Techniques in Gastrointestinal Endoscopy (2010) 12, 124-129

Techniques in
GASTROINTESTINAL
ENDOSCOPY

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Endoscopic techniques in bariatric patients: Obesity basics and normal postbariatric surgery anatomy

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KEYWORDS
Gastric bypass;
Vertical banded gastroplasty;
Laparoscopic gastric banding;
Biliopancreatic diversion;
Laparoscopic sleeve gastrectomy

With the sharp rise in the number of bariatric surgical procedures over the past 15 y, the number and array of complications have also risen. Many of these complications are now either diagnosed or managed endoscopically. However, the rising diversity of surgical options requires endoscopists to have a good working knowledge of normal postoperative anatomy for each procedure. This article reviews basic obesity epidemiology and describes postsurgical anatomy of the upper gastrointestinal tract, separating the procedures into those with normal small bowel anatomy (restrictive procedures) and procedures resulting in small bowel modifications (procedures with a "malabsorptive" component).
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Many classifications have been used to measure and define obesity, of which body mass index (BMI) is the most widely used. BMI is calculated by dividing weight in kilograms by the square of height in meters. Normal weight ranges from 18.5 to 24.9 kg/m^2. A BMI between 25 and 29.9 kg/m^2 is defined as overweight and an individual is obese when his or her BMI is $\geq$30 kg/m^2. There are 3 grades of obesity: grade 1 (BMI ranging from 30 to 34.9 kg/m^2), grade 2 (BMI ranging from 35.0 to 39.9 kg/m^2), and grade 3 (BMI $\geq$40 kg/m^2).[1,2]

Obesity is no longer a developing health issue; it is an established pandemic affecting both industrialized and emerging countries. If the United States has become a striking example of the extent of the bariatric epidemic, it is not the only country in terms of prevalence of obesity according to World Health Organization data. The Pacific Islands have a prevalence of obesity ranging from 40% in French Polynesia to 78.5% in Nauru, followed by Saudi Arabia (35%) and the United States (34%). In Europe, obesity incidence reports range from 8.1% in Switzerland[3] to 24% in the UK.[4]

The United States, however, is burdened with a high rate of severe obesity, with 14.3% of adults having a BMI $>$35 kg/m^2 in 2008.[5] This number represents approximately 40 million potential candidates qualifying for a bariatric surgical procedure. The often dramatic results of this surgery have lead to a sharp rise in the interest and number of bariatric surgical procedures performed over the past 15 y. The number of bariatric procedures performed in the United States and Canada was 14,000 in 1998,[6] compared with an estimated 220,000 in 2008.[7] Surgery is the most efficient therapy available for the treatment of morbid obesity,[8] and 4 procedures are accepted as standard for the primary treatment of morbid obesity: Roux-en-Y gastric bypass (RYGB), laparoscopic adjustable gastric banding (LAGB), biliopancreatic diversion (BPD) or BPD with duodenal switch (BPS/DS), and, more recently, laparoscopic sleeve gastrectomy (LSG).[9,10] Another procedure, the vertical banded gastroplasty (VBG), has been largely abandoned in favor of LAGB; however, endoscopists should remain familiar with the technique because some patients still have a VBG in place.

The latest data available from a worldwide poll in 2008[7] show that RYGB and LAGB account for over 90% of all bariatric procedures in the world. About 90% of primary RYGB in the United States are laparoscopic[11] and laparoscopic RYGB (LRYGB) is currently the most frequently performed bariatric surgery worldwide. Although it was a popular procedure in the late 1990s and early 2000s in Europe and Australia, LAGB has been losing ground for the past 5–8 y in these regions and in most other countries in favor of the RYGB. During the latter period, however,

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doi:10.1016/j.tgie.2010.10.004

LAGB has gained significant momentum in the United States. This explains the worldwide trend of LAGB increase because the United States and Canada account for over two-thirds of all bariatric cases in the world. Over 220,000 procedures were performed in these 2 countries in 2008, far more than in the runner-up country, Brazil, with 25,000 procedures recorded.

The result of bariatric surgery regarding weight loss is extremely favorable; however, the most important outcome relates to the reduction of overall mortality and the resolution of important comorbidities, particularly type 2 diabetes.[12] The impressive and nearly immediate effect of surgery, and notably RYGB, on the resolution or remission of this chronic disease is becoming the focus of much attention and is also leading to the development of a new postbariatric surgery population of nonobese, or at least non-morbidly obese, patients endoscopists will encounter in the near future.

