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Role of Flexible Endoscopy in the Practice of Bariatric Surgery

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Abbreviations

AGB	Adjustable gastric banding
BMI	Body mass index
BPD/DS	Biliopancreatic diversion with and without duodenal switch
CT	Computed tomography
EEA	End-to-end anastomosis
ERCP	Endoscopic retrograde cholangiopancreatography
GERD	Gastroesophageal reflux disease
GI	Gastrointestinal
GP	Gastric plication
IOP	Incisionless Operating Platform
PEG	Percutaneous endoscopic gastrostomy
RYGB	Roux-en-Y gastric bypass
SG	Sleeve gastrectomy
TTS	Through-the-scope
VBG	Vertical banded gastroplasty

Introduction

The burden of obesity continues to increase in the United States and worldwide. Surgical intervention has been demonstrated as an effective long-term treatment for obesity and obesity-related health comorbidities. Due to this, the number of bariatric procedures performed in the last decade has increased significantly and there has also been a shift in the type of procedures performed. Currently, the most commonly performed bariatric procedures include Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG), and adjustable gastric banding (AGB) [1, 2]. Other procedures less commonly performed include biliopancreatic diversion with and without duodenal switch (BPD/DS), vertical banded gastroplasty (VBG), and gastric plication (GP). Other historical bariatric surgical procedures, such as a jejunoileal bypass and horizontal gastroplasty, are no longer performed due to complications and lack of efficacy, respectively, but patients that have previously undergone these operations may present for evaluation. Consideration of the types of procedures performed, both anatomically and physiologically, is critical in evaluating patients pre- and postoperatively. Surgeons and physicians caring for bariatric surgery patients need to understand the anatomical changes as a result of such operations and how these changes relate to the mechanisms of weight loss. Furthermore, it is imperative to recognize the expected complications and long-term outcomes for these patients.

Flexible endoscopy is an increasingly valuable tool in managing bariatric surgery patients. Flexible upper endoscopy has roles in the evaluation, management, and treatment of patients undergoing all types of bariatric surgical procedures. Endoscopists that evaluate bariatric patients may include bariatric surgeons, general surgeons, gastroenterologists, and other physicians that incorporate these procedures into their practices. However, as a bariatric surgeon, one should give strong consideration to being adept with flexible upper endoscopy for use in the work-up and management of patients. Bariatric surgeons have the advantage of knowing the specific surgical details of each bariatric operation, and often they are the practitioners performing the procedure on the patient they are evaluating or treating.

The evolution of flexible endoscopy has allowed for both diagnostic and therapeutic procedures. Newer endoscopic technologies have been developed to enhance medical care, reduce costs, and also improve patient satisfaction. Such examples include: disposable endoscopy, capsule endoscopy, 3D endoscopy, and advanced endoluminal procedures including clipping, stent placement, and suturing devices.

The following chapter addresses applications of flexible upper endoscopy in bariatric surgery patients during the pre-, intra-, and postoperative periods and the unique clinical and technical considerations during these periods.

Electronic supplementary material: Supplementary material is available in the online version of this chapter at 10.1007/978-1-4939-1637-5_41. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4939-1636-8.

S.A. Brethauer et al. (eds.), *Minimally Invasive Bariatric Surgery*,
DOI 10.1007/978-1-4939-1637-5_41, © Springer Science+Business Media New York 2015

Preoperative Assessment and Management

The preoperative use of flexible upper endoscopy to evaluate a patient prior to bariatric surgery is typically based on the presence of foregut gastrointestinal (GI) symptoms. The most common symptoms are reflux, dyspepsia, dysphagia, and abdominal pain. In non-bariatric patients who present with upper GI symptoms, the guidelines for the utilization of upper endoscopy are well described [3, 4], and these recommendations can similarly be applied to the preoperative bariatric surgery patient. However, as many of the bariatric operations either alter the anatomy of patients or alter the physiologic mechanisms of the GI tract, there may be benefit to a more frequent use of preoperative endoscopy in bariatric patients. The anatomic alterations caused by an RYGB or BPD/DS create challenges in postoperative endoscopic evaluation of the distal stomach, duodenum, and biliary tree, as these areas are difficult to assess with standard endoscopic techniques after surgery. Utilizing endoscopy prior to surgery may eliminate or reduce the need to access these difficult anatomic locations. Early identification of patients at higher risk for postoperative complications may alter their treatment plan and possibly modify the choice of bariatric operation.

Though not widely implemented, there is evidence to support routine use of endoscopy before bariatric surgery in asymptomatic patients. Many obese individuals with esophageal dysmotility, reflux, or other upper GI pathology are asymptomatic or have atypical symptoms. These patients may present with chest pain, cough, or asthma. A recent study demonstrated that 71 % of patients with documented manometric esophageal motility disorders prior to bariatric surgery were asymptomatic [5]. Kuper and associates reported that 80 % of patients who underwent routine preoperative endoscopy had pathologic findings, and only 20 % of these patients had any symptoms [6]. Furthermore, there is a high prevalence of GI pathology in obese individuals. In support of this finding, a meta-analysis revealed that obesity alone was associated with a significantly increased risk of gastroesophageal reflux disease (GERD), erosive esophagitis, and esophageal adenocarcinoma [7]. Through the use of routine endoscopy in all preoperative patients, multiple studies confirm the high prevalence of GI disorders in obese patients (Table 1) [6, 8–12].

