INTRODUCTION
Patients who have undergone surgical procedures that altered the upper gastrointestinal (GI) anatomy are often referred for endoscopic evaluation. It is essential for gastroenterologists to understand the postoperative anatomical alterations to select the appropriate endoscope and accessories and obtain meaningful and accurate diagnostic information.

This chapter discusses the most common surgical procedures involving the upper GI tract. Technical details and common variations are described for each surgical procedure. The endoscopic correlates to anatomical alterations are described. Available surgical reports should always be reviewed before the endoscopic examination.

ANTIREFLUX PROCEDURES
Nissen Fundoplication
Fundoplication is an effective antireflux operation, performed by creating a gastric plication over the distal esophagus just proximal to the cardiosophageal junction to restore the competency of lower esophageal sphincter. This is a standard operative treatment in select patients with gastroesophageal reflux disease (GERD) (Fig. 12.1).

Fundoplication was first described by Dr. Rudolph Nissen in 1955. This procedure is frequently performed along with hiatal hernia surgery. A modified technique called a floppy Nissen fundoplication can be accomplished by shortening the wrap from 5 cm to 2 cm. Despite being more lax than a conventional Nissen fundoplication, it is equally effective for GERD management, with the additional benefit of a lower incidence of postoperative gas-bloat syndrome or dysphagia. A laparoscopic approach to this procedure has proved to be safe and reliable. Laparoscopic floppy Nissen fundoplication has become the surgical gold standard treatment for GERD.

To perform Nissen surgery, the distal esophagus, the cardioesophageal junction, the gastric fundus, and the right and left crura are dissected. Careful dissection is required to avoid transection of the nerve of Latarjet, a branch of anterior vagal trunk supplying the pylorus. Damage to this branch can result in delayed gastric emptying. After hernia reduction, the right and left crura are approximated with sutures (see Fig. 12.1A). Division of the short gastric vessels may be required to mobilize the fundus. The gastric fundus is mobilized posterior to the cardioesophageal junction, creating a 360-degree wrap by the placement of two or three sutures involving stomach-esophagus-stomach in the anterior portion of the wrap (see Fig. 12.1B1). The anterior and posterior vagus nerves are usually contained in the wrap and attached to the esophagus. At the end of the procedure, the wrap must lie below the diaphragm without tension.

During endoscopy, an intact Nissen fundoplication is easily identifiable. During antegrade endoscope passage, the gastroesophageal junction appears tight on visualization, but offers mild resistance to passage of the endoscope. The retroflexed view reveals an encircling redundant mucosa with several parallel rugal folds overlying the gastric cardia, as well as less capacious stomach fundus (see Figs. 12.1B2). Although this is a 360-degree wrap, the redundant fold appears as a 270-degree free cuff margin because the border continuous with the lesser curvature is not evident. The crural closure should maintain the cardia below the diaphragm with the stomach completely insufflated with air. Occasionally, sutures in the distal esophagus may be observed, indicating migration through the wall or inappropriate penetration depth of the stitches during the procedure; this may or may not be associated with symptoms.

Findings associated with failure of the fundoplication include esophagitis, lack of the encircling fold on a retroflexed view, patulous gastroesophageal junction, migration of the wrap through an enlarged esophageal hiatus, or hourglass appearance.
Abstract
Patients who have undergone surgical procedures that altered the upper gastrointestinal (GI) anatomy are often referred for endoscopic evaluation. It is essential for gastroenterologists to understand the postoperative anatomical alterations to select the appropriate endoscope and accessories and obtain meaningful and accurate diagnostic information. This chapter discusses the most common surgical procedures involving the upper GI tract. Technical details and common variations are described for each surgical procedure. The endoscopic correlates to anatomical alterations are described. Available surgical reports should always be reviewed before the endoscopic examination.

Keywords
postsurgical endoscopic anatomy
postsurgical anatomy
endoscopy
bariatric surgery
CHAPTER 12 Postsurgical Endoscopic Anatomy

125

FIG 12.1 Antireflux procedures. A, Esophageal hiatus is narrowed by sutures that approximate the crura of the diaphragm. B1, Nissen fundoplication: a short and loose 360-degree wrap is created around the distal esophagus; B2, Parallel rugal folds encircle the cardia and the insertion tube of the endoscope. The cardia is below the diaphragm, and there is no hiatal enlargement. C, Toupet fundoplication: a posterior partial wrap is created by suturing the edges of the stomach to the anterior esophagus, leaving a space in between. D, Dor procedure: a partial anterior fundoplication usually performed following a Heller myotomy. E, Belsey-Mark IV procedure: a partial wrap is created through a thoracotomy by progressive invagination of the esophagus into the stomach.
of the proximal stomach (indicating slippage and irregularity in the dome shape of the fundus, which in turn indicates parahiatal hernia). A squamocolumnar junction located more than 1 cm proximal to the margin of the wrap has been reported to be a major endoscopic clue in diagnosis of postfundoplication problems. Partial fundoplication is performed anteriorly, and is usually performed in patients who also require a Heller myotomy (see Fig. 12.1C). Toupet fundoplication is performed posteriorly and is best indicated in patients with impaired esophageal body motility and acid reflux controlling to damage to the vagus nerves during the procedure. Some patients with persistent dysphagia have a tight wrap that causes resistance to the advancement of the endoscope and these patients may benefit from endoscopic dilation.

**Partial Fundoplications (Dor and Toupet)**

A partial fundoplication is created with the fundus partially enveloping the distal esophagus, enabling a reduction in postoperative dysphagia and gas-related side effects. A Dor fundoplication is performed anteriorly, and is usually performed in patients who also require a Heller myotomy (see Fig. 12.1C). Toupet fundoplication is performed posteriorly and is best indicated in patients with impaired esophageal body motility (see Fig. 12.1D). Partial fundoplications also have a prominent fold overlying the cardia, which is less evident than 360-degree wraps when observed endoscopically.