Bariatric surgery procedures

The VBG is named vertical to distinguish it from the (horizontal) gastroplasty, which preceded it in the 1970s. As the first restrictive procedure, the horizontal gastroplasty had poor weight loss results and was replaced by the VBG in the 1980s. This restrictive procedure was one of the most popular procedures in the United States for a decade until the advent of RYGB in the 1990s. However, it is now practically obsolete. Indeed, LRYGB offers better results and LAGB is less invasive with similar outcomes.

LAGB is the latest variation of the gastric restriction procedures. Its success is a combination of 2 innovations: the development of an inert inflatable band (which offers the opportunity of precise adjustment of the degree of restriction) and laparoscopy (which allows LAGB to be performed with minimal surgical trauma). LAGB quickly gained popularity in Europe and Australia in the mid and late 1990s. In the United States, the adjustable band gained rapid popularity after its introduction; the Food and Drug Administration only approved its use in June 2001. To date, over 700,000 adjustable bands have been sold by various companies worldwide.[13]

RYGB was first reported in 1969 by Mason,[14,15] but its popularity only started to increase in the 1980s as the technique improved. RYGB became an attractive alternative to VBG and surpassed the restrictive procedure during the 1990s. Indeed, the advent of laparoscopy and specifically of reliable laparoscopic staplers transformed RYGB to LRYGB, the current mainstay of bariatric procedures worldwide.[7]

The latest procedure to hit the bariatric arena is LSG. LSG was originally described in 2003 as the first step preceding BPD/DS in superobese patients. The staged approach was aimed to improve results and lower morbidity in patients with a BMI over 50 or 60. LSG is now used as a stand-alone laparoscopic procedure with rapidly increasing popularity.[16]

BPD (and BPD/DS) is probably the most technically challenging bariatric procedure and has followed a course of its own since its description by Scopinaro in 1979.[17,18] This procedure has been advocated by a group of surgeons led by Scopinaro himself in Europe (the BPD is often referred as the Scopinaro procedure) and by Hess and Gagner in the United States, who had described the BPD/DS.[19] Its significant malabsorption, excellent weight loss, and comorbidity resolution have also made it a first-choice procedure for some surgeons in specific situations, including in the massively obese and in noncompliant patients, such as those with Prader-Willi syndrome.

Post-bariatric surgery endoscopy

Endoscopy has become an irreplaceable tool in the management of bariatric patients. However, endoscopists must be familiar with the new gastrointestinal anatomy and specificities of the surgical montage in order to be effective and safe. Management of these patients is a multidisciplinary endeavor, especially in the early postoperative period. This period usually extends for about 6-8 wk postoperatively. During this period, recent anastomoses or potential surgical complications can result in complications during even a simple diagnostic esophagogastroduodenoscopy. During this time frame, the surgeon who performed the procedure should be contacted if he or she is not directly referring the patient. The need for endoscopy during this period is relatively infrequent and usually implies a potential surgical complication, such as bleeding or a low-grade anastomotic leak. The endoscopist must therefore be made aware of any unusual postoperative course, unusual surgical event, or patient-related complication (complications with sedation, compliance, etc). During this early postoperative period, anastomoses are fragile and may be easily damaged by mechanical trauma from the endoscope or excessive air distention. Anastomotic edema can also complicate the endoscopic procedure and diagnosis.

After this early postoperative period, information from the surgical team may also be useful, and if there is no direct contact, copies of the OR report and discharge letter are invaluable. Indeed, if the procedures described below are standard, many modifications can be encountered because of surgical technique variation between surgeons, or complications leading to secondary procedures.

In summary, collaboration between the surgical and gastroenterology teams is essential. Such collaboration allows adequate preparation for the procedure as well as definition of the goals and limitations and determination of the best possible procedure to answer the specific clinical question.

We describe below normal gastrointestinal tract anatomy after bariatric surgery, dividing procedures into those with normal small bowel anatomy (restrictive procedures) and those resulting in small bowel modifications (procedures with a “malabsorptive” component).