Identification of anatomic defects or upper GI pathology in both asymptomatic and symptomatic patients can alter the course of treatment and also the surgical operation. Recommendations for upper endoscopy in all patients prior to bariatric surgery, regardless of the presence of symptoms, have already been suggested by guidelines outside of the United States [13]. A study conducted at the University of Virginia examined 667 patients with routine endoscopy prior to surgery; as a result, 4.6 % of patients had their operations altered by the findings from endoscopy [14]. The most common alteration in this cohort was the addition of a remnant gastrostomy tube based on preoperative endoscopic findings of the distal stomach. Another study of 447 patients demonstrated that preoperative endoscopy changed medical management prior to surgery in 18 % of patients but only altered or postponed surgery in <1 % [8]. Common findings by upper endoscopy that may impact the choice of operation or preoperative management include: esophagitis, GERD, ulcers, *Helicobacter pylori*, hiatal hernia, cancer, and polyps. Sharaf and colleagues retrospectively reviewed records of patients that were endoscopically evaluated prior to surgery and demonstrated that out of 195 patients, 89.7 % had one or more lesions, and of these, 61.5 % were clinically significant [15]. Biopsies for *H. pylori* should be obtained during endoscopy, especially in the presence of gastritis, and treated if positive. Studies have demonstrated a lower rate of marginal ulcers and foregut symptoms after bariatric surgery in patients that were either *H. pylori* negative or had been tested and treated [14, 16].

The utilization of preoperative flexible endoscopy is essential in the evaluation of patients prior to revisional bariatric surgery. Operative records should be reviewed before intervention, but specific anatomic constructs may not be accurately described in the report or the original operative reports may not be available. The indications for reoperation vary, and they often involve poor or failed weight loss, acute symptoms, or complications from the primary operation. This type of patient can present with complex problems and variable anatomy. Determination of the anatomy, assessment of the anastomoses and staple lines, and identification of any upper GI pathology will dictate the appropriate surgical intervention.

Table 1. Prevalence of pathologic findings during preoperative upper endoscopy in bariatric patients

Source	Year	No. of patients	Mean BMI (kg/m^2)	Prevalence of pathologic findings on endoscopy (%)
Madan et al. [10]	2004	102	48.2	91.0
Loewen et al. [8]	2008	448	48.6	29.2
de Moura Almeida et al. [9]	2008	162	44.1	77.2
Munoz et al. [12]	2009	626	42.0	46.0
Kuper et al. [6]	2010	69	47.6	79.7
Dietz et al. [11]	2012	126	51.2	57.9

BMI body mass index

Flexible upper endoscopy traditionally examines the mucosa of the upper GI tract and allows biopsies for histologic diagnosis. Supplemental techniques, such as the use of a pH probe and manometry, can provide further objective measures to evaluate a patient and determine treatment. In addition, radiographic studies may enhance medical decisions when used in combination with endoscopy. An upper GI series and a barium esophagram are two such examples. In a retrospective series of patients presenting for weight regain after previous bariatric surgery, Brethauer et al. demonstrated that the use of both endoscopy and upper GI series allowed for the detection of abnormalities in 90 % of patients [17].

Intraoperative Management and Techniques

Applications of endoscopy during bariatric surgery vary depending on the operation and technique. It has been described in the literature for many intraoperative applications, including identification of anatomy and inspection of surgical technique, and is also widely practiced.

For RYGB, different techniques have been described for the creation of the gastrojejunostomy, some utilizing endoscopy. Wittgrove and Clark described the use of endoscopy to pass the anvil of an end-to-end anastomosis (EEA) stapler into the gastric pouch during an RYGB [18]. Initial concerns for perforation with transoral passage of the anvil led to modifications in this technique, including manipulating the anvil to facilitate passage and also the development of a pre-tilted anvil [19]. Endoscopy also has a role in SG, and although sizing of the gastric tube is often done by means of a bougie, Diamantis and colleagues reported their experience of using an endoscope to perform a laparoscopic SG safely and effectively [20].

Anastomotic integrity is vital for a successful outcome and is often evaluated endoscopically at the time of operation. Failure to identify anastomotic leaks imposes significant morbidity [21]. Methylene blue dye injected near the gastrojejunal anastomosis via a nasogastric tube can identify leaks intraoperatively, and it has been used successfully in clinical practice. Unfortunately, positive leak tests stain the operative field, prohibit repeat exams, and may not precisely identify the area of leakage. Intraoperative endoscopy may circumvent these pitfalls. Endoscopy allows for visualization of the GI tract, for direct placement of the endoscope near the anastomosis or staple line, and for multiple leak tests since it does not utilize methylene blue dye. It also provides additional information about the pouch size and mucosal perfusion and allows for treatment of bleeding that may occur at staple lines. Intraoperative endoscopy can be used to evaluate both the gastrojejunostomy as well as the jejunojejunostomy. Schauer and colleagues described the use of endoscopy to evaluate the staple line of all gastrojejunostomies during RYGB as well as to perform a leak test [22]. A leak test is performed by clamping the Roux limb and submerging the gastrojejunal anastomosis and pouch in saline, while the lumen is inflated endoscopically. Leaks may be evidenced as bubbles emanating from a staple line. If a leak is present, it can be directly repaired at that time. The utilization of intraoperative endoscopy identified a 3.7 % anastomotic leak rate in 290 patients in one study [23] and a 4.1 % incidence of intraoperative technical errors in another, including 29 suture and staple line leaks, 2 bougie perforations, 2 inadvertent stoma closures secondary to the suture line, and 1 mucosal perforation in a gastric pacemaker, during 825 bariatric procedures [24]. Alaedeen and colleagues performed a retrospective review of 400 bariatric cases that included intraoperative endoscopy or methylene blue to identify leaks [25]. Postoperatively, all the patients underwent an upper GI series to evaluate for missed leaks, and the reported anastomotic leak rate was significantly lower after the use of endoscopy instead of methylene blue, at 0.4 % vs. 4 %, respectively. Similar techniques can be applied to SG to assess the staple line construction with a leak test, to check for bleeding, and to identify any technical errors such as narrowing at the esophageal–hiatal junction or incisura or endoluminal twisting of the sleeve. A leak test in an SG is performed by clamping proximally to the pylorus and submerging the stomach and staple line in saline while the lumen is inflated.