**Belsey Mark IV**

The Belsey Mark IV fundoplication requires a thoracotomy. A partial 240-degree anterior wrap is created by the placement of three sutures involving stomach fundus and distal esophagus, resulting in a progressive invagination of the esophagus into the proximal stomach. The crura are also sutured to narrow the esophageal hiatus (see Fig. 12.1E). Endoscopically, the Belsey Mark IV and Nissen fundoplications appear similar, with folds encircling the endoscope at the level of the cardia. However, coils of gastric rugae as seen after Nissen repair are not evident, and there is an anterior compression that corresponds to the attachment of the esophagus to the diaphragm.

**Collis Gastroplasty**

A short esophagus, usually caused by chronic scarring resulting from GERD, can be repaired surgically through a Collis gastroplasty. This gastroplasty creates a tubular segment of stomach in continuity to the esophagus, long enough to be encircled by a 360-degree fundoplication placed below the diaphragm. The fundoplication around this tubular segment within the positive pressure of the abdomen prevents the gastroesophageal reflux. Short esophagus is identified less often presently, because GERD is diagnosed and treated earlier, reducing the incidence of esophageal scarring and shortening. Endoscopically, the squamocolumnar junction is observed above a short tubular segment of stomach, which may not distend properly because of the wrap. The Collis gastroplasty resembles the Nissen fundoplication on a retroflexed view, except with a less capacious fundus.

**OPERATIONS WITHOUT ALTERATION OF THE PANCREATICOBILIARY ANATOMY**

**Billroth I**

The Billroth I operation is a type of reconstruction after a partial gastrectomy in which the stomach is anastomosed to the duodenum (Fig. 12.2A). The gastric resection is usually limited to the antrum, and a truncal vagotomy is often performed in conjunction with the resection. The gastrojejunostomy Anastomosis is found toward the greater curvature. A prominent gastric fold representing the closed part of the stomach is often observed along the lesser curvature ending at the gastroduodenostomy. A mucosal pattern change from gastric folds to flat duodenal surface indicates the anastomosis site. The duodenal bulb is partially resected, and the circular folds of the second portion are visualized endoscopically immediately distal to the anastomosis. Major and minor papillae appear to be more proximal in the duodenum than in a patient with intact anatomy. Following the loss of the pylorus, bile reflux is very commonly seen.

**Billroth II**

In a Billroth II reconstruction after a partial gastrectomy, the duodenal stump is closed and a gastrojejunostomy is created (see Fig. 12.2B). This type of reconstruction is commonly used for complicated peptic ulcer disease or localized gastric antral carcinoma wherein extensive resection is required. The remaining stomach is variable in length and may allow retroflexion maneuver if an adequate residual stomach remains. The gastric remnant usually contains frothy bile and mucosal erythema from the alkaline reflux. The gastrojejunostomy is located at the distal end of the stomach where two stomal openings corresponding to an end-to-side anastomosis can be identified (see Fig. 12.2C). There are several variations in surgical technique to perform the gastrojejunostomy, each with a distinct endoscopic appearance. The technique selected depends on surgeon preference, and there is no uniform approach. The gastrojejunalostomy can vary with regard to the size of the anastomosis, orientation of the jejunal loop to the stomach, and position of the anastomosis relative to the transverse colon. If the whole length of the transected stomach is anastomosed to the jejunum (oralis totalis or Polyga), several rows of jejunal folds are observed between the two stomal openings (Fig. 12.3A). Conversely, if only a segment of the transected stomach is anastomosed to the jejunum (oralis partialis or Hoffmeister), few or no folds are evident. In this case, the stomach is partially closed from the lesser curvature to reduce the diameter of the anastomosis, which is located toward the greater curvature. A prominent fold may be seen emanating from the lesser curvature to the anastomosis. Some surgeons attach the jejunal limb to the suture line that is closing the stomach to prevent dehiscence when performing an oralis partialis anastomosis (see Fig. 12.3B). In this case, a sharp angulation might be negotiated to enter the corresponding jejunal limb. The small anastomosis diameter in association with the sharp angulation of this type of reconstruction may make the anatomy difficult to define endoscopically.

In some cases, the stomach is completely closed at the distal end, and the gastrojejunal anastomosis is performed with a linear or a circular stapler in a side-to-side fashion at the posterior wall, 2 cm proximal to the end of the stomach. When observed endoscopically, however, this side-to-side anastomosis is almost indistinguishable from a short end-to-side anastomosis. The jejunal can be anastomosed to the stomach with the afferent limb attached to the greater curvature (isoperistaltic) or to the lesser curvature (antiperistaltic). The afferent limb refers to the jejunal limb that is in continuity with the duodenum, whereas the efferent limb refers to the one that leaves the stomach toward the distal jejum. The two stomal openings observed
endoscopically may represent the afferent or efferent limb depending on how the reconstruction was performed (see Fig. 12.3C and D). If the reconstruction is isoperistaltic, the opening linked to the greater curvature corresponds to the afferent limb. If the reconstruction is antiperistaltic, the opening linked to the greater curvature corresponds to the efferent limb. Usually the stomal opening linked to the lesser curvature is more difficult to access with the endoscope because of the relative tangential approach of the endoscope to the anastomosis (see Fig. 12.3E).35

