for malignant gastric outlet obstruction. Dig Endosc. 2015;27:37–43.
30. Kim CG, Choi IJ, Lee JY, et al. Covered versus uncovered self-expandable metallic stents for palliation of malignant pyloric obstruction in gastric cancer patients: a randomized, prospective study. Gastrointest Endosc. 2010;72:25–32.
31. Ge PS, Watson RR, Chen DC, Muthusamy VR. Delayed migration of a wallflex enteral stent resulting in jejunal perforation. Case Rep Gastrointest Med. 2013;2013:652597].
32. Liu SY, Mao AW, Jia YP, et al. Placement of a duodenal stents bridge the duodenal papilla may predispose to acute pancreatitis. Hepato-Gastroenterology. 2014;61:475–9.
33. Hamada T, Nakai Y, Isayama H, et al. Duodenal metal stent placement is a risk factor for biliary metal stent dysfunction: an analysis using a time-dependent covariate. Surg Endosc. 2013;27:1243–8.
34. Zheng B, Wang X, Ma B, et al. Endoscopic stenting versus gastrojejunostomy for palliation of malignant gastric outlet obstruction. Dig Endosc. 2012;24:71–8.
35. Mortenson MM, Ho HS, Bold RJ. An analysis of cost and clinical outcome in palliation for advanced pancreatic cancer. Am J Surg. 2005;190:406–11.
36. Johnsson E, Thune A, Liedman B. Palliation of malignant gastroduodenal obstruction with open surgical bypass or endoscopic stenting: clinical outcome and health economic evaluation. World J Surg. 2004;28:812–7.
37. Siddiqui A, Spechler SJ, Huerta S. Surgical bypass versus endoscopic stenting for malignant gastroduodenal obstruction: a decision analysis. Dig Dis Sci. 2007;52:276–81.
38. Irani S, Itoi T, Baron TH, et al. EUS-guided gastroenterostomy: techniques from East to West. VideoGIE. 2020;5:48–50.
39. Itoi T, Itokawa F, Uraoka T, et al. Novel EUS-guided gastrojejunostomy technique using a new double-balloon enteric tube and lumen-apposing metal stent (with videos). Gastrointest Endosc. 2013;78:934–9.
40. 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;65:193–5.

41. Itoi T, Tsuchiya T, Tonozuka R, et al. Novel EUS-guided double-balloon-occluded gastrojejunostomy bypass. Gastrointest Endosc. 2016;83:461–2.
42. Abidi WM, Thompson CC. Endoscopic choledochoduodenostomy and gastrojejunostomy in the treatment of biliary and duodenal obstruction. Gastrointest Endosc. 2016;83:1287–8.
43. Brewer Gutierrez OI, Nieto J, Irani S, et al. Double endoscopic bypass for gastric outlet obstruction and biliary obstruction. Endosc Int Open. 2017;5:893–9.
44. Binmoeller KF, Shah JN. Endoscopic ultrasound-guided gastroenterostomy using novel tools designed for transluminal therapy: a porcine study. Endoscopy. 2012;44:499–503.
45. Khashab MA, Kumbhari V, Grimm IS, et al. EUS-guided gastroenterostomy: the first U.S. clinical experience (with video). Gastrointest Endosc. 2015;82:932–8.
46. 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;7:1474–82.
47. Itoi T, Baron TH, Khashab MA, et al. Technical review of endoscopic ultrasonography-guided gastroenterostomy in 2017. Dig Endosc. 2017;29:495–502.
48. Chen YI, Kunda R, Storm AC, et al. EUS-guided gastroenterostomy: a multicenter study comparing the direct and balloon-assisted techniques. Gastrointest Endosc. 2018;87:1215–21.
49. Kerdsirichairat T, Irani S, Yang J, et al. Durability and long-term outcomes of direct EUS-guided gastroenterostomy using lumen-apposing metal stents for gastric outlet obstruction. Endosc Int Open. 2019;7:144–50.
50. Tyberg A, Perez-Miranda M, Sanchez-Ocana R, et al. Endoscopic ultrasound-guided gastrojejunostomy with a lumen-apposing metal stent: a multicenter, international experience. Endosc Int Open. 2016;4:276–81.
51. Khashab MA, Bukhari M, Baron TH, et al. International multicenter comparative trial of endoscopic ultrasonography-guided gastroenterostomy versus surgical gastrojejunostomy for the treatment of malignant gastric outlet obstruction. Endosc Int Open. 2017;5:275–81.
52. Perez-Miranda M, Tyberg A, Poletto D, et al. EUS-guided gastrojejunostomy versus laparoscopic gastrojejunostomy: an international collaborative study. J Clin Gastroenterol. 2017;51:896–9.
53. Chen YI, Itoi T, Baron TH, et al. EUS-guided gastroenterostomy is comparable to enteral stenting with fewer re-interventions in malignant gastric outlet obstruction. Surg Endosc. 2017;31:2946–52.
54. Sanchez-Ocana R, Penas-Herrero I, Gil-Simon P, et al. Natural orifice transluminal endoscopic surgery salvage of direct EUS-guided gastrojejunostomy. VideoGIE. 2017;2:346–8.
55. James TW, Grimm IS, Baron TH. Intraperitoneal echoendoscopy for rescue of a gastrojejunal anastomosis. VideoGIE. 2019;4:528–9.
56. Eisen GM, Baron TH, Dominitz JA, et al. Role of endoscopy in enteral feeding. Gastrointest Endosc. 2002;55:794–7.
57. Chang M, Anand G, Fehmi S, et al. Novel palliative gastric venting using a bariatric gastric drainage tube for cancer patients with malignant bowel obstruction in advanced ovarian cancer patients. Gastrointest Endosc. 2017;85:459–60.
58. Laval G, Arvieux C, Stefani L, et al. Protocol for the treatment of malignant inoperable bowel obstruction: a prospective study of 80 cases at Grenoble University Hospital Center. J Pain Symptom Manag. 2006;31:502–12.
59. Pothuri B, Montemarano M, Gerardi M, et al. Percutaneous endoscopic gastrostomy tube placement in patients with malignant bowel obstruction due to ovarian carcinoma. Gynecol Oncol. 2005;96:330–4.
60. Silas AM, Pearce LF, Lestina LS, et al. Percutaneous radiologic gastrostomy versus percutaneous endoscopic gastrostomy: a comparison of indications, complications and outcomes in 370 patients. Eur J Radiol. 2005;56:84–90.
61. Ryan JM, Hahn PF, Mueller PR. Performing radiologic gastrostomy or gastrojejunostomy in patients with malignant ascites. AJR Am J Roentgenol. 1998;171:1003–6.
62. Kwong WT, Fehmi SM, Lowy AM, et al. Enteral stenting for gastric outlet obstruction and afferent limb syndrome following pancreaticoduodenectomy. Ann Gastroenterol. 2014;27:413–7.
63. Barkin JS, Goldberg RI, Sfakianakis GN, et al. Pancreatic carcinoma is associated with delayed gastric emptying. Dig Dis Sci. 1986;31:265–7.