Endoscopy also serves as a valuable technique when facing challenging surgical cases or when treating complicated patients. Intraoperative endoscopy can be used to control bleeding and to deliver instruments. It can also be used for direct, percutaneous placement of feeding or decompression tubes into the Roux limb if needed.

Intraoperative endoscopy during revisional surgery is often helpful as an adjunct to external, surgical views. Even after extensive preoperative evaluation, intraoperative endoscopy is important to verify the distorted anatomy as well to determine the placement of new anastomoses. Similarly to an initial bariatric operation, endoscopy can be used to assess the integrity of anastomoses and to inspect for bleeding [26]. In reoperative bariatric surgery, a leak test may be performed on the newly revised or created pouch prior to anastomosis creation, evaluating the staple line integrity before committing to an anastomosis, thus allowing for immediate revision if needed. Intraoperative endoscopy during revisional bariatric surgery can also decrease operating times by helping to locate and identify gastrogastric fistulas, stenotic lesions, and gastrojejunal stoma locations [27].

Intraoperative endoscopy can also advance the training of future gastrointestinal and bariatric surgeons. It allows for the development and mastery of endoscopic skills under a structured and supervised setting [28, 29].

Postoperative Management and Techniques

Experience and skill in flexible endoscopy are important to bariatric surgeons in the postoperative period as well. Patients may present with varying symptoms suggestive of postoperative GI pathology or complications that require evaluation. Flexible endoscopy allows visualization of anatomy, identification of pathology, and potential intervention. Furthermore, the utilization of endoscopy by the surgeon who performed the primary operation establishes a unique firsthand knowledge when treating a patient; however, this is not always possible. Physicians unfamiliar with the anatomic changes as a result of bariatric surgery may potentially misinterpret findings on upper endoscopy.

Indications for Endoscopy

Symptoms frequently direct the clinical evaluation of postoperative bariatric surgery patients. Common symptoms include nausea, emesis, abdominal or retrosternal pain, dysphagia, and inadequate weight loss or weight regain [30, 31]. In general, the two most common indications for endoscopy in these patients are the evaluation of symptoms and the treatment of complications. The etiology of symptoms is often multifactorial; however, symptoms are frequently associated with dietary noncompliance and insufficient mastication. Patients with persistent symptoms should be further evaluated as these symptoms may indicate the development of complications after surgery. Patient history may be helpful in differentiating the etiology of pain and may guide patient work-up. Endoscopy is often the preferred diagnostic strategy and can effectively assess mucosal integrity, detect stenosis, and/or exclude other pathologic abnormalities in the surgically altered GI tract. Nausea, emesis, and bloating, with or without abdominal pain, can suggest an obstructive cause (strictures, internal hernias, or bezoars), a marginal ulcer, and band erosion or slippage or be indicative of dumping syndrome [26]. Dysphagia can be caused by esophageal dysmotility or anastomotic stenosis. In a study by Wilson and colleagues, 62 % of patients who were seen with persistent nausea and emesis after RYGB had significant findings of upper endoscopy (ulcers, stomal stenosis, staple line dehiscence) [32]. Retrosternal or abdominal pain may be caused by acid reflux, bile reflux, ulceration, or band erosion and should be evaluated by endoscopy. In addition to endoscopic evaluation, an upper GI contrast series or computed tomography (CT) scan with oral contrast should be considered.

Endoscopic Findings in Normal Postsurgical Anatomy

Roux-en-Y Gastric Bypass—The esophagus and esophagogastric junction should appear normal after an RYGB (Fig. 1a). It is important to limit the amount of air insufflation when evaluating the gastric pouch as it is of variable size. Further, special care should be made to examine the pouch and suture line for fistulas and ulcerations. The gastrojejunostomy will normally have a stoma measuring 10–20 mm in diameter. When an endoscopy is not performed by the surgeon who operated on the patient, variation in surgical technique must be determined and thoroughly identified. There can be variations in the anastomosis of the gastrojejunostomy and also in the length of the Roux limb. The gastrojejunostomy anastomosis is dependent on surgical technique, handsewn or stapled, and also the type of stapler used, circular or linear. Distal to the gastrojejunostomy, a short, blind limb is often seen alongside the efferent jejunal limb, often referred to as a candy cane. The Roux limb length typically ranges from 75 to 150 cm. The jejunojejunostomy may or may not be able to be reached with a standard upper endoscope.