Gastrectomies usually include the lesser curvature more than the greater curvature in the resection. In addition, the information from surgical notes about the type of reconstruction, peristalsis, and bile flow might help define the limbs endoscopically. On careful observation of the anastomosis, bile may be seen coming...
FIG 12.3 Variations of Billroth II reconstruction. A, Oralis totalis (Polya): the anastomosis occupies the entire length of the distal stomach. B, Oralis partialis (Hoffmeister): the anastomosis occupies only part of the distal stomach. In some cases, the jejunal limb is sutured to the lesser curvature to protect the suture line of the stomach from disruption. In this scenario, a sharp angulation must be negotiated to advance the endoscope through the stomal opening linked to the lesser curvature. C, Antiperistaltic anastomosis: the afferent limb is attached to the lesser curvature. D, Isoperistaltic anastomosis: the afferent limb is attached to greater curvature. E, Sharp verticalization of the gastroenteroanastomosis impairs advance of the endoscope to this afferent limb. F, Retrograde view of the major papilla through the afferent limb. G, Antecolic reconstruction: the anastomosis is anterior to the transverse colon leading to a longer afferent limb. H, Retrocolic reconstruction: the anastomosis passes through the mesocolon creating a shorter afferent limb.
predominantly from the afferent limb. Introducing the endoscope through this opening should reveal an increasing volume of bile as the endoscope advances toward the bulb, although bile may also be observed in the efferent limb. Visible peristaltic waves advancing away from the endoscope suggest that the instrument is in the efferent limb. When the duodenal stump is reached, the flat mucosa of the residual bulb with a scar-like deformity in a cul-de-sac can be identified. A careful withdrawal of the endoscope exposes the major papilla, usually located at the right upper quadrant at radiography (see Fig. 12.3F).

In patients with Billroth II anatomy, the papilla is rotated 180 degrees in the endoscopic visual field. This "upside down" position requires distinct techniques to perform endoscopic retrograde cholangiopancreatography (ERCP), including dedicated sphincterotomes, needle-knife cut technique over the stent, or balloon dilation of the papilla.47,48 If the duodenal stump cannot be identified, the endoscope should be withdrawn, and the other limb should be intubated as far as possible. Fluoroscopic visualization may indicate that the efferent limb has been entered when the instrument is seen to pass deep into the pelvis. Conversely, passage of the endoscope into the right upper quadrant toward the liver or previous cholecystectomy clips suggests entry into the afferent limb.41

The length of the afferent limb also varies depending on the surgical technique. The afferent limb, naturally fixed at the ligament of Treitz and surgically fixed to the stomach, should be tensionless but not redundant. There are two ways to position the afferent limb in relation to the transverse colon during a Billroth II reconstruction. If an antecolic anastomosis is performed, the gastrojejunostomy is placed anterior to the transverse colon (see Fig. 12.3G). Antecolic reconstructions frequently have long afferent limbs because of the distance between the ligament of Treitz and the remaining stomach, over the omentum, and transverse colon. Conversely, retrocolic reconstructions are performed through an opening in the transverse mesocolon, shortening the distance between the ligament of Treitz and the remaining stomach (see Fig. 12.3H).42,43 Antecolic and retrocolic anastomoses are similar endoscopically except for the length of the limbs. Caution should be taken if a percutaneous endoscopic gastrostomy is indicated for a patient with a previous partial gastrectomy and retrocolic reconstruction.

Billroth II reconstruction can be created as a side-to-side jejunojejunostomy, referred to as the Braun procedure (Fig. 12.4A).44 This variant results in an anastomosis between the afferent and efferent limb to divert bile from the gastric remnant and to release the pressure of the afferent limb, supposedly preventing duodenal stump fistula.45 The Braun anastomosis is performed 10 to 15 cm distal to the gastrojejunostomy and requires a longer afferent limb to accommodate the jejunojejunostomy.46 Endoscopically, the gastrojejunostomy is similar to a standard Billroth II. Frothy bile is present in the stomach because the Braun procedure only partially diverts biliopancreatic fluids from the gastrojejunostomy. After advancing the endoscope through either opening of the gastrojejunostomy, the side-to-side Braun anastomosis can be found in the afferent and efferent limb, and three openings can be identified (see Fig. 12.4B). One leads to the distal jejunum, another leads to the afferent limb, and the third one leads back to the stomach. A complete reverse intubation of the stomach may be carried out through the loop created with the Braun anastomosis. The same anatomic landmarks described for other Billroth II procedures are helpful in directing the endoscope through the limbs. However, a trial-and-error approach may be ultimately necessary to reach the duodenal stump.

A higher rate of perforation has been reported during ERCP while traversing the afferent limb compared with standard ERCP, particularly when a stiff therapeutic duodenoscope is used.47,48 The Braun procedure has also been associated with perforations during ERCP. The use of a forward-viewing endoscope in these patients can reduce the risk of jejunal perforations.49 The ability to use a duodenoscope elevator may increase the success of the procedure, and a flexible diagnostic duodenoscope may be safer...
than a stiff therapeutic instrument. If the papilla cannot be located with a side-viewing endoscope, the forward-viewing endoscope used should be either a pediatric colonoscope or one of the deep small bowel intubation technologies such as single or double balloon endoscopes to maximize the chances of reaching the papilla.

**Roux-en-Y Gastrectomy**

In a Roux-en-Y reconstruction, the jejunum is transected close to the ligament of Treitz, creating two distinct segments. The distal segment is sutured to the gastric remnant (gastrojejunostomy), becoming the efferent limb. The proximal segment is sutured to this efferent limb (jejunojejunostomy) approximately 40 cm below the gastrojejunal anastomosis (see Fig. 12.2D). The proximal segment is called the afferent limb, which connects the duodenum to the efferent limb instead of the stomach as in Billroth II reconstructions. The Roux-en-Y reconstruction prevents biliopancreatic fluids from refluxing into the stomach in patients who have undergone gastric resection. It can be performed as the initial reconstruction after a gastrectomy or as the treatment for postgastrectomy syndrome resulting from a previous Billroth II reconstruction.\(^5^0\)–\(^5^3\) Truncal vagotomy is commonly performed in association with Roux-en-Y to prevent peptic ulcers in the efferent limb, which is no longer washed by the alkaline contents of the biliopancreatic fluid.\(^5^4\)