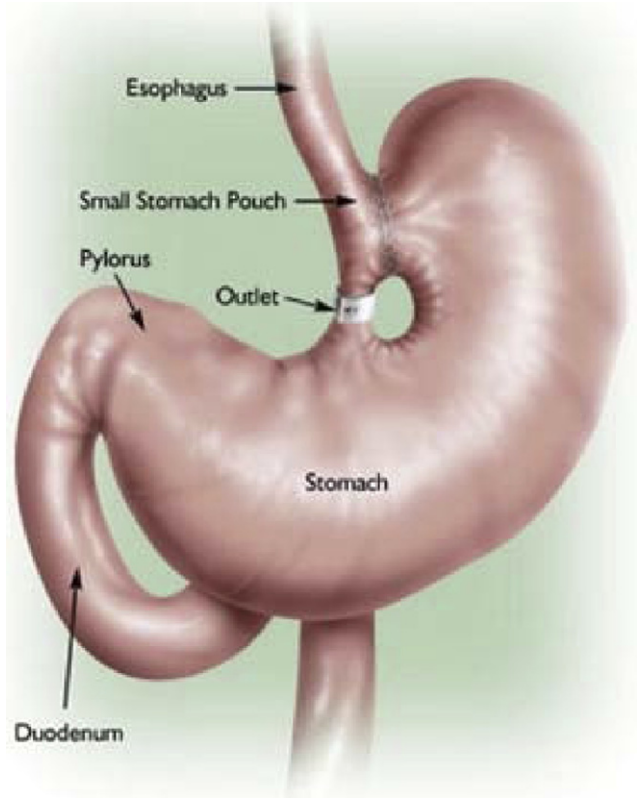

Figure 1 Vertical banded gastroplasty. (Color version of figure is available online at www.techgiendoscopy.com.)

Normal postgastric anatomy

Vertical banded gastroplasty

The VBG creates a small gastric pouch and a restricted outlet with a nonabsorbable, nonadjustable band at the level of the proximal gastric body (Figure 1). Contrary to the LAGB, the band is not placed around the entire body of the proximal stomach, but the stomach is partially divided to place the band. This vertical division is created proximally to the band, extending vertically to the angle of His, using a linear stapler, creating a 30-cc gastric pouch. The band consists of a Marlex or silastic ring, 1 cm in length, which is placed at the outlet of the new gastric pouch.

Endoscopically, the pouch extends from the Z-line and appears to be about the same diameter as the esophagus, occasionally slightly wider. The gastric pouch can be up to 10 cm long, followed by a narrowing caused by the band. The outlet should be at least 10 mm wide and should always allow easy passage of a standard upper endoscope. The gastric pouch should be carefully inspected because a breakdown of the staple line may occur and the creation of a gastrogastric fistula with a connection to the gastric fundus is not uncommon. The staple line should also be inspected with retroflexion into the gastric fundus after exiting the pouch. The area of the ring or band should also be thoroughly inspected both proximally and distally for signs of intragastric erosion or migration. Distal to the band or ring, anatomy should be completely normal if no other procedure has been performed.

Laparoscopic adjustable gastric banding

Unlike the VBG, the LAGB is wrapped around the entire proximal stomach, without any stapling or sectioning of the stomach (Figure 2). The LAGB is secured to the stomach itself by wrapping the outside of the stomach wall around the band. The band is a silicone ring, the inner portion of which is lined with an inflatable cushion linked to a subcutaneous port. At the time of placement, the ring is completely deflated and creates a narrowing around the proximal stomach, with a gastric pouch proximal to this narrowing in the gastric cardia. This pouch has a standard maximum volume of 30 cc. The inflatable portion is used to increase the restrictive component of the LAGB and is first inflated at 6 to 8 wk after surgery. Inflation is then increased or decreased, balancing between weight loss results and the level of restriction perceived by the patient. When the band is inflated, the pouch outlet can be just a few millimeters in diameter and complete band deflation may be required before endoscopy.

Endoscopically, after crossing the Z-line the small gastric pouch will be encountered, with the band's stenosis as the outlet. The pouch, outlet, and "normal" stomach should all be inspected, looking for signs of band slippage or erosion. The length of the band is typically about 10 mm. The location of the band should also be noted because band slippage (usually proximally) is a possibility. It is important

Figure 2 Laparoscopic adjustable gastric banding. (Color version of figure is available online at www.techgiendoscopy.com.)