Adjustable Gastric Banding and Vertical Banded Gastroplasty—Endoscopy is relatively straightforward after AGB and VBG. Dependent on the fluid volume in the band, AGB can produce a variable amount of extrinsic circumferential compression on the stomach that can be seen with the endoscope (Fig. 1b). At the time of endoscopy, it is important to determine the length of the pouch above the compression of the band to the gastroesophageal junction in order to assess for pouch dilatation or band slippage. The endoscopist should also evaluate for possible band erosion into the gastric wall. This may best be seen on retroflexion. In a VBG, the lesser curvature channel allows endoscopic visualization of the pouch, and the stoma is typically located 7–8 cm distal to the gastroesophageal junction. The banded portion in a VBG is variable in diameter, and once this area is traversed, the distal stomach and duodenum are accessible. In both procedures, retroflexion of the endoscope within the antrum will reveal the greater curvature and gastric fundus.

Sleeve Gastrectomy—The SG creates a long tubular stomach limited in expansion by a staple line that parallels the lesser curvature. During endoscopy, the staple line should be examined for defects and ulcerations (Fig. 1c). Specific attention should also be paid to patency at the incisura, located approximately midway to 2/3 of the distance to the pylorus from the esophagogastric junction, as well as to twisting of the lumen of the sleeve.

Biliopancreatic Diversion/Duodenal Switch—This procedure is often performed in conjunction with a partial gastrectomy, but it also involves a duodeno-ileal anastomosis that can be visible just distal to an intact gastric pylorus. The ampulla is not available for visualization or for endoscopic retrograde cholangiopancreatography (ERCP) in a standard fashion.

Bariatric Surgery Complications

Complications after bariatric surgery may present early or late in the postoperative course. Studies have reported varying rates of postoperative complications (Table 2) [22, 33–36];

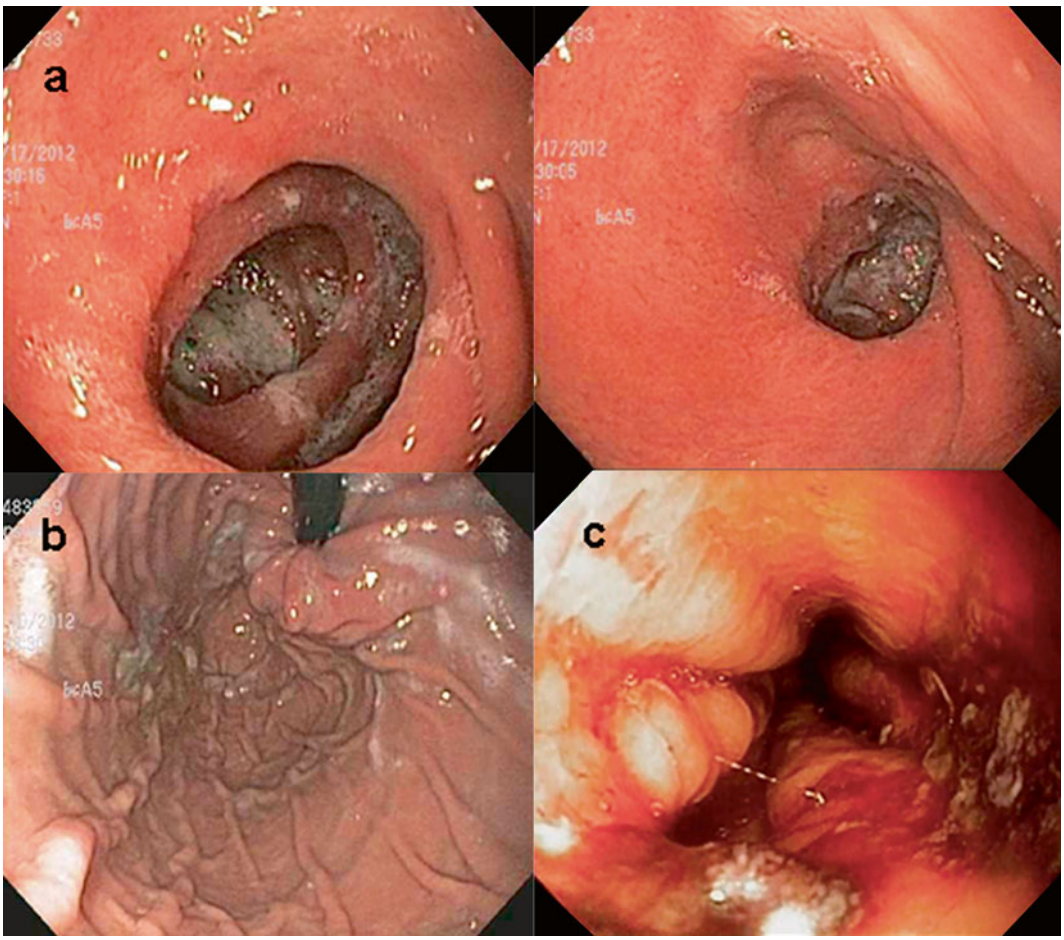

FIG. 1. Endoscopic appearance of (**a**) normal gastrojejunostomy and gastric pouch after gastric bypass, (**b**) normal compression from band seen on retroflexed view after adjustable gastric banding, and (**c**) normal staple line after sleeve gastrectomy.