The gastrojejunal anastomosis is end-to-side, and two stomal openings are seen. The reconstruction can be oralis totalis or partialis, isoperistaltic or antiperistaltic, and antecolic or retrocolic, as described for Billroth II. In contrast to the Billroth II, one of the two limbs is extremely short and ends blindly almost immediately. On entering a long limb with a patent lumen, it is almost certain that the endoscope is within the efferent limb. If the Roux-en-Y was performed after an initial Billroth II reconstruction, the endoscopist should be aware that the blind limb might be patent for several centimeters before ending in a cul-de-sac. This short segment of patent limb occurs because conversion from a Billroth II to a Roux-en-Y sometimes has to be performed farther from the gastrojejunostomy to avoid adhesions from the initial surgery.

In effective Roux-en-Y reconstructions, the remnant stomach is completely clean of bile (Fig. 12.5A and B). The absence of bile in an operated stomach should always alert the endoscopist for a Roux-en-Y reconstruction, and the presence of residual food in this case should not lead to an erroneous conclusion of efferent limb obstruction. Total obstruction of the afferent limb in a Billroth II reconstruction could also prevent bile to reflux to the stomach, mimicking a Roux-en-Y, but this is uncommon.\(^5^5\)

Conversely, presence of bile does not exclude a Roux-en-Y reconstruction. In this case, a short-length efferent limb may be responsible for the reflux. To be effective, the efferent limb has to measure at least 40 cm from the gastrojejunal anastomosis to the jejunojejunal anastomosis.\(^5^6\) Longer limbs (up to 60 cm) may also be encountered.\(^5^7\)

Intubation through the efferent limb usually follows a straight route with variable looping. The enterenteric anastomosis is usually end-to-side, but it may be side-to-side with a blind end. In either case, the endoscope has to leave the efferent limb and enter the afferent limb to reach the major papilla in the duodenum (see Fig. 12.5C). If a side-to-side anastomosis is present, three openings can be observed. The opening in continuity with the efferent limb leads to the distal jejenum, the second opening leads to a blind distal end of the afferent limb, and the third one leads to the duodenum through the afferent limb (see Fig. 12.5D). An end-to-side anastomosis has two openings. One is a continuation of the efferent limb and leads to the distal jejenum; the other opening leads to the afferent limb. Different degrees of angulation have to be negotiated to enter the afferent limb depending on the anastomosis configuration. Once the afferent limb is entered, progressively more bile should be seen until the duodenal stump is reached.

A complete visualization of the Roux-en-Y gastrojejunostomy during a routine upper endoscopy can be performed with a forward-viewing gastroscope, including the jejunojejunostomy. In contrast, if patients require ERCP, a longer insertion tube is usually needed (pediatric and adult colonoscopies, dedicated enteroscopes, single or double balloon enteroscopes).\(^5^8\) Overtube-assisted enteroscopy (OAE) techniques, single or double balloon enteroscopes, have increased the ability to perform ERCP in patients with altered upper GI anatomy. ERCP success rates are 90% in patients with Billroth II anatomy, 76% in patients who had undergone either a Roux-en-Y or a pancreaticoduodenectomy, pylorus-preserving pancreaticoduodenectomy, or hepaticojejunostomy, and 70% in patients who underwent Roux-en-Y with gastric bypass surgery. Cannulation success rates appeared to be equivalent in patients with both native papilla and biliary-enteric or pancreaticoenteric anastomoses (90%–92%).\(^5^9\)–\(^6^1\)

**Gastrojejunostomy Without Gastric Resection**

Gastrojejunostomy without gastric resection is performed to bypass the distal stomach or the duodenum, mostly in cases of malignant obstruction that cannot be resected. In major duodenopancreatic trauma with a high risk for fistulas, a gastrojejunostomy may also be performed in association with a temporary closure of the pylorus as part of the duodenal exclusion.\(^6^2\) Occasionally, the gastrojejunostomy is created prophylactically during the surgical exploration of a patient with unresectable adenocarcinoma of the head of the pancreas to prevent subsequent gastric outlet obstruction.\(^6^3\) The gastrojejunostomy is usually performed along the greater curvature of the distal body or the proximal antrum of the stomach (Fig. 12.6A). It may involve the anterior or the posterior wall at the surgeon’s discretion. In all cases, a side-to-side anastomosis is performed with the first jejunal loop that can be sutured without tension to the stomach. The anastomosis can be isoperistaltic or antiperistaltic, antecolic or retrocolic, as described for a Billroth II gastroenteroanastomosis. The definition for the length of the anastomosis does not apply (oralis totalis or oralis partialis) because this is a side-to-side anastomosis. However, this anastomosis usually resembles an oralis partialis in length.

The gastrojejunostomy appears endoscopically as a vertical anastomosis with two stomal openings that correspond to the afferent and efferent limbs. Either one of the limbs may be in a superior (upper) or inferior (lower) position, depending on the technique used during the surgery. If an isoperistaltic gastrojejunostomy has been created, the opening of the afferent limb should be expected in the upper position. The endoscopist should look carefully for a gastrojejunostomy in a patient with an upper tract obstruction who had undergone surgery. This anastomosis may become easily overlooked because it is typically not large, usually located among edematous gastric folds, and associated with gastric contents resulting from outlet obstruction (see Fig. 12.6B). Ulcerations are also common and may impair intubation of the jejunal openings resulting from tissue retraction.\(^6^4\) Access to the papilla can be achieved by passing the endoscope retrograde
prevalence of obesity, including childhood obesity, and the lack of effective nonsurgical treatments. The National Institutes of Health (NIH) Consensus Conference in 2004 recognized bariatric surgery as the most effective therapy available for morbid obesity and that it can result in improvement or complete resolution of obesity-related comorbidities. Bariatric surgical procedures include laparoscopic or open Roux-en-Y gastric bypass, sleeve gastrectomy (SG), vertical banded gastroplasty (VBG), laparoscopic adjustable gastric band (LAGB), biliopancreatic diversion with duodenal switch (BPD/DS), and laparoscopic mini gastric bypass. A growing number of patients with altered anatomy should be expected in endoscopy units because GI complaints are frequent after bariatric surgery. The same complaints in uncomplicated postoperative courses can be present in patients through the afferent limb when a gastric outlet obstruction has been established. The Braun procedure may be added to the gastrojejunostomy as previously described for Billroth II reconstruction (see Fig. 12.6C).