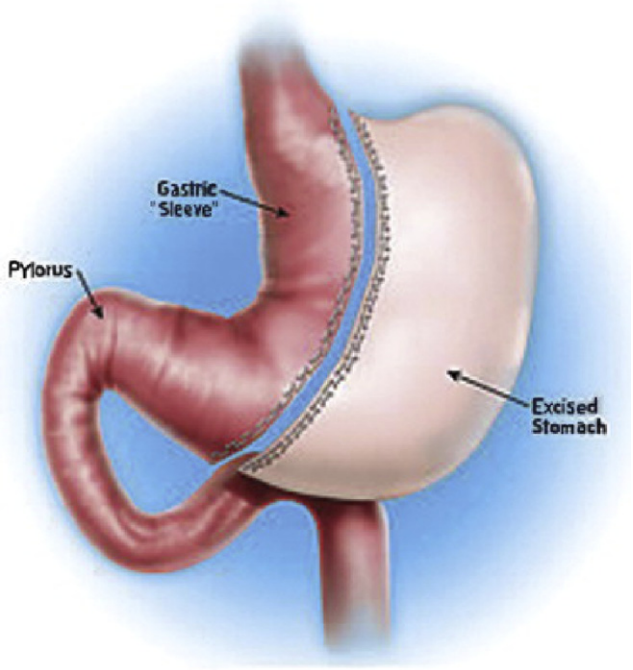

Figure 3 Laparoscopic sleeve gastrectomy. (Color version of figure is available online at www.techgiendoscopy.com.)

to thoroughly investigate the folds at the pouch outlet and perform a retroflexed examination. As with the VBG, distal to the band, anatomy is completely normal if no other procedure has been performed.

Laparoscopic sleeve gastrectomy

As mentioned, LSG as a stand-alone procedure is the newest of the bariatric procedures (Figure 3). It is sometimes the first part of a 2-stage procedure in patients with a BMI over 60 and is then typically followed by a BPS/DS. LSG is done laparoscopically, and about 75% of the volume of the stomach is removed.

A sleeve of stomach, the caliber of which is based on a bougie, is created following the lesser curvature. The caliber of the bougie varies between surgeons and usually is between 32 and 48 Fr, and the stomach volume ranges from 70 to approximately 150 cc. This sleeve extends the entire length of the stomach, from the angle of His to the antrum, and ends a few centimeters before the pylorus.

Endoscopically, the LSG will appear as a long, narrow tube of stomach widening from the Z-line to the pylorus. The gastric staple line is the primary potential concern and extends for about 30 cm; it should be carefully inspected, especially proximally. The area with the greatest risk of staple line disruption is at the angle of His, and retroflexion to clearly visualize this portion may be difficult because of the narrow sleeve. A nasal or pediatric endoscope may be useful. Distal to the pylorus the anatomy is normal.

Altered postgastric anatomy

Roux-en-Y gastric bypass

For decades, RYGB has been the mainstay of bariatric procedures, and over 1 million patients have some sort of RYGB anatomy (Figure 4). Therefore, many endoscopists are familiar with this anatomy. However, variations of the technique are relatively common and these details should be sought before initiation of the procedure.

Currently, most RYGB are performed laparoscopically.[7] A small gastric pouch is created, with a volume of about 15 cc. The stomach is stapled and cut a few centimeters (usually about 5 cm) below the gastroesophageal junction, starting at the lesser curvature. The first stapling is horizontal and then vertical toward the angle of His, creating a pouch nearly as narrow as the esophagus. When RYGB was performed in an open fashion, the pouch was created by stapling, without dividing the stomach. This greatly increased the risk of gastrogastric fistulae, particularly at the upper proximal limit near the gastroesophageal junction. One important variation is the presence of a silastic (or Fobi) ring around the gastrojejunostomy to prevent dilation over time. This procedure is sometimes called banded RYGB.[20] As with other implants, this band has the potential of eroding and migrating into the gastric pouch.