TABLE 2 Complication rates after bariatric surgery

Source	Year	No. of patients	Late complication rate (%)	Early complication rate (≤30 days) (%)
Schauer et al. [22]	2000	275	47.3	30.5
Weller et al. [34]	2008	19,156	NR[a]	5.0
Encinosa et al. [33][b]	2009	2,522/7,060	41.7/32.8	33.7/25.5
Flum et al. [35]	2009	4,610	NR	4.1
Masoomi et al. [36]	2012	226,043	NR	4.9

[a]*NR* not reported
[b]Two time frames: 2001–2002 and 2005–2006

however, the rate of major adverse postoperative complications has been demonstrated between 4 and 6 % [35, 37]. Early complications such as bleeding, infection, and anastomotic leaks often require surgical intervention [37–39]. Furthermore, if a leak is suspected shortly after surgery, a contrast radiologic study can serve as the initial diagnostic test and is helpful to delineate anatomy. Complications can also develop later in the postoperative period. Late complications, such as ulcers, stenosis, gastrogastric fistulas, obstruction, band slippage or erosion, pouch dilation, and primary weight loss failure or weight regain, can occur with varying rates after any operation; however, some are more procedure specific (e.g., erosion after adjustable gastric banding). Several of these complications can be managed successfully endoscopically.

Endoscopic Management of Postoperative Complications

Marginal Ulcers—Defined as ulcers that occur at the gastrojejunal anastomosis, they can occur in 1–16 % of patients following RYGB [40–43]. Marginal ulcers typically present with

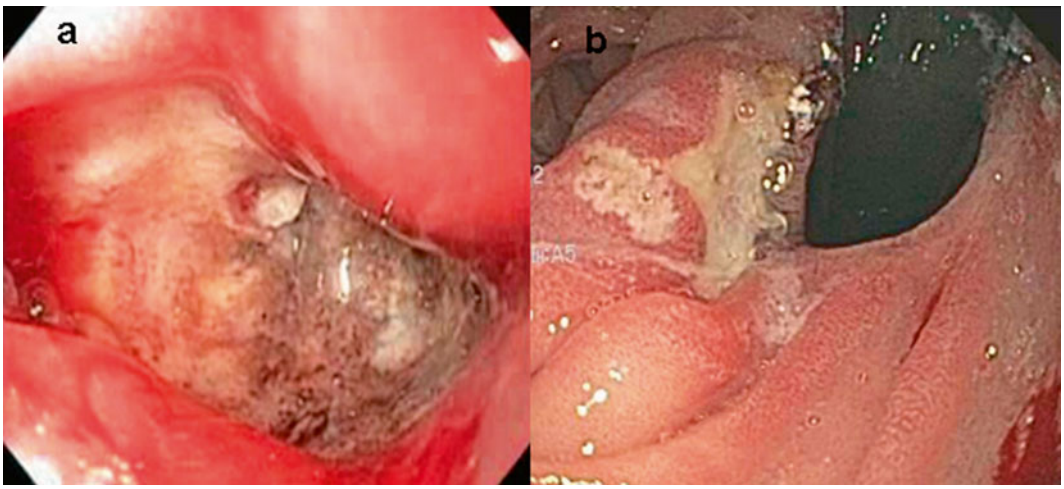

FIG. 2. (**a**) Endoscopic view of large marginal ulcer and (**b**) retroflexed view of marginal ulcer.

epigastric or abdominal pain, bleeding, or nausea, although they may be asymptomatic [32]. Ulceration can occur at any time postoperatively, but most ulcers occur in the first several months following surgery [44]. In a study conducted on all patients who underwent bariatric surgery, postoperative endoscopic examination 1 month after surgery demonstrated ulcers in 4.1 % of patients after open RYGB and in 12.3 % of patients after laparoscopic RYGB. 28 % of the demonstrated ulcers occurred in the absence of symptoms [45]. Marginal ulcers are frequently located on the jejunal side of the anastomosis, so careful attention should be paid to this area during endoscopy (Fig. 2). When possible, a retroflexed view can identify a potentially missed location of an ulcer. Even though the exact etiology is unknown, ulcers may result from gastric acidity (due to staple line dehiscence or gastrogastric fistula), pouch orientation and size (that may incorporate a greater parietal cell mass), *H. pylori* infection, the presence of staples and suture material (inciting a localized inflammatory reaction), and local ischemia and tension at the anastomosis [41, 44, 46]. Smoking and nonsteroidal anti-inflammatory drug use increase the risk of marginal ulcers, and the use of proton pump inhibitors appears to decrease risk [1].

The role of endoscopy for marginal ulcers is primarily diagnostic with limited therapeutic use. When identified during endoscopy, the pouch must be carefully examined for a fistula. Staple line dehiscence and the formation of a gastrogastric fistula can result in an increase in acid exposure in the pouch, stoma, and jejunum and make the mucosa more vulnerable to damage [26]. One study reported that stomal ulcers were associated with gastrogastric fistula in as many as 65 % of cases [46]. Ulcers may also represent foreign body reactions to sutures or staples, and judicious removal of foreign material with endoscopic tools may cause ulcer resolution [30]. If marginal ulcerations are not associated with staple line dehiscence or foreign body reaction, the management includes evaluation of the pouch for *H. pylori* status, proton pump inhibitor therapy, and liquid sucralfate and the elimination of ulcerogenic medication [38]. If marginal ulcers are severe and persist despite these measures, surgical revision may be required to prevent complications such as perforation, recurrent bleeding, and anastomotic strictures.

