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Review

Upper gastrointestinal endoscopy in the surgically altered patient

Purnima Bhat,[1,2] Arthur John Kaffes,[3,4,5] Kristoffer Lassen[6,9] and Lars Aabakken[7,8]

[1]Gastroenterology and Hepatology Unit, Canberra Hospital, [2]College of Health and Medicine, Australian National University, Canberra, [3]Interventional Endoscopy, Chris O'Brien Lifehouse, [4]AW Morrow Gastroenterology and Liver Centre, Royal Prince Alfred Hospital, [5]Department of Medicine, University of Sydney, Sydney, Australia, [6]Department of HPB Surgery, Oslo University Hospital, [7]Institute of Clinical Medicine, University of Oslo, [8]Department of Transplantation Medicine, Oslo University Hospital, Oslo and [9]Institute of Clinical Medicine, UiT The Arctic University of Norway, Tromsø, Norway

As management of upper gastrointestinal malignancies improves, and with popularization of bariatric surgery, endoscopists are likely to meet patients with altered upper gastrointestinal anatomy. Short-term, the surgery can cause complications like bleeding, leaks, and fistulas, and longer-term problems such as intestinal or biliary anastomotic strictures or biliary stones can arise, all necessitating endoscopy. In addition, the usual upper gastrointestinal pathologies can also still occur. These patients pose unique challenges. To proceed, understanding the new layout of the upper gastrointestinal tract is essential. The endoscopist, armed with a clear plan for navigation, can readily diagnose and manage most commonly occurring conditions, such as marginal ulcers and proximal anastomotic strictures with standard endoscopic instruments. With complex reconstructions involving long segments of small bowel, such as Roux-en-Y gastric bypass, utilization of balloon-assisted enteroscopy may be necessary, mandating modification of procedures such as endoscopic retrograde cholangiopancreatography. Successful endoscopic management of patients with altered anatomy will require prior planning and preparation to ensure the appropriate equipment, setting, and skill set is provided.

Key words: balloon enteroscopy, endoscopic retrograde cholangiopancreatography, fistula, marginal ulcer, Roux-en-Y gastric bypass

INTRODUCTION

SURGICAL ALTERATION OF the upper gastrointestinal (GI) tract causes anatomical and physiological changes that can result in pathology necessitating endoscopy, in addition to the added complexity of endoscopic access for regular diseases. Improved staging and surgical techniques for malignancies have dramatically increased the number of patients presenting for GI endoscopy with altered anatomy. As global obesity rates grow, the number of weight-loss procedures being performed have dramatically risen. Over 558,000 procedures are performed per year worldwide, mostly in the United States, which has a population obesity rate of over 33%.[1,2] Knowledge of the variants of altered anatomy from these procedures is essential to every endoscopist, as it is to be expected that most will encounter these patients. Surgically altered anatomy presents a unique set of challenges for the unprepared endoscopist. Here we summarize the most common conditions and provide a guide to endoscopic interpretation and management (Fig. 1).

Corresponding: Purnima Bhat, Gastroenterology and Hepatology Unit, Canberra Hospital, Yamba Drive, Garran, ACT 2605, Australia. Email: purnima.bhat@anu.edu.au
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NONBARIATRIC SURGICAL PROCEDURES

Esophageal resection

GI pathology

TO CURE ESOPHAGEAL cancer, some, or all, of the esophagus may be resected (Table 1). The stomach, often stapled into a tube, is then pulled up into the chest, or a jejunal or colonic segment is interpositioned to recreate an esophagus. Postsurgical perianastomotic leak occurs in 10–14% of patients.[3] Longer term, patients may present with dysphagia or, especially after gastric pull-up, reflux. Anastomotic stenosis is seen in 12–33%.[4] Adjuvant radiotherapy to the esophagus may exacerbate these effects. Disease recurrence should be considered in patients with dysphagia.

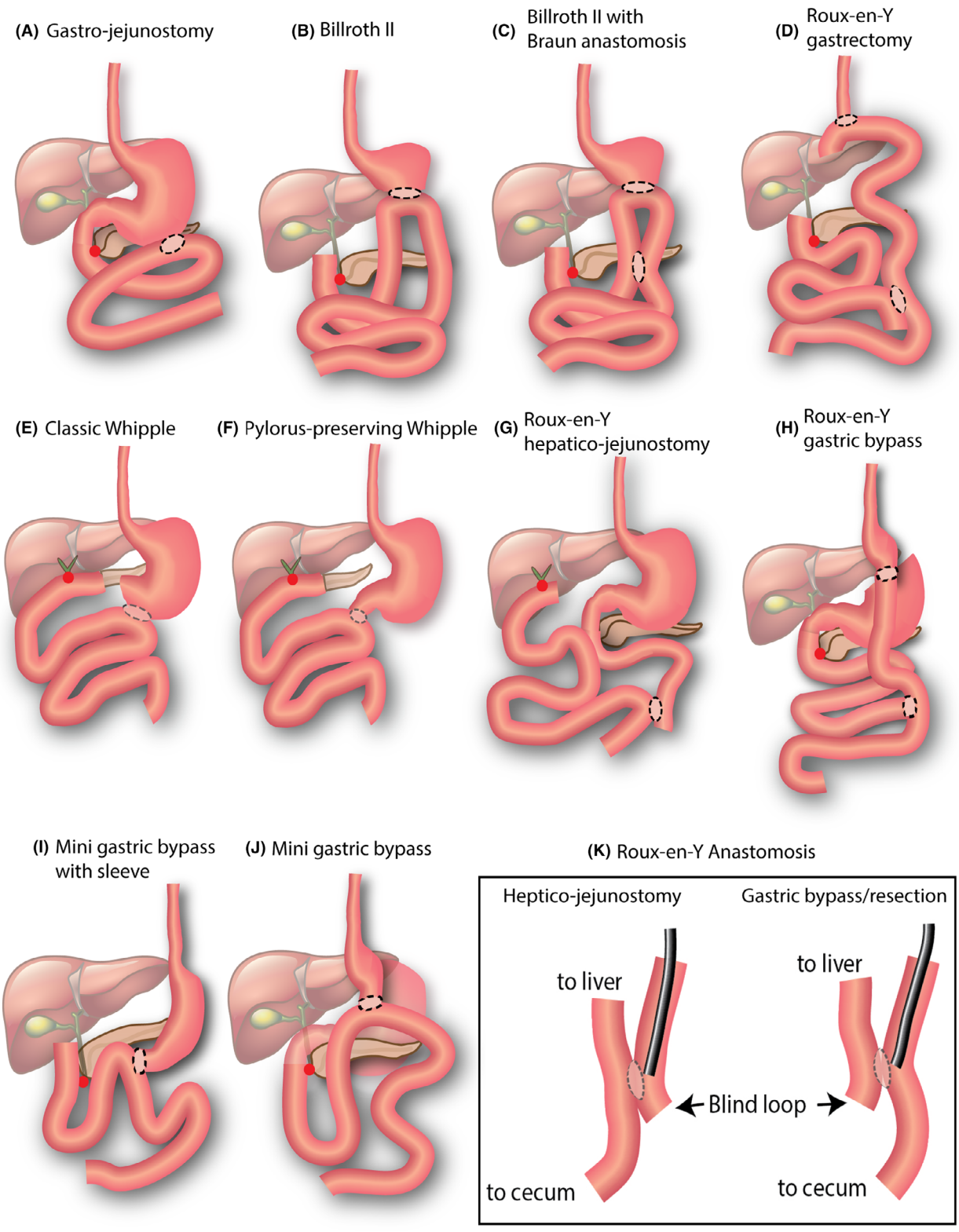

Figure 1 Altered anatomy reference chart. Red dot denotes hepaticobiliary access for endoscopic retrograde cholangiopancreatography.