Next, the small bowel is cut approximately 40 to 60 cm after the angle of Treitz, creating the so-called bilio-pancreatic (or BP) limb. The distal loop of bowel is then brought up to the gastric pouch and is anastomosed in 1 of 3 fashions:

- A circular stapler may be used. This creates a gastrojejunal anastomosis of constant diameter and shape, usu-

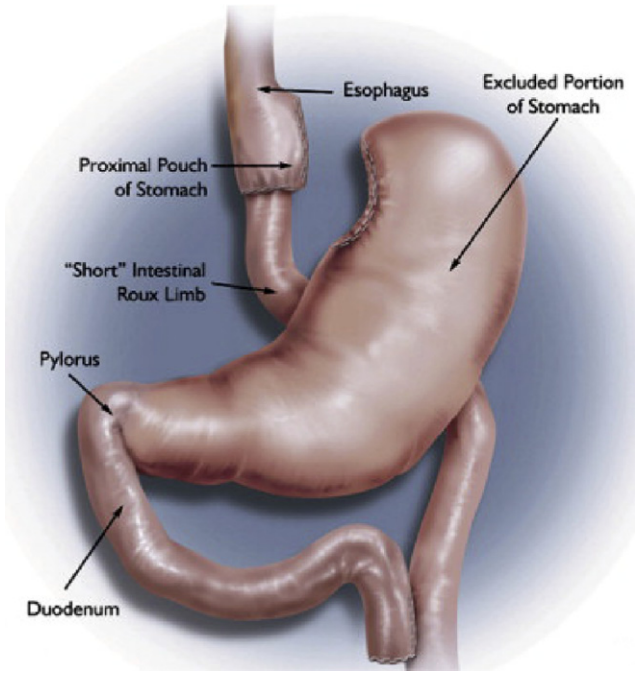

Figure 4 Roux-en-Y gastric bypass. (Color version of figure is available online at www.techgiendoscopy.com.)

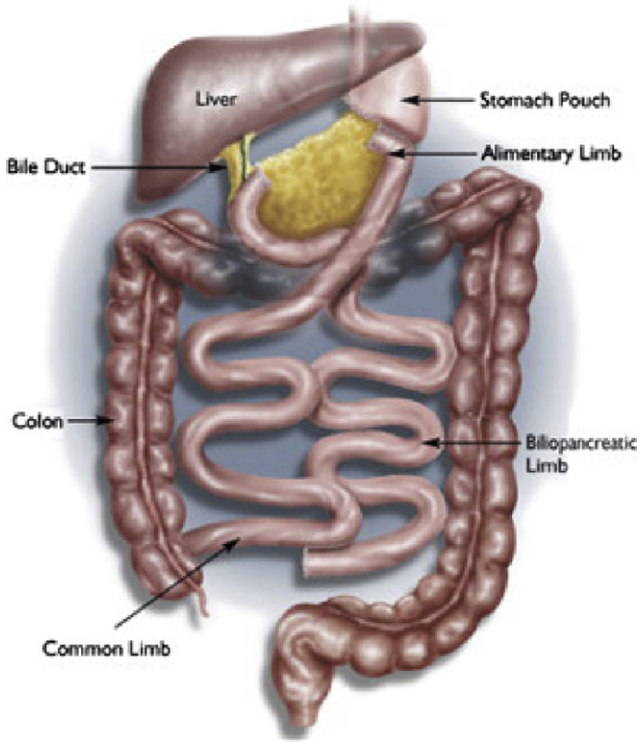

Figure 5 Biliopancreatic diversion (Scopinaro procedure). (Color version of figure is available online at www.techgiendoscopy.com.)

ally 21 or 25 mm outer diameter. However, these anastomoses are more prone to strictures, and dilations can be difficult because of the presence of a triple layer of metal staples.

- A linear stapler may be used, which creates a slightly more oval-shape anastomosis and leaves a defect that must be closed manually with sutures.
- Some surgeons create a completely hand-sewn anastomosis, using only sutures and no staples.

The last notable variations are the length of the Roux limb (the bowel extending from the gastric pouch) and type of jejunojejunal anastomosis. The limb is commonly 75 to 100 cm long, but has been created anywhere from 40 to 200 cm. The jejunojejunal anastomosis or Y anastomosis may be end to side or side to side, the endoscopic appearance of which differs significantly.