Stenosis—Luminal stenosis or stricture is an important complication of bariatric surgery. After RYGB, postoperative stricture formation is around 3 % [28]. The gastrojejunal anastomosis is the most common site of stenosis after bariatric surgery and has been reported in 5.1–6.8 % of patients after laparoscopic RYGB, typically within the first year [30]. Other locations where stenosis can develop include the gastric band, site of passage through the mesocolon, jejunojejunal anastomosis, and at adhesions. Anastomotic strictures are defined as anastomoses that are smaller than 10 mm in diameter [1]. Stenosis may arise from ischemia or ulceration, but the rates of stenosis are also somewhat technique dependent; the use of circular staplers has a higher rate of stricture than hand-sewn or linear staplers. Also, the use of 25 mm circular stapler reduced the rates of stricture when compared to the use of a 21 mm circular stapler [47]. Patients may present postoperatively with nausea, emesis, dysphagia, malnourishment, or unhealthy weight loss. Stenosis can be diagnosed by contrast radiography, but direct endoscopic visualization is preferable because it has high sensitivity and therapeutic measures can be performed (Fig. 3) [48]. Typical findings on endoscopy include a narrowed orifice precluding the passage of the endoscope; however, other potential findings include gastric pouch dilatation, undigested food, or foreign material [49].

Endoscopic treatment of strictures can be safely and effectively performed by using through-the-scope (TTS) balloon dilators or wire-guided bougie dilators [30, 50, 51]. Although initial success rates of up to 93 % have been reported, management may require multiple dilations. The length of time from surgery to stricture formation and the diameter achieved

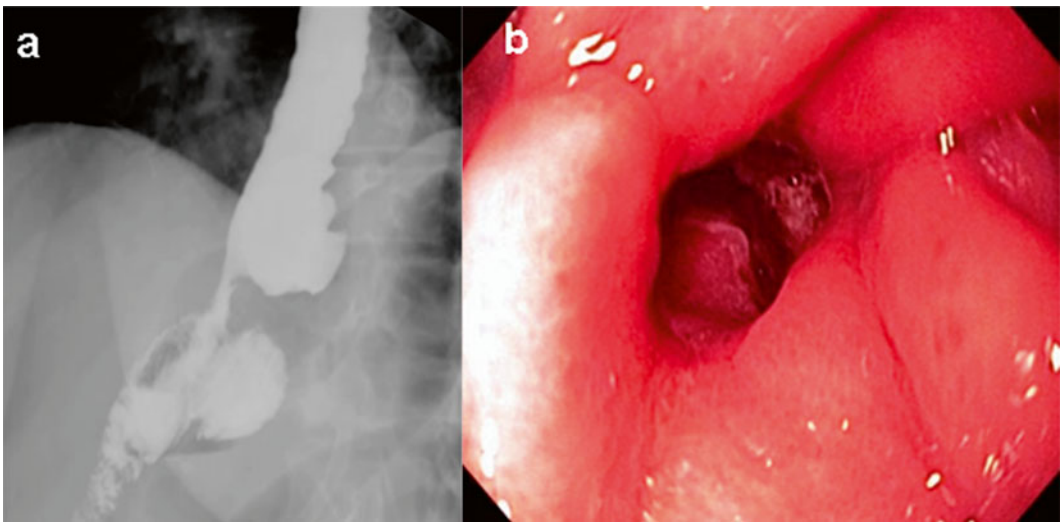

FIG. 3. (**a**) Radiographic evidence of a stricture and (**b**) endoscopic appearance of stenosis after gastric bypass.

with the first dilation procedure are significant predictors of the need for further dilations [52]. Repeat dilation with progressively larger balloons may also be required to achieve more durable results, and gradual dilations over multiple sessions may reduce the risk of perforation [53, 54]. Even still, some stenoses cannot be sufficiently dilated, and these patients will require surgical revision. Overaggressive dilation should be avoided, not only to reduce perforation risk, but also because dumping symptoms and weight regain can occur [49]. There have been reports of successful dilation up to 20 mm [55] without weight regain, but data is controversial on dilation greater than 15 mm, and many authors recommend against it [49]. When standard dilation is unsuccessful, additional strategies can be utilized such as the removal of exposed sutures with endoscopic scissors, injection at the anastomosis with saline or steroids after dilation, needle-knife electrocautery of scar tissue, or even argon plasma coagulation combined with diathermy [26, 30, 56].

Stenosis following AGB may be due to fibrosis of gastric tissue in the region of the band, formation of adhesions, or band angulation or slippage. Endoscopic dilation may be effective when the cause is fibrosis or adhesions but is rarely useful in the setting of band angulation or rotation [26]. Such patients should not have repeated dilations but instead treated surgically with either band removal, removal and replacement, or conversion to another procedure. After a VBG, stenosis is usually the result of stricturing and scarring of the outflow tract in the proximal stomach and thus the creation of a hypertrophic scar or frank erosion. The incidence of stricture has been reported at 13 % [57]. Endoscopic balloon dilation is not durable in the long term but may transiently alleviate symptoms [58]. Operative revision is typically required due to the fixed nature of the mesh band or for erosion into the lumen.

Stenosis can occur after SG with an incidence that ranges from 0.2 to 4 % [59]. Strictures have a higher occurrence with the use of a smaller bougie size and a tighter sleeve. They are generally seen in the proximal to mid stomach, at the incisura, or at the esophagogastric junction. The incisura is a common spot of narrowing resulting from stapling too close to the lesser curvature. Management options of strictures and stenosis after SG include: observation, endoscopic dilation with or without stent placement, seromyotomy, and conversion to RYGB. If endoscopic dilation has failed for 6 weeks, reoperation is typically recommended [60]. After SG, torsion or rotation of the remnant sleeve may present similarly to a stenosis with obstructive symptomatology and can be managed with dilation, myotomy, or revisional surgery.