Table 1 Nonbariatric upper GI surgical procedures

Surgery	Indication	Notes
Esophageal resection (partial or complete)	Esophageal cancer treatment: squamous cell carcinoma more common proximally, adenocarcinoma, more common distally.	Resected esophagus replaced by either: A. Gastric pull-up (Ivor-Lewis procedure) into the chest, with a tube fashioned from the greater curve of the stomach with a single anastomosis in the neck or chest, OR B. Interposition with colonic or jejunal segment to recreate an esophagus with an additional gastric anastomosis.
Nissen fundoplication	Gastroesophageal reflux disease failing medical therapy, or treatment of a large hiatal hernia.	The upper stomach is folded around the lower esophageal sphincter and sutured as a wrap to itself; may be circumferential (complete) or segmental (partial) fundoplication.
Gastro-jejunostomy (without resection)	Bypass of a gastric outlet obstruction from a benign or malignant stricture or obstruction at the duodenum.	The native gastric and duodenal anatomy is left intact. A side-to-side anastomosis is formed between the greater curve of the stomach and a loop of jejunum, at a variable length from the ligament of Treitz. Orientation of the jejunal loop placement can vary.
Billroth II (distal) gastrectomy with Gastro-jejunostomy	Gastric or duodenal adenocarcinoma or (rarely) for bleeding or scarred obstruction from gastric or duodenal ulcers.	Variation of the gastro-jejunostomy. The distal stomach and duodenal bulbus are resected and the remnant is anastomosed end-to-side to jejunum. The afferent limb leads to the intact duodenum. May be natural in orientation (afferent limb proximal and angulated) or at 180° (afferent limb distal). A Braun anastomosis, an additional anastomosis between the afferent and the efferent jejunal loops, is sometimes created to avoid biliary-pancreatic reflux into the stomach.
Gastric resection with a Roux-en-Y reconstruction	Gastric cancer, or occasionally for gastric ulcers. Roux-en-Y removes the biliary system further away from the stomach, reducing the incidence of biliary gastritis.	Gastrectomy. A distal limb of jejunum is mobilized and transected, connecting the remnant gastric pouch or the esophagus end-to-side. Jejunal stump is closed off. The proximal limb of jejunum (Roux limb) becomes a pancreaticobiliary limb, reconnected for bowel continuity through a jejuno-jejunal anastomosis.
Pancreatoduodenectomy (Whipple procedure)	Tumors in the head of the pancreas, duodenum, or ampulla. Premalignant masses such as mucinous cystic neoplasms or intraductal papillary mucinous neoplasms, or occasionally for chronic pancreatitis.	*Classic*: pancreatic head resection, cholecystectomy, resection of the extrahepatic bile duct, duodenectomy and distal gastrectomy. *Pylorus-preserving variant*: gastric antrum and the pylorus are preserved. *Reconstruction*: the proximal end of the remnant jejunum is pulled up to a pancreatico-jejunostomy (if the remnant pancreas is preserved) and a hepatico-jejunostomy is created on the same jejunal limb, then a gastro-enterostomy or duodeno-enterostomy is created further downstream.
Hepatico-jejunostomy with Roux-en-Y reconstruction	Benign or malignant biliary strictures, as part of liver transplantation (particularly pediatric or living-related donor transplants, or in primary sclerosing cholangitis). Repair of bile ducts damaged by surgical complication or trauma. Resection of choledochal cysts.	Proximal jejunum is transected, bringing the distal end up to the liver as a biliary Roux-en-Y limb. An end-to-side anastomosis of the proximal common bile duct or sometimes the hepatic bile ducts or liver hilum to the jejunal limb is made. An entero-enteric anastomotic reconstruction of the jejunum recreates continuity.

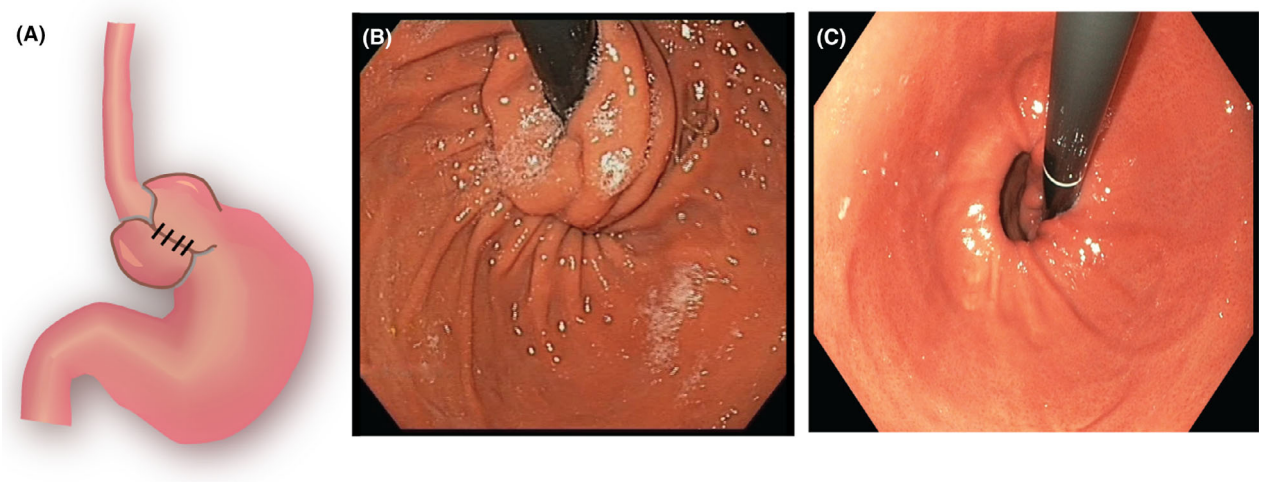

Figure 2 Nissen fundoplication. (A) Illustration of the gastric wrap created at the gastro-eosophageal junction. (B) Intact plication seen retroflexed in the stomach. (C) The plication has slipped proximally through the diaphragm.

Endoscopy

Postsurgical anastomotic leak may not be apparent endoscopically, requiring oral contrast imaging for diagnosis. Leaks can often be managed by deployment of a self-expanding covered metal stent across the anastomosis or, increasingly, by endoscopic vacuum therapy across the defect.[5] Similarly, gastric resection staple lines can fistulate, requiring management with vacuum sponges or stents.

For management of strictures, an ultraslim <6 mm ("pediatric") gastroscope may traverse a tight stricture and confirm guidewire position for safe dilatation. If the stricture is nontraversable, without knowing stricture length, fluoroscopy for guidewire placement is advisable. Dilatation of strictures, by sequential bougie or balloon dilator, or stricturoplasty, depends on stricture length and the endoscopist's preference.

Nissen fundoplication

GI pathology

While newer endoscopic procedures such as antireflux mucosectomies are emerging, with increasing success,[6,7] most patients with intractable reflux will still undergo a fundoplication (Fig. 2A). The gastric fundus is wrapped around the gastro-eosophageal junction (GOJ) to increase sphincter pressure and confine the stomach to the abdomen (Fig. 2B). Dysmotility in the first 6 weeks postoperatively is common and is mostly self-limiting. The surgery can cause an overtight sphincter in 2% of patients,[8] presenting as dysphagia. Recurrent reflux is common, with 28% needing proton pump inhibitors[9] and 2–6% needing repeat surgery, usually for recurrence of the hiatal hernia.[10]

The fundoplication may "slip" proximally (Fig. 2C), usually causing dysphagia, or occasionally causing severe esophageal dilatation, threatening ischemia. The wrap may also "slip" distally onto the body of the stomach, causing gastric malfunctioning. Finally, it may dehisce altogether by disruption of the wrap sutures.

Endoscopy

For nonsevere symptoms, avoid early postoperative endoscopy, as the findings may not reflect the eventual surgical outcome.[11] On endoscopy, a restricted opening at the GOJ may indicate an over-tightened lower esophageal sphincter, which responds to dilatation. In a loose, or partially dehisced wrap, open folds may be seen from above at the GOJ. Ulceration from recurrent reflux may hide in GOJ folds. From the stomach, retroflexion will show the wrap as a large fold at the fundus (Fig. 2B), or show a partial dehiscence as a partial wrap. Migration of the wrap, presenting as acute pain, can cause ischemia requiring decompression endoscopically or by tube. A distally slipped Nissen will manifest as a normal proximal stomach followed by a narrow passage into the body and the antrum. In a proximally slipped Nissen, the wrap may be seen from below as disappearing up through the diaphragm orifice (Fig. 2C).