Endoscopically, the small gastric pouch is seen after the Z-line. Because of its small size, maneuvers can be challenging, but the pouch should be inspected for evidence of fistulae or erosion from a band. The gastrojejunal anastomosis (pouch outlet) should measure between 6 and 16 mm (most often 9 to 12 mm) and should be inspected for evidence of foreign bodies, such as staples or loose sutures. Once the outlet is passed, the blind portion of the Roux limb should be visualized because it is usually short. The Roux limb then extends distally for up to roughly 150 cm, and reaching the jejunojejunal anastomosis can require an enteroscope. The Y anastomosis, as well as the biliopancreatic limb, can sometimes be missed because of the acute angle that it approaches the anastomosis. Standard[21] and double-balloon enteroscopes[22,23] have been used to reach the excluded stomach by going back up the BP limb; percutaneous access directly into the excluded stomach has also been described.[24] Endoscopic retrotrade cholangiopancreatography (ERCP) has also been achieved repeatedly with similar methods.[25-27]

Biliopancreatic diversion

BPD actually comprises 2 endoscopically (and surgically) different procedures, BPD and BPD/DS (BPD with duodenal switch) (Figures 5 and 6). The procedures are, however, similar in their combination of both restrictive and malabsorptive principles, with a profound lean toward malabsorption.

The BPD described by Scopinaro somewhat resembles RYGB, with 2 major differences. As with RYGB, a gastric pouch is created to provide a restrictive component, the jejunal limb is anastomosed to the gastric pouch, and a Y anastomosis is created distally with the biliopancreatic limb. The resemblance ends here. The gastric pouch is approximately 10-fold larger than that for RYGB, with about one-third of the stomach remaining and a volume of 300 cc. Contrary to RYGB, the excluded stomach is removed in this procedure, and the duodenal stump is closed (distal gastrectomy). The other major difference is the length of the bypass. In RYGB the Roux limb is roughly 100 cm long, but in BPD, the anastomosis is extremely distal (at the distal ileum) and leaves about 50-100 cm of common (absorptive) limb, creating an important element of malabsorption.

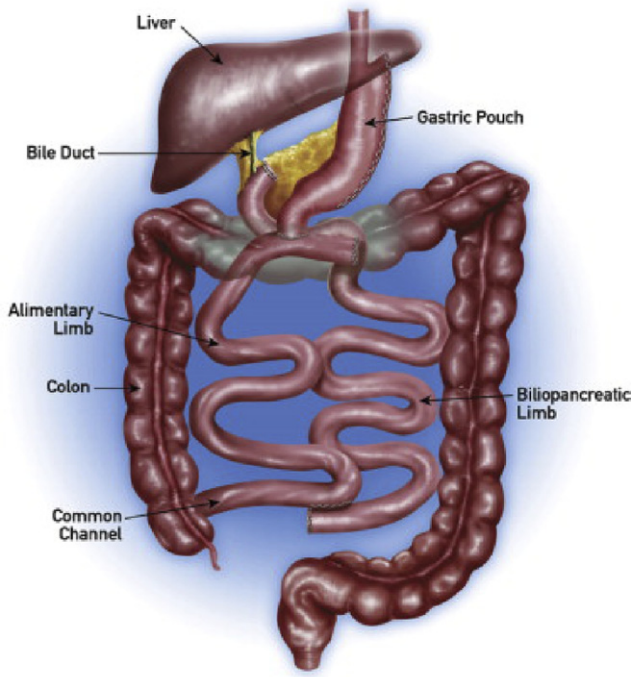

Figure 6 Biliopancreatic diversion with duodenal switch. (Color version of figure is available online at www.techgiendoscopy.com.)

Endoscopically, a relatively large gastric pouch is first encountered, and the jejunal outlet is located near the greater curvature, near the distal end of the pouch. The integrity of gastric closure should be assessed but the distal gastrectomy typically impedes fistula formation. The jejunal limb is easily intubated, but the distal anastomosis is virtually unreachable endoscopically and access to the duodenal papilla is therefore impossible from the mouth, and laparoscopic assisted endoscopy may also be needed for ERCP.[28]

The BPD/DS can be described as a combination of LSG and BPD. The gastric portion of the procedure is identical to an LSG. However, after the pylorus, the duodenum is divided and the distal stump closed. The jejunal limb, with the same length and distal anastomosis as in BPD, is then anastomosed in continuity to the pylorus. The distal portion of the procedure is identical to BPD.

Endoscopically, the gastric portion is practically identical to the LSG with a long, narrow gastric tube and a long (approximately 30 cm) staple line, which should be carefully inspected, especially proximally. Immediately after the pylorus, the duodenojejunostomy will appear and the jejunal limb will be entered. As with BPD, the distal jejunoileal anastomosis is virtually unreachable endoscopically from the mouth, and access to the duodenal papilla is therefore nearly impossible. This again may require laparoscopic assistance.

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