Gastrointestinal Bleeding—Bleeding in patients after bariatric surgery may be acute or chronic or present as an iron deficiency anemia [61]. Bleeding can occur anywhere in the GI tract, including in the biliopancreatic limb and remnant stomach after an RYGB. Significant upper GI bleeding occurs in about 1–4 % of patients after RYGB [62], about 0.1 % after AGB [63, 64], and between 1 and 2 % after a sleeve gastrectomy [65, 66]. Patients with signs or symptoms of acute or chronic bleeding should be evaluated with endoscopy, preferably in close consultation with a surgeon, should complications arise or endoscopic interventions fail [62, 67]. The benefit of endoscopy is the ability to provide diagnosis and treatment simultaneously. However, endoscopy in the early postoperative period may be challenging, especially after RYGB and BPD because of the inaccessibility of the biliopancreatic limb, remnant stomach, and the jejunojejunostomy and the potential risks associated with early postoperative endoscopy such as perforation at the surgical anastomoses [68]. If more advanced endoscopic techniques, such as double-balloon enteroscopy, are unsuccessful at

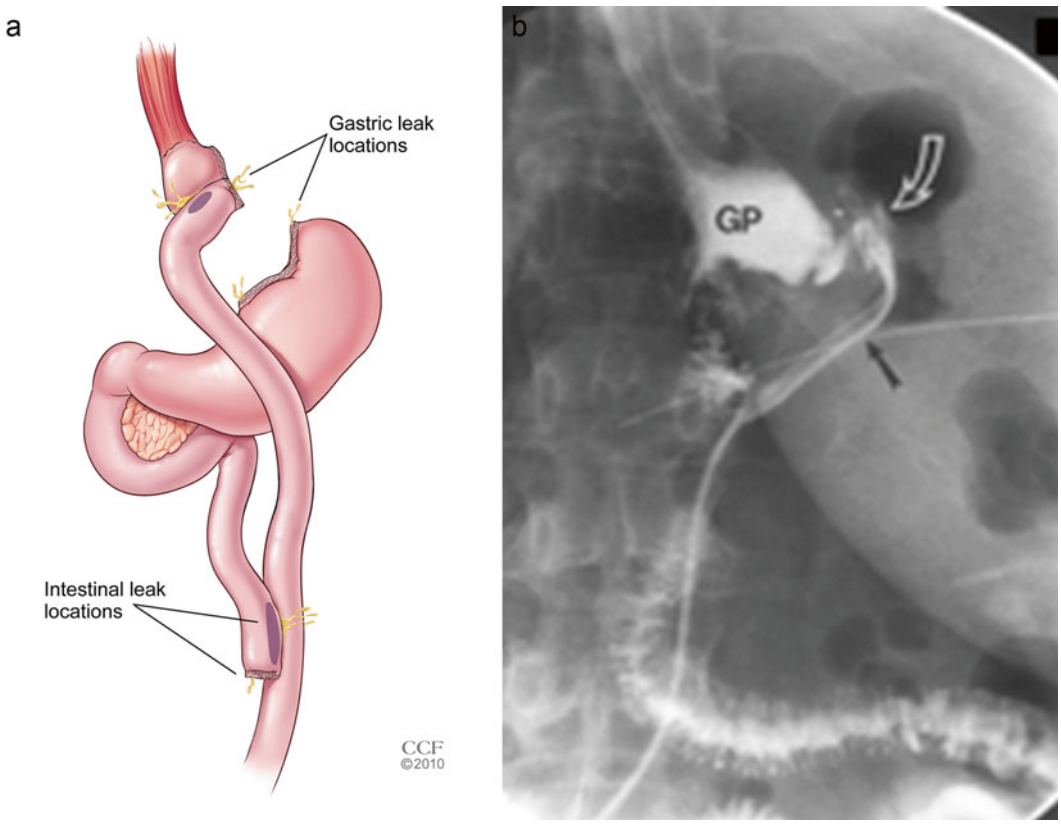

FIG. 4. (**a**) Illustration of common leak locations after Roux-en-Y gastric bypass (RYGB). (**b**) Upper gastrointestinal study showing leak at gastrojejunal anastomosis after RYGB (*white arrow* pointing at leak). Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010–2013. All Rights Reserved.

accessing the bypassed anatomy, access may be gained through a surgically created gastrostomy [69]. Endoscopy after an SG, VBG, and AGB is relatively straightforward, and standard flexible upper endoscopy is usually sufficient for the management of endoluminal bleeding in this situation.

Numerous approaches for treating active upper GI bleeds have been described in the literature. Techniques that involve the use of thermal energy (electrocoagulation, heater probe, and argon plasma coagulation), mechanical application of clips, and local injections with epinephrine, sclerosants, and thrombin/fibrin glue have all been successfully reported [70]. A retrospective review of 933 patients after RYGB reported a 3.2 % incidence of postoperative hemorrhage and an 80 % rate of successful endoscopic intervention [71]. Bleeding after an SG tends to occur at the staple line and is usually self-limited. Rarely, the use of endoscopy to suction out or push out a blood clot may be necessary [66].