Gastro-jejunostomy (without resection)

GI pathology

Creation of a gastro-jejunostomy, usually between the gastric greater curve and the proximal jejunum, bypasses an obstructed gastric outlet (Fig. 1A). Anastomotic ulcers (marginal ulcers) occur in over 6% of patients[12] and can bleed, causing melena, hematemesis, and/or chronic iron deficiency anemia. Ulcers may also be due to anti-inflammatory drug use or *Helicobacter pylori*, but in the acute/subacute postsurgical phase, typically result from postsurgical trauma, or anastomotic ischemia. Ischemic ulcers are less likely to respond to medical or endoscopic management with clipping or injection, often necessitating reoperation. Alternatively, an endoscopic ultrasound (EUS)-guided lumen-apposing stent can replace a surgical procedure with up to 97% success.[13,14] These can obstruct from tumor or food impaction, or migrate, requiring endoscopic intervention.

Endoscopy

Endoscopy through the pylorus and duodenum is often limited to the duodenal bulb and the cause of the gastric outlet obstruction may be apparent. A surgical anastomosis is usually situated in the greater curve where two lumens of the jejunal loop will be visible: afferent and efferent, indistinguishable upon inspection (Fig. 3A).

Marginal ulcers are typically just beyond the gastric edge, often between folds and under a pool of fluid and/or blood (Fig. 3B,C). Left lateral patient position may drain content to the proximal stomach and expose the anastomosis. A cap can help visualization around folds.

For placement of an enteral feeding tube, fluoroscopy can help to identify the efferent loop heading down to the colon.

For endoscopic retrograde cholangiopancreatography (ERCP), transpyloric access to the biliary system may be obstructed, requiring retrograde access through the anastomosis into the afferent jejunal loop to the duodenum. If the length of the afferent jejunum is short, a duodenoscope or therapeutic gastroscope with a cap may reach the papilla, simplifying the papillary negotiation and accessing the full range of ERCP accessories. However, with longer loops or adhesions, balloon-assisted enteroscopy (BAE) may be needed, to ease passage and minimize intestinal perforation risk.

Entering the afferent loop from the stomach can be challenging, because it can be fixed and angulated upwards. Passage of a catheter/guidewire may be helpful, or even biopsy forceps or a dilating balloon, for reducing the angulation and offering some degree of fixation. Forward-viewing endoscopes enter the afferent loop more easily. There is no fool-proof way of determining which of the lumens is the correct one from the stomach; the other continues towards the colon. Bile in the lumen can be misleading, as it may be found in both limbs. Fluoroscopy may help to determine if the endoscope is traveling towards the liver, including visualizing the air-enterogram. If the duodenum from the retrograde approach is not visualized within 80 cm of the anastomosis, the wrong lumen may have been taken, necessitating withdrawal to the stomach to take the other (see Box 1). Accessing the pancreato-biliary system from below requires specific considerations (see Box 2).

Billroth II

GI pathology

The Billroth II procedure, comprising a distal or subtotal gastrectomy and connection end-to-side to a loop of jejunum, is used for treatment of distal gastric cancers (and historically, also peptic ulcers) (Fig. 1B). The complications are like those of a gastro-jejunostomy with an obstructed duodenal bulb. Marginal ulcers at the gastro-jejunal anastomosis can bleed dramatically (Fig. 3B,C).

Endoscopy

For access to the ampulla, the Billroth II anatomy presents the same challenges as a gastro-jejunostomy. Identification of the correct limb is dependent on its surgical orientation, often with the biliary loop proximally (Fig. 3D).

Sometimes a Braun anastomosis is fashioned by creating a distal connection between the intestinal loops to avoid bile backflow into the stomach (Fig. 1C). Once in the afferent intestinal loop, it is important to identify and deliberately not cross the second surgical raphe, which will head the scope towards the colon, or back to the stomach, instead of towards the duodenum. Fluoroscopy to help orient the scope may be very helpful. The preferred instruments are a duodenoscope or a therapeutic gastroscope with a cap, but BAE may be necessary. Using a duodenoscope allows for better access and maneuverability at the papilla, but there is a higher risk of injury to the afferent loop with the stiffer instrument during insertion.

From the duodenum, the techniques described for accessing the ampulla from the retrograde position apply (Box 2). Straight catheters with a guidewire are usually used, but needle knife access is sometimes needed. Once inside, for sphincterotomy we prefer a needle knife precut

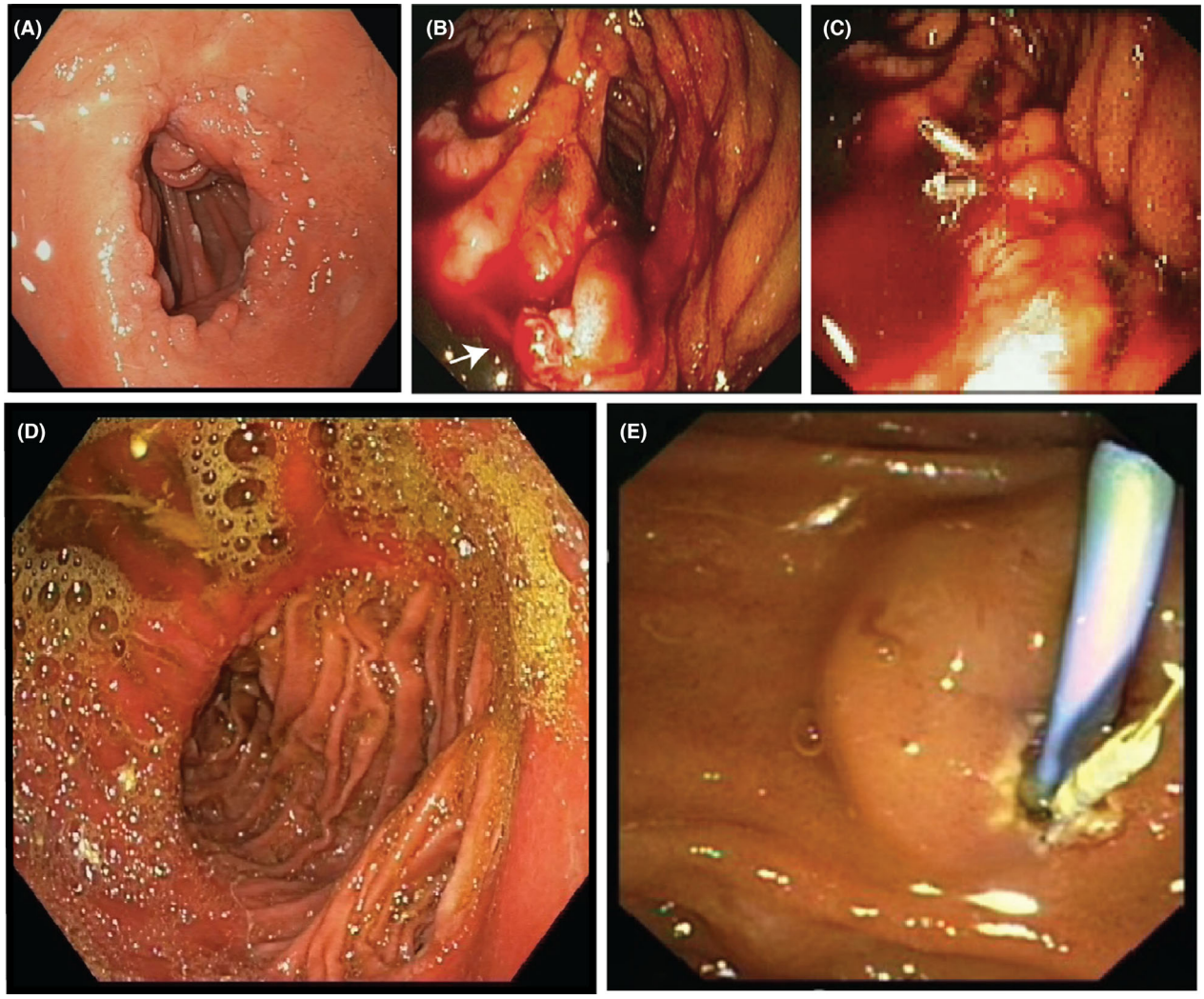

Figure 3 (A) Gastro-jejunostomy seen from the gastric aspect, usual view without gastric resection. (B) Acute arterial bleeding from a marginal ulcer (arrow) successfully treated by clipping (C). (D) Billroth II anatomy shows wide open gastro-jejunal anastomosis when there has been gastric resection. Biliary (efferent) loop proximally. (E) Retrograde access to papilla with duodenoscope. Sphincterotomy by needle knife over temporary plastic stent.

along the wire, then balloon dilation according to the indication (Fig. 3E).