**Bariatric Surgery**

Obesity is associated with serious health consequences including hypertension, type 2 diabetes, hyperlipidemia, coronary artery disease, peripheral vascular disease, cerebral vascular accidents, thromboembolic conditions, obstructive sleep apnea, obesity-hypoventilation syndrome, weight-bearing osteoarthritis, nonalcoholic fatty liver disease, hepatic cirrhosis, and an increased risk of developing colorectal and pancreatic cancer. Indications for bariatric procedures are increasing because of the increase in prevalence of obesity, including childhood obesity, and the lack of effective nonsurgical treatments. The National Institutes of Health (NIH) Consensus Conference in 2004 recognized bariatric surgery as the most effective therapy available for morbid obesity and that it can result in improvement or complete resolution of obesity-related comorbidities. Bariatric surgical procedures include laparoscopic or open Roux-en-Y gastric bypass, sleeve gastrectomy (SG), vertical banded gastroplasty (VBG), laparoscopic adjustable gastric band (LAGB), biliopancreatic diversion with duodenal switch (BPD/DS), and laparoscopic mini gastric bypass. A growing number of patients with altered anatomy should be expected in endoscopy units because GI complaints are frequent after bariatric surgery. The same complaints in uncomplicated postoperative courses can be present in patients...
Equipment and General Principles of Endoscopy

FIG 12.6 Gastroenteroanastomosis. A, Antiperistaltic gastroenteroanastomosis is created along greater curvature. B, Gastrojejunostomy without gastric resection: residual contents, enlarged gastric folds, and suboptimal air insufflation may obscure this anastomosis. C, Isoperistaltic gastroenteroanastomosis is created on the posterior wall of the stomach in association with Braun procedure.

with important surgical complications, which may require surgical revision. Early post–bariatric surgery complications include early postoperative hemorrhage, anastomotic leak, and fistula. Late complications include anastomotic stricture, marginal ulcer, obscure GI bleeding, and gastric band slippage.

Some endoscopic findings may represent either a normal postsurgical appearance or a complication depending on the surgery that was performed. An example is the endoscopic finding of a communication between a short proximal gastric pouch and a normal-size remnant stomach. This communication is normally expected in a VBG, but it represents a failure (gastrogastric fistula) if the surgical procedure was a gastric bypass (GB). Familiarity with the most common bariatric procedures is essential for optimal endoscopic assistance to bariatric patients and surgeons. Surgical procedures to treat obesity have evolved during the last 6 decades. They can be simplified into two types, restrictive and malabsorptive. Selection of a procedure is based on individual patient characteristics and surgeon preference.

Jejunoileal Bypass

Jejunoileal bypass (JIB) was the first procedure proposed to induce malabsorption in 1954. It is technically simple and safe because it involves only enterointerostomy, and the surgical steps are performed in the middle abdomen. In JIB, the proximal jejunum and the distal ileum are transected. The long jejunouleal segment in between these two transections is excluded from the intestinal transit by closing the proximal margin and connecting the distal margin to the sigmoid colon. An enterointerostomy is performed between the proximal jejunum and the distal ileum, leaving a short segment of small bowel for absorption (Fig. 12.7). This procedure does not alter the endoscopic anatomy of the upper GI tract. JIB is no longer performed because of severe hepatic complications. Patients with an intact JIB should consider reversion of the operation.

Gastric Bypass

GB is a restrictive and malabsorptive procedure. It is the most popular bariatric procedure performed worldwide along with sleeve gastrectomy. The operation includes partition of the stomach, creating a small-volume pouch (15 to 50 mL) in the proximal stomach. With the distal stomach completely disconnected, the proximal gastric pouch is anastomosed with a Roux-en-Y limb that ranges from 75 to 150 cm in length to reestablish the alimentary transit. The extent of the bypass of the intestinal tract determines the degree of macronutrient malabsorption (Fig. 12.8A). Gastric bypass can be performed by both open and laparoscopic techniques. The laparoscopic approach has a higher rate of intraabdominal complications but a shorter duration of hospitalization, fewer wound complications, and improved postoperative patient comfort. Surgical technical variations can
small bowel and a long limb before reaching the jejunojejunal anastomosis, which may be inaccessible depending on the length of the limb (see Fig. 12.8E). The gastric partition may include only the staple line, without division of the stomach (undivided bypass), or a complete transection of the stomach (divided bypass) (see Fig. 12.8F). Undivided bypass presents a higher rate of fistulas between the pouch and the distal stomach compared with divided bypass. A gastrogastric fistula leads to a failure in weight loss and to a higher incidence of peptic ulcers beyond the gastrojejunal anastomosis.