Gastrectomy with Roux-en-Y reconstruction

GI pathology

With the stomach resected, usually for cancer, jejunal reconstruction by Roux-en-Y configuration removes the biliary system further from the esophagus, reducing the risk of biliary reflux (Fig. 1D). The proximal jejunum is sometimes fashioned into a pouch to recreate a reservoir for improved quality of life.[19] Nausea and vomiting are frequent presentations, which may be from altered motility, ulcers, or intestinal obstruction. Esophago-jejunal strictures causing obstruction occur in 3–7% of patients postoperatively.[20] Marginal ulcers can cause anemia in up to 16% of patients.[21] Small bowel obstruction from internal hernias, adhesions, or anastomotic stenosis can occur in up to 5% of patients.[22] Biliary stone formation occurs in over 30% of patients, likely from weight loss, and often necessitating ERCP.

Endoscopy

Endoscopic access to the altered anatomy is identical to the Roux-en-Y gastric bypass method discussed below. Access

Box 1. Choosing the right loop—negotiating small bowel limbs in altered anatomy

A standardized approach to enteroscopic access to the pancreaticobiliary system will result in improved likelihood of success. Planning is key and starts with reviewing the detailed surgical notes and notes and images from any previous endoscopic procedures. Balloon enteroscopy with a cap is recommended for almost all procedures. We found very little difference between using a single or double balloon instrument. Utilizing fluoroscopy will be of significant benefit in guiding progress through indication of direction as well as in resolving loops in long small bowel limbs. In fact, limb selection using "air-inflation" (actually, it is CO_2 inflation) enterography has been shown to improve accuracy and is of great benefit as an added tool.[15,16] Underwater enteroscopy aids safe, deep progress, but can lead to missed landmarks; judicious switching to CO_2 inflation is advised. The procedure should be defined by the serial identification of anatomical landmarks including each anastomosis, surgical raphe, and each limb at each anastomotic site. Estimating how far you have progressed is always difficult with enteroscopy, but can be useful in difficult situations.[17] If you think you have been progressing down the wrong limb, there is no recourse but to withdraw to the anastomosis and try another lumen. Leaving a catheter or wire in a limb from which you have just withdrawn can help mark it, so you don't re-enter it. As shown in Fig. 1K, with hepatico-jejunostomy with Roux-en-Y reconstruction, cross the raphe and choose the limb at the most acute angle. With gastric resection/Roux-en-Y gastric bypass: cross the raphe and take the only (nonblind) loop, usually at an angle. Once in the correct loop, the route to your target is usually not too long, and direction on fluoroscopy towards the liver will be reassuring.

to the duodenum/pancreatobiliary system with a standard duodenoscope may be possible, but normally requires BAE. There will be an esophago-jejunostomy (with or without a pouch) or a small stomach remnant, leading directly to the Gastro-jejunal anastomosis. There may be a short, blind jejunal limb at the anastomosis. The area is susceptible to ulcerations, or occasionally strictures. Dilatation of anastomotic strictures here requires guidewire placement directly visualized with an ultraslim gastroscope, or under fluoroscopy, to ensure the balloon is not in the blind limb to avoid complications.

Identification of the jejuno-jejunal anastomosis requires careful examination of a variable length of proximal jejunum. To access the pancreatobiliary system via the duodenum, the endoscopist must identify and cross the surgical raphe at the fork to intubate the only continuing limb on the other side. Retrograde-access ERCP through a straight-viewing instrument requires some adjustment to the usual ERCP techniques due to differences in angulation and instrument stability (see Box 2).

Pancreatoduodenectomy (Whipple procedure)

GI pathology

The Whipple procedure, performed for pancreatic cancers and premalignant cysts, is renowned for significant nutritional and symptomatic effects even after 12 months (Fig. 1E,F). Nausea and weight loss are the most common early manifestations. Functional obstruction with gastric retention is common and may necessitate temporary placement of a naso-jejunal nutritional tube.

Fistula or leak from the pancreatico-jejunal or hepatico-jejunal anastomoses occurs in 12–21%, leads to considerable morbidity and mortality, and may necessitate ERCP for assessment or resolution, or surgical closure.[23]

Strictures are the most common late pathology, but stones, leaks, local tumor recurrence, and even anastomotic dehiscence may be encountered. Strictures occur in 8% at the biliary anastomosis, but rarely at the pancreatic anastomosis.[24] Dilatation by ERCP is very often successful,[25] although recurrence is common.[26] Gastric and gastro-jejunal marginal ulceration can contribute to anemia. Enteral varices from postsurgical complications or venous thrombosis can appear and be extensive, requiring devascularization.

Subacute massive bleeding occurs rarely but is the main cause of early postoperative mortality. It typically stems from a pseudoaneurysm of the ligated and divided gastroduodenal artery in the presence of a pancreatic duct fistula. Importantly, patients may paradoxically present with massive hematemesis or melena as blood "drains" into the jejunum through the fistula. Significant hematemesis within 40 days of surgery should mandate immediate angiography rather than endoscopy.

Endoscopy

The gastro-enteric anastomosis is usually wide open but varies in appearance, location, and orientation depending on whether the pylorus was preserved (Fig. 4A,B). Endoscopy is commonly required post-Whipple for placement of a nutritional tube, requiring identification of the efferent limb towards the colon. This is usually confidently achieved by the fluoroscopically visualized air enterogram created

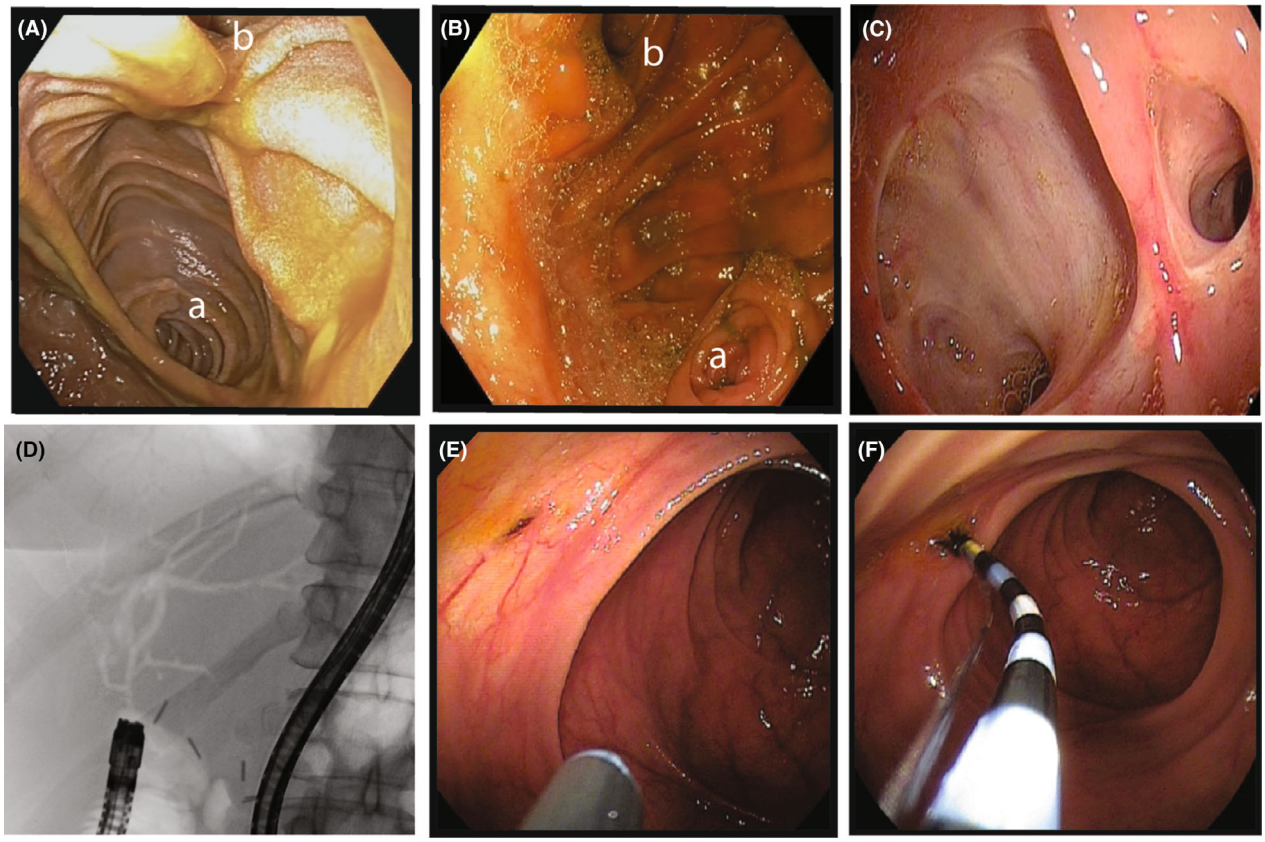

Figure 4 Whipple resection. (A) Classic Whipple, gastric anastomosis, (a) efferent loop straight ahead, (b) Biliary loop at the top, at an angle, often invisible. (B) Pylorus-preserving Whipple, (a) efferent loop at 5 o'clock, (b) biliary loop at 11 o'clock. (C) Wide open hepatico-jejunostomy at the level of the hilum. (D) An air-cholangiogram helps to identify a difficult-to-find biliary anastomosis. (E) Strictured anastomosis at an angle, which was accessed with bent sphincterotome (F).

by insufflation. A pediatric colonoscope may facilitate deep tube placement to avoid it slipping back into the stomach. In our experience, in a classic Whipple anatomy, we choose the most distal/forward-facing orifice (Fig. 4A). In pylorus-preserving Whipple anatomy, aim for the 5 o'clock lumen just beyond the pylorus (Fig. 4B). If in doubt, identify the hepatico-jejunostomy and choose the other limb.

Access to the pancreaticobiliary systems usually requires BAE, although a pediatric colonoscope or even a gastroscope can sometimes reach. If the pylorus is preserved, the stomach will appear normal, followed immediately by an end-to-side anastomosis to the jejunum. The afferent limb (usually oriented at 11 o'clock) leads to the Hepatico-jejunostomy and the pancreatico-jejunostomy (Fig. 4B). In classic Whipple resections, aim for the uppermost/retrograde lumen (Fig. 4A). The route is usually short, and rarely a challenge to intubate unless adhesions or local recurrence of malignancy causes fixation of the loops.

The hepatico-jejunostomy anastomosis can vary greatly, from widely patent to pinhole. Patent ones are susceptible to reflux cholangitis (Fig. 4C), while anastomosis with small ducts or ischemic effects are more likely to stricture, resulting in pinholes (Fig. 4E). Identification of the anastomotic orifice(s) therefore may be a challenge. Typically, a pancreatic anastomosis is close to the end of the jejunal loop, with the biliary orifice 5–10 cm downstream. Orient the search by fluoroscopy and visualization of the air-cholangiogram (Fig. 4D). The anastomosis may be hidden behind a fold, or in the case of stricture, sometimes invisible, revealed only by scarring or discoloration by submucosal sutures.

Cannulation may pose a challenge from angulation, and strictures may be very tight, even for a guidewire (Fig. 4E, F). If only a guidewire passes, meticulous needle-knife expansion of the orifice may be needed, followed by catheterization and balloon dilation. Careful choice of the

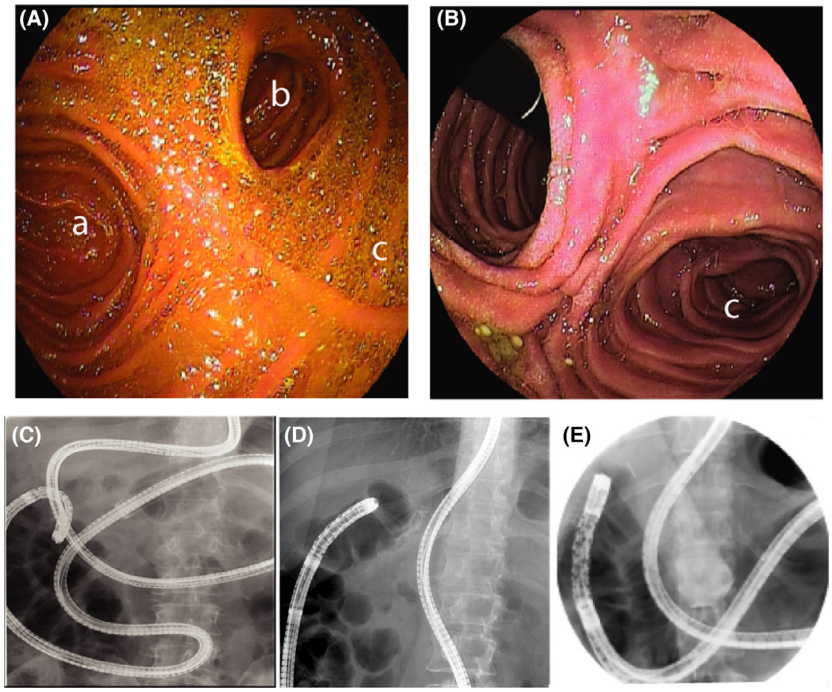

Figure 5 Hepatico-jejunostomy with Roux-en-Y reconstruction. (A) Enteroenterostomy characterized by widening of the lumen and surgical raphe separating the blind end of the proximal jejunal loop (a) from the efferent loop towards cecum (b). The biliary loop is hidden (c). (B) The inverted position reveals the biliary loop (c). Fluoroscopy guidance for enteroscopy can help to resolve large complex intestinal loops (C) leading to a straight scope (D) and promising air-enterogram towards the liver. (E) Another typical straight configuration of the endoscope once it reaches the top of the biliary limb.

balloon diameter based on duct diameter will minimize the likelihood of perforation. Beware of the possibility of separate anastomoses to segmental biliary drainage, sometimes suggested by the magnetic resonance cholangiopancreatogram appearance or the surgical report. For ERCP in nonstrictured anastomoses, a balloon catheter is normally needed for occlusion and quality cholangiograms. Balloon dilatation is commonly required for anastomotic strictures (Box 3). Where a dilatation and plastic stent placement is ineffective in opening a very stiff anastomotic stricture, a temporary metallic stent can be considered,[29] although a short or absent common hepatic duct limits its use due to the risk of dislocation and hepatic hilar obstruction.

Hepaticojejunostomy with Roux-en-Y reconstruction (HJRY)

GI pathology

Performed in liver transplantation, after resection of perihilar cholangiocarcinoma, or to repair injury to bile ducts, the HJRY can result in surgical complications, weight loss, and biliary stone pathology (Fig. 1G). These procedures rarely result in anastomotic problems at the entero-enteric anastomosis, although ulceration, and rarely obstruction, can occur. However, more than 30% of patients have biliary pathology requiring intervention.[30,31] Postoperative bile leaks occur in 30%. Biliary anastomotic strictures occur in up to 37% of cases, average 13%,[32,33] with increasing risk with small-caliber bile ducts.[34] Biliary stones may also occur.