The gastrojejunostomy may be to the side or to the end of the jejunal or stomach. The small gastric pouch makes lateral and terminal gastric anastomoses indistinguishable. However, lateral and terminal anastomoses are different on the jejunal side. A lateral jejunal anastomosis has two openings. One ends blindly shortly after the anastomosis; the other leads to the distal jejunum (efferent limb) (see Fig. 12.8G). A terminal anastomosis has one opening that should be readily accessible endoscopically. The blind end of a lateral anastomosis should not be confused with stenosis of the efferent limb, particularly when scarring alters the anatomy. Abnormal endoscopic findings include esophagitis, pouch or esophagus dilation, stomal stenosis, stomal ulceration, prosthesis erosion at the stoma, and breakdown of the partition staple line. Stomal ulceration has been related to staple line dehiscence in which a gastrogastric fistula occurs, although other factors may be involved.

Access to the major papilla and to the disconnected part of the stomach is often impossible transorally in patients with GB using regular endoscopes. A percutaneous gastrostomy tract created in the distal stomach is used as an alternative to access these areas with the endoscope. Double-balloon and single-balloon enteroscopy has emerged as an alternative to access the biliopancreatic ducts and the disconnected part of the stomach in these patients.

Sleeve Gastrectomy

SG is a restrictive laparoscopic procedure in which the greater curvature is removed and a small gastric tube is left. Over the past decade, SG has emerged as a popular bariatric surgical approach. It was first introduced as the two-staged approach to duodenal switch (DS) or GB for the super obese patient. The stand-alone SG has provided comparable results with the GB operation in regards to weight reduction and amelioration of obesity-related comorbidities. Although GB is still the most common bariatric operation performed worldwide (45%), SG is now the most common bariatric operation performed in the United States/Canada (43%) and Asian/Pacific regions (49%) and the second most common worldwide (37%).

The endoscopic view after sleeve gastrectomy reveals a long, tubular stomach limited in expansion by a staple line that parallels the lesser curvature (Fig. 12.9). The DS procedure is often performed in conjunction with a SG, but also includes a duodenjejunal anastomosis visible just distal to an intact gastric pylorus. In the latter, the ampulla is thus not available for visualization or ERCP in a standard fashion.

Vertical Banded Gastroplasty

The initial gastroplasty procedure was inadequate in terms of weight loss and was refined by Mason into VBG. VBG is a purely restrictive procedure resulting from a search for a simpler operation compared with GB. VBG involves the creation of a small pouch in the proximal stomach and the encirclement of the

FIG 12.7 Jejunoileal bypass. This operation reduces the small bowel absorptive surface and leaves a long, nonfunctional segment of small bowel. Endoscopically, there is no change in the anatomy for upper endoscopy and endoscopic retrograde cholangiopancreatography (ERCP).
FIG 12.8 Gastric bypass. A, Small-volume pouch (15 to 50 mL) is created just beyond the gastroesophageal junction and is anastomosed to a jejunal loop in a Roux-en-Y fashion. The efferent limb ranges from 75 to 150 cm. The distal stomach is not resected and may be used to create a gastrostomy through which the endoscope can be advanced to perform endoscopic retrograde cholangiopancreatography (ERCP) or gastroduodenoscopy. B, A technical variation includes the attachment of the jejunal limb to the gastric partitioning to prevent gastrogastric fistulas and the placement of a Silastic ring in the distal portion of the pouch to prevent dilation. C, Small gastric pouch with a subtle circumferential compression proximal to the anastomosis indicating an external ring. D, Intact stapler line at the gastric pouch. E, Small-diameter gastrojejunostomy. F, Undivided gastric bypass: The staple line is not transected, and the pouch is horizontal. This type of gastric bypass has been associated with failures in weight loss because of dilation of the pouch and disruption of the staple line. G, End-to-side gastrojejunostomy with two openings. The right one is the efferent limb. The left one ends blindly.
CHAPTER 12  Postsurgical Endoscopic Anatomy

135

duodenal bulb, and biliopancreatic ducts are readily accessible for endoscopy if the outlet channel permits passage of the endoscope. The outlet channel is ideally 11 mm wide and 15 mm long, and is amenable to endoscopic dilation in case of stenosis.

Laparoscopic Adjustable Gastric Banding
LAGB is the least invasive of the purely restrictive bariatric surgery procedure. LAGB was commonly performed in European countries and Australia, but now GB and SG account for almost 75% of bariatric surgery outside of the United States.80,105,106 LAGB involves placing a band around the proximal stomach to create a 15-mL pouch without the need of resecting or stapling the stomach (Fig. 12.11A).

FIG 12.10 Vertical banded gastroplasty. A 15-mL pouch is created at the angle of His, and the outlet channel is encircled by a circumferential band. A, Circular and linear staplers are used to create this uncut gastroplasty. B, The staple line may be divided, separating the two gastric parts to prevent gastrogastric fistula.

Upper endoscopy in patients with intact VBG shows a small tubular pouch immediately after the esophagogastric junction with a narrow outlet channel that, once traversed, leads to the remaining distal stomach. Abnormal endoscopic findings include esophagitis, staple line dehiscence, food impaction, stenosis of the pouch outlet, and erosion of the gastric wall by the material used to encircle the outlet channel.103,104 The remaining stomach, duodenal bulb, and biliopancreatic ducts are readily accessible for endoscopy if the outlet channel permits passage of the endoscope. The outlet channel is ideally 11 mm wide and 15 mm long, and is amenable to endoscopic dilation in case of stenosis.

Laparoscopic Adjustable Gastric Banding
LAGB is the least invasive of the purely restrictive bariatric surgery procedure. LAGB was commonly performed in European countries and Australia, but now GB and SG account for almost 75% of bariatric surgery outside of the United States.80,105,106 LAGB involves placing a band around the proximal stomach to create a 15-mL pouch without the need of resecting or stapling the stomach (Fig. 12.11A).