Endoscopy

While the pancreatic system can be reached as usual from the duodenal papilla, endoscopic access to the bile ducts requires retrograde BAE via the jejunum (see Box 1). Bile staining indicates proximity to the anastomosis, recognizable by the widened lumen, a longitudinal raphe, and the presence of foam (Fig. 5A). Across the surgical raphe, one limb leads to the liver, and the other to the colon. The take-off of the biliary limb can be difficult to see but is typically at the most acute angle to the endoscope tip

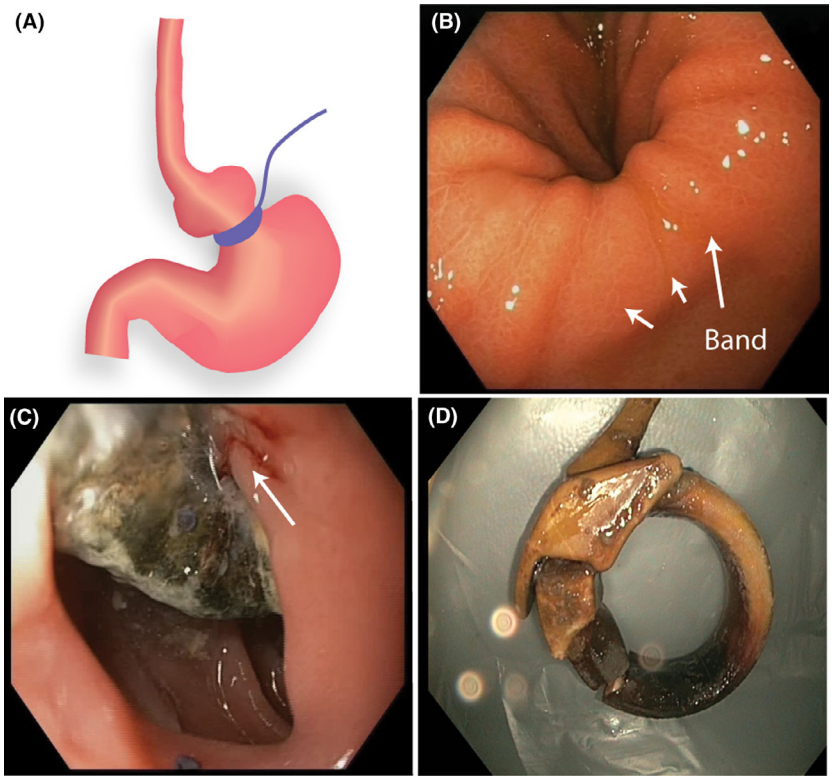

Figure 6 Gastric banding. (A) Illustration of gastric banding creating a small proximal gastric pouch. (B) Intact gastric band with circular narrowing of the proximal gastric lumen. Band impression (arrows) is seen on retroflexed view of the cardia. (C) Eroded gastric band with rubber section visible inside stomach. Mucosal erosion is seen (arrow). (D) The band was completely cut and removed endoscopically.

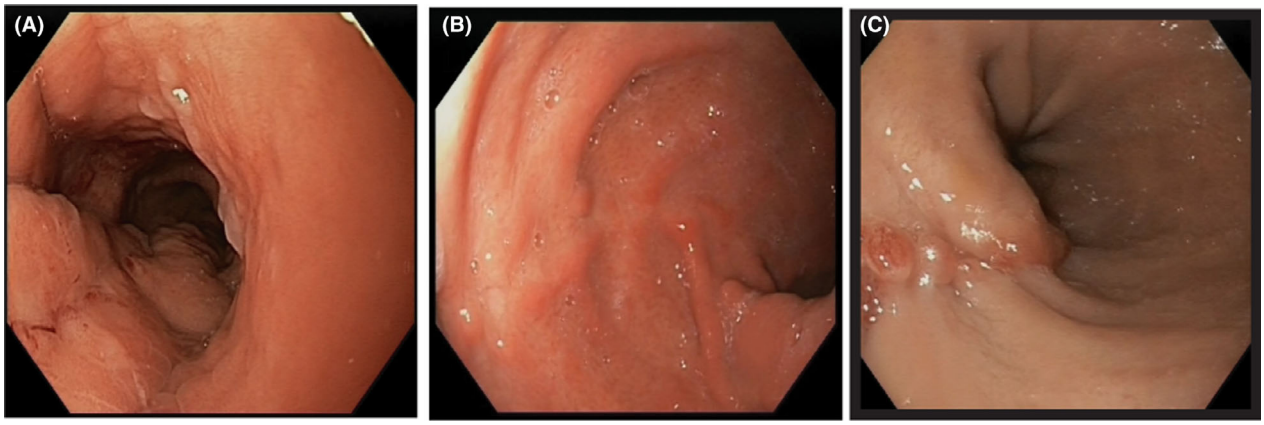

Figure 7 (A) Endoscopic sleeve gastroplasty with a typical narrow irregular lumen. (B) Laparoscopic sleeve gastrectomy scar along the inferior surface of the stomach, which may sometimes be friable (C).

(Fig. 5A,B). From there, it is usually a short loop to the liver, aided greatly by fluoroscopy and the air-enterogram pattern (Fig. 5C–E).

Identification of the hepatico-jejunal anastomosis and cannulation principles are as described for Whipple resections.

Table 2 Bariatric upper gastrointestinal (GI) surgical procedures. Indication: to achieve weight loss

Surgery	Notes
Gastric band	The gastric band is an extraluminal hollow band placed laparoscopically around the proximal stomach. The band can be accessed through a subcutaneously placed port for filling with saline, or emptying, to vary the constriction.
Sleeve gastrectomy	Using a laparoscopic approach, the greater curve of the stomach is stapled off, leaving a narrow stomach lumen about 25% of its original volume. The size of the remnant stomach is variable, with smaller volumes more efficacious but with more side-effects.
Roux-en-Y gastric bypass	The stomach is transected and closed off, leaving a small gastric pouch which is attached end-to-end to a distal segment of jejunum which is pulled up as a Roux-en-Y limb. The bypassed stomach, duodenum, and proximal jejunum are reattached further down the distal jejunum. Thus gastric, hepatic, and pancreatic secretions continue to flow into the digestive tract. The anatomy is thus similar to that of the gastric resection Roux-en-Y, but with substantially longer limbs, and with a remnant excluded stomach as a potential source of pathology.
Mini-gastric bypass	The mini bypass is a simplification of the Roux-en-Y gastric bypass. A sleeve-shaped gastric pouch at the lesser curve is created, anastomosing it end-to-side to the lower jejunum. The excluded stapled greater curve of the stomach (if not resected from an initial sleeve gastrectomy) with duodenum and jejunum intact are in continuity with the rest of the GI tract. No Roux limb is created, rather the situation is similar to a normal gastro-jejunostomy. The gastro-jejunal anastomosis may be created at a variable distance along the jejunum, but is usually placed 150–250 cm from the ligament of Treize.

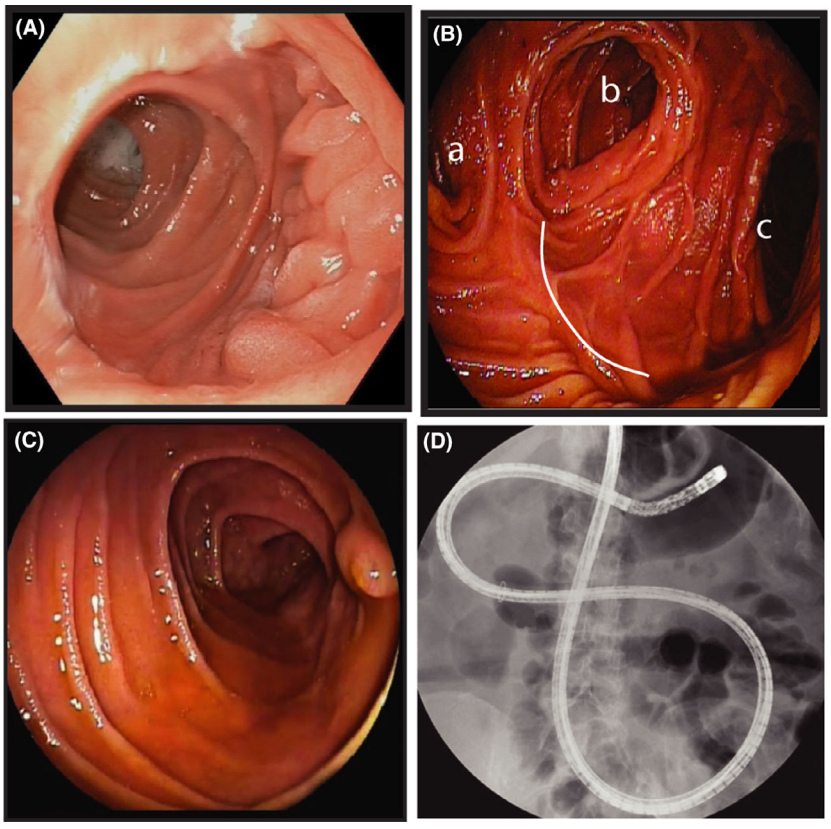

Figure 8 Roux-en-Y gastric bypass. (A) The proximal anastomosis between gastric pouch and jejunum. (B) The entero-enteric anastomosis. The efferent loop towards the cecum (a) is proximal to the surgical raphe (line), which must be crossed to access the (b) blind end of biliary limb and (c) biliary limb. (C) Retrograde position of the papilla at 2 o'clock in the second part of the duodenum. (D) Balloon enteroscope with retrograde access to air-filled stomach.

BARIATRIC SURGICAL PROCEDURES

Gastric band

GI pathology

THE GASTRIC BAND is a fluid-filled tube placed around the fundus of the stomach to create a restrictive pouch to induce satiety and weight loss (Table 2; Fig. 6A). Exacerbation of reflux is a common consequence due to the restricted pouch volume. Overdistension at meals can cause abdominal pain. Dysmotility and esophageal dilatation occur in more than half of patients, often leading to band removal.[35] GI bleeding from band erosion or band slippage can occur at any time after band placement.

Endoscopy

Endoscopy in a functioning, appropriately placed band will show a constriction to the stomach just beyond a normal gastro-esophageal junction, similar to the appearance of a hiatal hernia (Fig. 6B). Retroflexion in the stomach will show the band's anatomical placement. Eroded bands appear as foreign material emerging through the wall of the stomach (Fig. 6C). While band erosion is usually an indication for laparoscopic band removal, where a segment of the band has completely eroded through, a wire placed around the ring can cut the band and retract it into the stomach (Fig. 6D). Slipped bands may be seen as a narrowing at the GOJ where they will be unlikely to be causing restriction, and unlikely to be effective in weight loss.

Sleeve gastrectomy

GI pathology

Sleeve gastrectomy by stapled resection of the greater curve of the stomach reduces gastric volume and shapes the organ into a tube-like structure that induces satiety. Early postoperatively, there is potential for staple-line

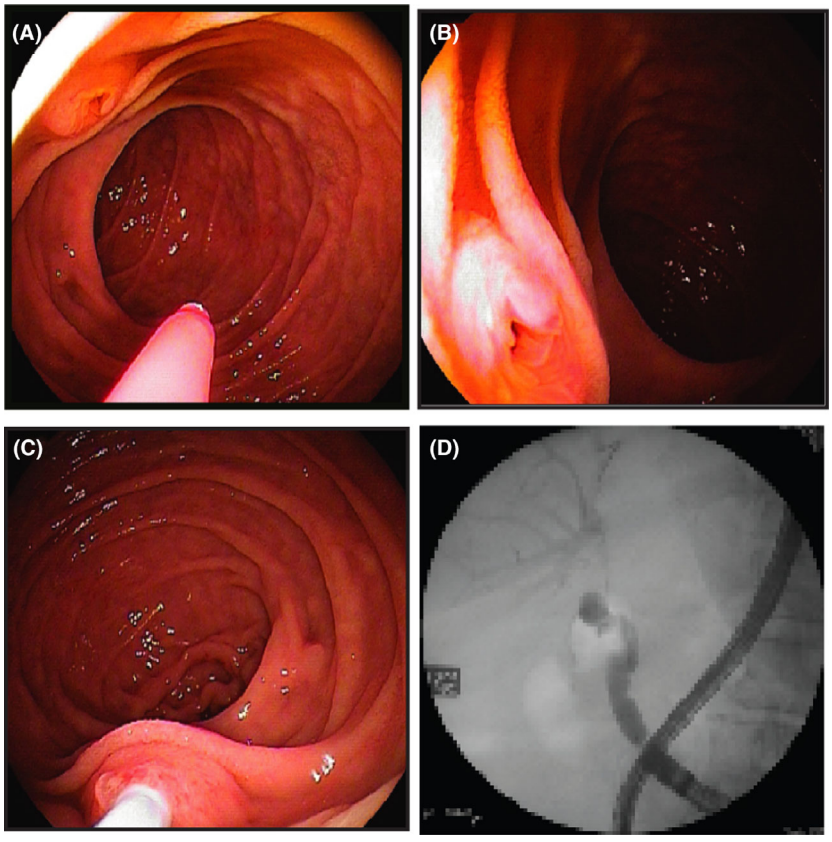

Figure 9 ERCP in Roux-en-Y gastric bypass. (A) Retrograde approach to the duodenum shows the papilla at 11 o'clock. (B) Rotated position to get papilla close to the 7 o'clock position of the enteroscopy catheter. (C) Cannulation by straight catheter and guidewire. (D) ERCP with balloon-assisted enteroscopy.

Box 2. Retrograde ERCP with a forward-viewing scope

Frequently, you will appreciate arrival in the duodenum by visualizing the pylorus from below, then retracting to find the papilla (see Fig. 9). Visualizing the papilla from below with a forward-viewing scope usually requires some searching, and acute angulation of the tip of the scope which otherwise tends to follow the lateral duodenal wall. Pull back slowly and use fluoroscopy as guidance for direction and duodenal positioning. Positioning the scope optimally is the key to gain stability; various methods have been described.[18] Once at the papilla, try positioning it at 7 o'clock, and use the cap to manipulate the direction of the papillary orifice. A straight catheter with a preloaded guidewire is the preferrable tool; bending sphincterotomes are rarely helpful with the enteroscope. Accidental wire insertion to the pancreatic duct should be maintained for double-wire technique access. If you fail to gain duct access, needle knife precut is an option, depending on the indication for the procedure and expertise. Once deep cannulation is achieved, our preferred technique for sphincterotomy is needle knife cutting alongside a wire, then balloon dilation to the required caliber.

leaks that are usually managed endoscopically, and subacutely, staple site ulceration can ensue. Longer term, the reduced gastric volume combined with the loss of the antireflux effect of the angle of His can lead to significant reflux, mandating permanent proton pump inhibitor therapy.

Endoscopic sleeve gastroplasty is an alternative approach to narrow the gastric lumen by closing off the greater curve using endoscopically placed sutures (Fig. 7A). The lumen is less restricted than in sleeve gastrectomy, suture dehiscence is common, leading to regain of weight, but reflux is much less common because the angle of His is retained.

Endoscopy

Identification of the GOJ is usually straightforward. The stomach will usually appear narrow, but the volume is variable and can expand over time. Dehisced gastroplasty sutures may be visible and possibly ulcerated. Staples are usually not visible, but a mucosal scar may be apparent along the greater curve (Fig. 7B), with mucosal hyperplastic change that sometimes looks inflamed (Fig. 7C). Leaks can be resolved by endoscopic placement of a draining stent through the fistula in more than 80% of cases, although repeated procedures may be needed.[36,37]

Roux-en-Y gastric bypass (RYGB)

GI pathology

Similar to the gastrectomy with Roux-en-Y, the RYGB separates most of the stomach and duodenum from the intestinal continuity (Fig. 1H). A small gastric pouch is left, but also the excluded part of the stomach remains in situ, adding a level of complexity. Abdominal pain from varied etiologies occurs in up to 54% of patients.[38] Marginal ulcers at the proximal anastomosis occur in about 16%. Internal herniation, although uncommon, mandates surgery.[39] Formation of a gastro-gastric fistula between the gastric pouch and the excluded stomach occurs in 1–2% of cases,[40] necessitating revision. The bypassed stomach may still develop peptic ulcers, gastritis, and gastric cancers; also, duodenal ulcers and polyps may develop. Thus, inspection of the stomach and duodenum by endoscopy is not uncommonly required. In addition, weight loss may precipitate biliary stone disease requiring ERCP.