LAGB is now performed using a silicone material device that can be inflated with saline solution to adjust the gastric-pouch outflow. The inflatable part of the band device is connected by tubing to a reservoir, then implanted and secured to the abdominal fascia, which can be accessed via a needle.107 There are unique long-term complications of LAGB, which include gastric prolapse, stomal obstruction, esophageal and gastric pouch dilation, gastric

FIG 12.11 Laparoscopic adjustable gastric banding. A, A 15-mL pouch is created in the proximal stomach with a banding device. The device can be adjusted to narrow the opening to the distal stomach by percutaneous injection of fluids. B, A gastrogastric suture is placed anteriorly over the band to prevent gastric herniation.
Erosion and necrosis, and access port problems. Use of a prosthetic device introduces additional potential problems of malfunction and infection.

Upper endoscopy in a patient with LAGB shows a small gastric pouch at the level of the cardia with a narrow outlet channel that leads to the distal normal stomach. Esophageal dilation, esophagitis, gastric pouch dilation, gastric slippage, outlet channel stenosis, and gastric wall erosion by the band device are the most common abnormal findings observed after LAGB.108,109 Occasionally, a marked gastric fold surrounding the pouch outlet channel can be observed in a retroflexed view within the distal stomach. This fold corresponds to the gastrogastric sutures placed anteriorly over the band device to decrease the risks of gastric herniation (see Fig. 12.11B). Similar to VBG, once the endoscope is advanced through the pouch-outlet channel, examination of the distal stomach, duodenum, and biliopancreatic ducts can be performed as in a regular endoscopy.

**Biliopancreatic Diversion**

Biliopancreatic diversion (BPD) is a malabsorptive procedure to delay contact between ingested food material, bile, and pancreatic juice.110 BPD was first reported in 1979 by Scopinaro et al and is also known as the Scopinaro procedure.111 In BPD, the small bowel is divided, creating two limbs. The distal limb is anastomosed to the stomach, and the proximal limb is anastomosed to the ileum. After completion, the small bowel has a new anatomic configuration with three distinct channels: common, alimentary, and biliopancreatic (Fig. 12.12A). BPD requires no small bowel resection and does not leave a nonfunctional small bowel segment. The results of the procedure depend on the length of the channels, which are variable because of the individual patient characteristics and surgeon preferences. Typically, a 50-cm to 100-cm common channel and a 150-cm to 200-cm alimentary channel are created. The remaining small bowel constitutes the biliopancreatic channel.

The common channel length is the determinant for long-term weight maintenance and steatorrhea, and the total common alimentary channel is for the temporary mild short-gut syndrome. In addition, the stomach is altered via a partial resection or a GB to prevent peptic ulcer and to limit food intake. The gastric component of the BPD is easily accessible endoscopically, and the findings vary according to the procedure performed. Nevertheless, bile should never be observed, and peptic ulceration at the gastroenteroanastomosis and small bowel always should be

---

**FIG 12.12** Malabsorptive bariatric surgeries. A, Biliopancreatic diversion: a partial gastrectomy is reconstructed in a Roux-en-Y fashion with long afferent and efferent limbs (biliopancreatic and alimentary channels). Shadowed area represents the short length common channel (50 to 100 cm). B, Duodenal switch: a sleeve gastrectomy with preservation of the pylorus leads to a duodeno-jejunostomy rather than a gastrojejunostomy. Jejunal limbs are reconstructed as in a biliopancreatic diversion.
OPERATIONS WITH ALTERATION OF THE PANCREATICOBILIARY ANATOMY

Pancreateoduodenectomy (Whipple Procedure)
The Whipple procedure is performed to resect malignant or benign lesions in the head of the pancreas, distal bile duct, or in the second portion of the duodenum. The extent of the resection classifies this procedure as classic or pylorus-preserving.

Classic Whipple Procedure
In the classic Whipple procedure, the gastric antrum, duodenum, head of the pancreas, and distal bile duct are resected. There are over 68 variations for reconstruction of the alimentary and pancreaticobiliary tract. Currently, one well-accepted technique is to create all necessary anastomoses with a single limb of small bowel (Fig. 12.13A). In this case, a side-to-side gastroenteroanastomosis is encountered endoscopically, usually oralis partialis and with the resection limited to the antrum. All the variations regarding orientation, position to the transverse colon, and stoma size described for the Billroth II gastroenteroanastomosis apply here. On entering the afferent limb, which may range from 40 to 60 cm and include a Braun procedure, the anastomosis with the biliary and pancreatic ducts can be identified. Sharp angulations resulting from fixation to adjacent organs may be encountered before reaching the blind end of the most proximal portion of the afferent limb, where the pancreaticojejunostomy is found.

Duodenal Switch
The DS procedure is a variation of BPD. This procedure includes an SG preserving the pylorus and anastomosis of the enteric limb end-to-end with the postpyloric duodenum (see Fig. 12.12B). A lower prevalence of side effects has been reported for DS compared with BPD. The same principles described in regard to BPD apply to DS during the endoscopic evaluation, except that a duodenojejunostomy rather than a gastrojejunostomy is present.

Performing ERCP in a patient with BPD is nearly impossible per os because the endoscope has to be advanced all the way through the small bowel, except for the common channel, to reach the major papilla. Alternatives to access the major papilla are through a gastrostomy (surgical or radiologic) or through a disrupted staple line between the pouch and the stomach. These alternatives apply only for patients who had a GB because gastric resection precludes both options. Double-balloon enteroscopy has the potential to advance through the altered BPD anatomy and reach the major papilla.

FIG 12.13 Whipple operations. A, Classic Whipple: the distal stomach, head of the pancreas, distal biliary duct, and duodenum are resected. A single loop of jejunum is used to the anastomoses with the stomach and biliary and pancreatic ducts. A partial isoperistaltic gastroenteroanastomosis is shown. B, Pylorus-preserving Whipple: a duodenojejunostomy rather than a gastrojejunostomy is created in this procedure.
The pancreaticojejunostomy may be end-to-end or end-to-side. In either case, the pancreaticojejunostomy may also be a mucosa-to-mucosa or a “dunking” anastomosis. A mucosa-to-mucosa anastomosis creates a small opening by suturing the pancreatic duct to the jejunal mucosa. The dunking anastomosis differs from the mucosa-to-mucosa anastomosis in that the pancreas is invaginated into the jejunum (Fig. 12.14). The opening of the pancreatic duct varies from a flat, small-diameter anastomosis (mucosa-to-mucosa) to a protuberant, sometimes downward-oriented anastomosis (lateral dunking), making the identification and cannulation of this duct technically challenging. The pancreaticojejunostomy is located approximately 10 cm proximal to the pancreaticojejunostomy. It is always an end-to-side anastomosis located in the antimesenteric border of the limb, occasionally subtle or hidden by a fold.

**Pylorus-Preserving Whipple Procedure**

The pylorus-preserving Whipple procedure differs from the classic Whipple operation in that the stomach is not resected and a short segment of the proximal bulb remains to be anastomosed with the jejunum (see Fig. 12.13B). This modification has proved to decrease the morbidity of pancreaticoduodenectomies, such as malnutrition due to the reduced volume of the stomach, without compromising the oncologic principles of the resection. A duodenojejunostomy rather than a gastrojejunostomy is observed in patients with a pylorus-preserving Whipple procedure. After traversing a normal stomach and the pylorus, a two-opening, small-diameter anastomosis is identified in a short segment of bulb. Depending on the orientation of the reconstruction, the afferent limb is to the right (antiperistaltic) or to the left (isoperistaltic). Antecolic or retrocolic anastomosis can also be observed, creating variations on the length of the jejunal limb. Usually, a trial-and-error approach is necessary to define the afferent limb, in which the pancreatic and biliary anastomosis are performed as described for the classic Whipple procedure. In patients who have undergone either Whipple operation, the biliary and pancreatic anastomosis may be reached with a side-viewing or a forward-viewing endoscope, owing to the relatively short afferent limb.

**Roux-en-Y Hepaticojejunostomy**

Anastomosis of the hepatic duct to a loop of jejunum without disturbing the gastroduodenal anatomy is usually performed for biliary disease or during liver transplantation when the native bile duct cannot be used to create a duct-to-duct anastomosis (e.g., in the setting of sclerosing cholangitis). The hepaticojejunostomy is usually end-to-side, but side-to-side anastomosis can also be encountered (Fig. 12.15A). The anatomy of the stomach, duodenum, and pancreas is not altered, and endoscopic evaluation of these organs is similar to a nonoperated stomach. If the bile duct must be accessed, the endoscope has to be advanced through a normal stomach and duodenum before reaching the jejunojejunal anastomosis that leads to a Roux-en-Y limb with the hepaticojejunostomy. Long-length endoscopes are usually necessary, and in most cases balloon enteroscopy systems employing an overtube are now used.

In contrast to the anatomy after a Roux-en-Y gastrectomy, the duodenojejunal limb merges into the small bowel rather than merging with a loop of small bowel. At the level of the jejunojejunal anastomosis, three lumens (side-to-side) or two lumens (end-to-side) can be observed, depending on the reconstruction (see Fig. 12.5E). One lumen leads to the distal jejunum, and the other leads to the limb that contains the hepaticojejunostomy. The third lumen (only if side-to-side) observed along the initial limb occupied by the endoscope ends blindly just beyond the anastomosis. A trial-and-error approach to the first two limbs reveals the one with the hepaticojejunostomy. The end-to-side hepaticojejunostomy is similar to the one described in the Whipple procedure except that here the location is closer to the blind end of the limb. In contrast to the end-to-side hepaticojejunostomy, the side-to-side hepaticojejunostomy preserves the access to the biliary ducts through the major papilla if the distal common
bile duct is not obstructed. In this case, a cholangiogram can be obtained with the aid of an occlusion balloon inflated proximal to the hepatojejunostomy, avoiding the demanding insertion of the endoscope through the Roux-en-Y limb. Air within the intrahepatic ducts is common in biliary-enteric anastomosis and may be useful to evaluate patients in whom the hepatojejunostomy is not reachable with the endoscope (air cholangiogram).4,123

**Choledochoduodenostomy**

Choledochoduodenostomy is the anastomosis of the bile duct to the second portion of the duodenum, usually performed in a side-to-side fashion (see Fig. 12.15B). Endoscopically, after traversing the pylorus, the choledochoduodenostomy is found proximal to the major papilla. The anastomosis may be sufficiently wide to allow visualization and partial intubation of the extrahepatic ducts. A side-to-side anastomosis has two lumens. One lumen leads to the proximal biliary tree, and the other leads to the distal common bile duct. Because there is no alimentary diversion from the anastomosis, food impaction may occur in the distal common bile duct causing the sump syndrome, which may require an ERCP.124 Because the biliary duct can be accessed both through the major papilla and through the choledochoduodenostomy, a combination of accesses can be used to manipulate the different portions of the ducts, including anterograde cannulation of the papilla. The approach to the pancreatic duct is the same as for standard ERCP.

**FIG 12.15 Bilioenteric anastomoses.** A, Roux-en-Y hepaticojejunostomy: the bile duct is anastomosed to a limb of jejunum in a lateral or terminal fashion. A side-to-side anastomosis preserves cannulation of the intrahepatic ducts through the papilla if no obstruction is present. The pancreatic duct remains accessible through the second portion of the duodenum. B, Choledochoduodenostomy: usually a side-to-side anastomosis is accessible on the second portion of the duodenum. The distal bile duct may be filled with residual enteric contents leading to the sump syndrome.

**KEY REFERENCES**


A complete reference list can be found online at ExpertConsult.com