Endoscopy

Like gastric resections with Roux-en-Y reconstructions, the approach to the duodenum in RYGB requires traversing the gastric pouch-jejunal anastomosis, almost immediately on emerging from the esophagus, into the jejunum. The small gastric pouch and anastomotic site to the jejunum must be investigated for ulcerations. The caliber of the anastomosis should be assessed (Fig. 8A) as widening removes the satiety effect of the pouch, leading to weight regain, and it may respond to endoscopic anastomotic tightening.[41]

The jejuno-jejunal anastomosis is typically 80–100 cm distal to the gastric remnant; fluoroscopically, it may be in the pelvis. If this anastomosis is missed, the enteroscope may proceed unwittingly towards the colon (Box 1). However, if the surgical raphe is clearly identified and confidently crossed, there will be only one continuing loop on the other side of it, the other being blind (Figs 1K, 8B). Beyond the surgical raphe, the scope travels retrograde from the jejunum via the ligament of Treitz to the duodenum (and excluded stomach). Retrograde access to the papilla is like the Billroth II situation, but the longer loops of the enteroscope can limit tip control and navigation (Fig. 8C). To enter the stomach, the enteroscope must traverse the pylorus from the duodenal bulb, potentially challenging because it is mobile and the access more angulated. Insertion and inflation of a large-caliber dilation balloon through the pylorus can help to anchor the stomach (Fig. 8D). Once inside, inspection of the excluded stomach may reveal ulcers, tumors, or, more frequently, biliary gastritis.

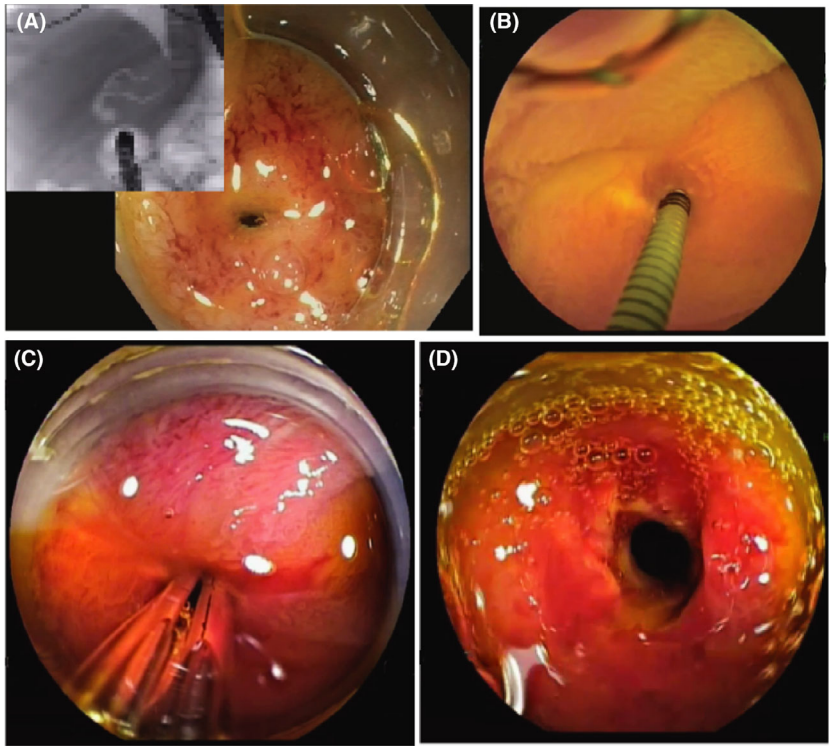

Figure 10 Dilatation of a tight biliary stricture initially requires identification of the biliary lumen, which may be very pinpoint (A). Air-cholangiogram (inset) will confirm the position. (B) Access with a guidewire permits the placement of a dilation balloon (C), leading commonly to a good outcome (D).

One-anastomosis (mini) gastric bypass

GI pathology

This simplified version of the gastric bypass is often performed after a sleeve gastrectomy for extra weight loss, or a sleeve is created during the bypass, excluding the greater curve and duodenum (Fig. 1I,J). The small-volume stomach is anastomosed further along the jejunum without creation of a Roux limb. Gallstone disease from weight loss is frequent, while anastomotic problems are rare. The excluded stomach and duodenum may have the same problems as discussed with the RYGB above, necessitating inspection of the bypassed anatomy.

Endoscopy

Reaching the papilla usually requires BAE. At the level of the gastro-enteric anastomosis, the correct limb must be chosen to head to the liver. Fluoroscopy may assist in the decision. Loops are shorter than in the RYGB, and navigation mostly easier. Duodenal navigation is similar to Billroth II but with longer loops.

Alternative approaches

While most of the altered anatomy is currently accessible by BAE, some surgical procedures and variations may be

Box 3. Identifying and dilating a tight biliary stricture

This is one of the most common procedures required in the management of longer-term complications of any surgical procedure involving bile duct anastomosis (see Fig. 10). These duct orifices can be very difficult to identify, as they may be pinhole size and/or hidden behind a fold. The use of a cap during balloon-assisted enteroscopy is essential for negotiating folds. Visualizing an air-cholangiogram with fluoroscopy can guide the search for a hidden anastomosis. A guidewire can then be inserted and a dilation balloon over it. Resilient strictures may require repeat dilatation or stenting. Plastic stent placement for 6 months provides patency at 12 months postremoval in 94% of cases.[27] Limited reports using biodegradable stents that don't need repeat procedures for removal have shown promise.[28]

nontraversable. Longer loops of intestine (e.g., in the infrequently performed "duodenal switch" procedure), and surgical adhesions may prove insurmountable barriers to per oral BAE. In addition, ERCP with a BAE may prove too challenging with the limited instrument navigation at the papilla. Alternative methods include hybrid laparoscopic access, primarily for RYGB, where a standard duodenoscope is passed through a laparoscopically placed 15 mm trochar to the proximal stomach. Per oral BAE may be laparoscopically assisted, passing the intestine gently over the enteroscope. Endoscopic access can also be created through EUS-directed transgastric ERCP: the two gastric components of an RYGB anatomy are temporarily reconnected with a lumen-apposing stent through which a standard duodenoscope can be passed to reach the papilla. EUS-guided access is also an option for other anatomical variants. Radiologically guided percutaneous transhepatic access to the biliary tree is an alternative when endoscopic access is not possible. The optimal management of these patients warrants a multidisciplinary approach through discussions with surgeons and interventional radiologists (Box 4).

Box 4. ERCP with balloon-assisted enteroscopy (BAE)

In many cases, accessing the duodenum, pancreatobiliary limbs, or excluded limbs of bowel in altered anatomy will require the use of BAE. The smaller caliber of the instrument and its flexibility and maneuverability lends itself to safe navigation through the thin-walled small intestine, which may additionally be adherent from the surgical procedures or pathology. Double-balloon enteroscopy is still the most widely-used instrument and has a longer history, reflected in most studies. It has the advantage of a second balloon on the tip of the instrument that can be used to stabilize during shortening. Using a forward-viewing instrument to perform ERCP can be challenging because there are fewer accessories available for use, the angle of the papilla on the side wall can be hard to access, and the enteroscope can be in an unstable position due to the longer lengths of small bowel that must be traversed. Lack of an elevator further complicates the navigation of accessories. Nevertheless, double-balloon enteroscopy has been shown to lead to successful ERCP in 90–98% of cases, with 4–10% adverse event rate.[42,43] Single-balloon enteroscopy is a very accessible instrument, requiring only the use of a balloon over-tube. Techniques for tip stabilization using acute tip angulation are helpful during shortening, and as very deep enteroscopy is rarely required, single-balloon enteroscopy is often a sufficient and less cumbersome option. Reported success rates are somewhat lower, at 62–76%, with lower reported adverse events rates of 6.6–8.4%,[44,45] possibly reflecting less experience with the newer instrument. Some of the main determinants of success are scope stability and depth. When the enteroscope won't advance, applying abdominal pressure and/or patient position change can help, with loop resolution confirmed by fluoroscopy.

CONCLUSION

SURGICAL ALTERATION OF the upper GI tract sometimes necessitates endoscopic intervention from resultant or concomitant pathology. Frequently, endoscopic intervention obviates the need for more invasive therapy like reoperation, and this document may assist in improving the understanding of the expected anatomy. However, variations of even the main surgical procedures are common. Detailed documentation of the procedure by the surgical team is crucial in mapping the new gut layout for planning the endoscopic procedure. It is well worth discussion with the surgeon whenever possible. Where the surgical notes are unclear, cross-sectional abdominal imaging such as computed tomography or magnetic resonance imaging may be helpful in improving the understanding of the new anatomy, and in estimating distances to the target site. High-quality upper GI endoscopy in surgically altered anatomy depends on a clear understanding of the surgery and its potential clinical outcomes, as well as the new layout of the upper GI tract.

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