Leaks and Fistulas—Gastric leaks and fistulas are potentially serious complications of bariatric surgery and cause significant morbidity. Overall, the occurrence of leaks is between 0.4 and 6 % in gastric bypass patients [24, 50, 72] and is 2.4 % in SG patients [73]. High-volume centers tend to report anastomotic leak rates of less than 2 % [24, 74, 75]. Identification of a leak in the immediate postoperative period suggests that either an intraoperative leak test with endoscopy missed the defect or that the leak developed after the completion of the operation. Staple line disruption can result in extraluminal leaks or eventually gastrogastric fistulas (most common type). Extraluminal leaks tend to present early in the postoperative period and can result in peritonitis, abscess, sepsis, organ failure, and even death [30, 76]. After RYGB, most leaks occur at the gastrojejunal anastomosis followed by the remnant stomach; leaks at the jejunojejunal anastomosis are rare but do occur and usually need reoperation (Fig. 4a). After SG, leaks are typically found in the proximal third of the stomach and specifically at the areas of the esophagogastric junction [73]. Upper GI studies are typically used to diagnose extraluminal leaks (Fig. 4b). CT scans are another common imaging modality used to examine the anatomy of the anastomoses and staple lines. Typically, leaks with clinical signs of sepsis require operative repair, drainage of infection, and establishment of enteral access. Endoscopy has an adjunct role in the operating room, for example, to define the precise location of the leak and, increasingly, to be used as a therapeutic measure. There have

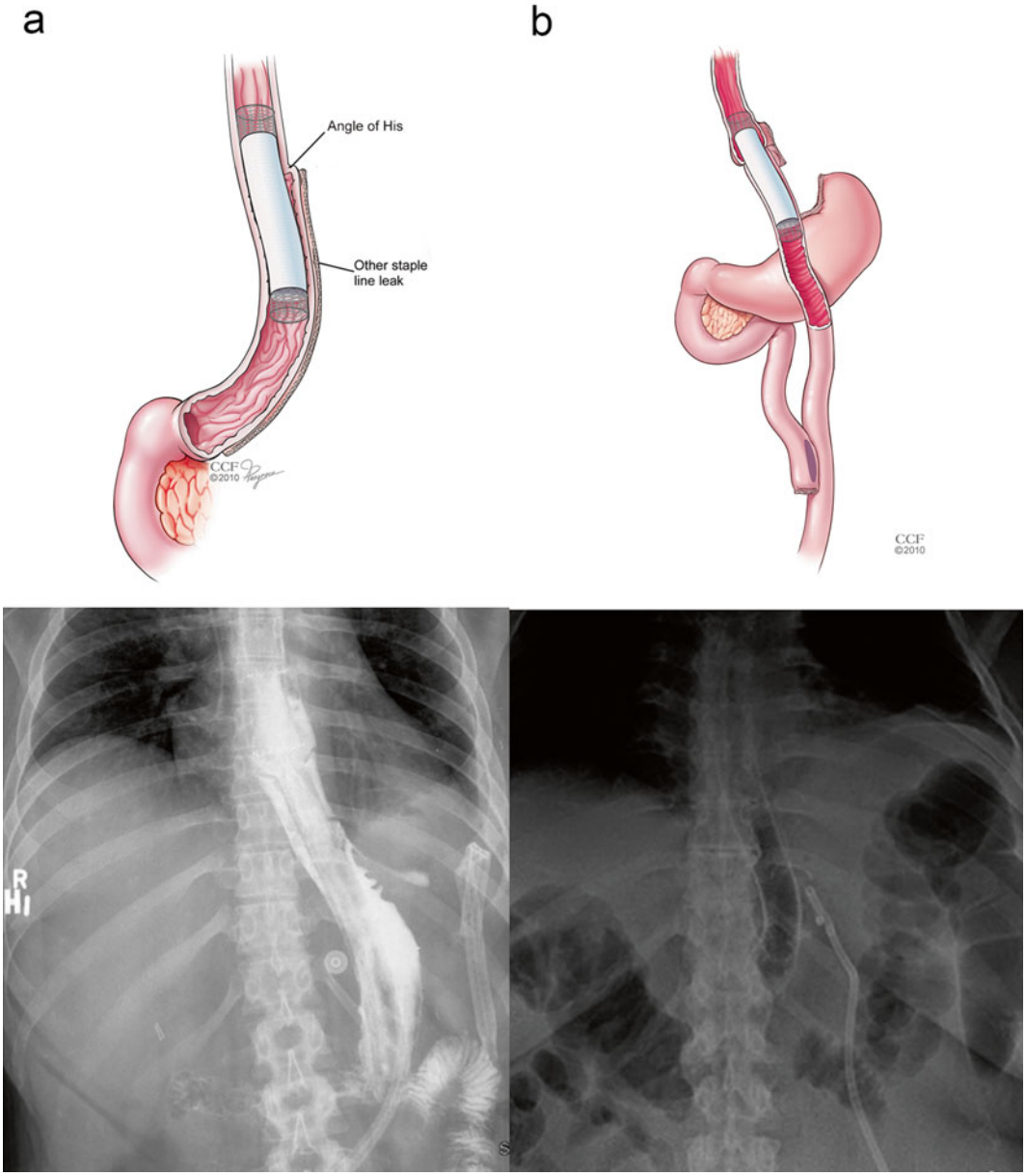

FIG. 5. (**a**) Sleeve gastrectomy with stent and radiographic appearance of stent after placement. (**b**) Roux-en-Y gastric bypass with stent and radiographic appearance of stent. Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010–2013. All Rights Reserved.

been small series that have described endoscopic management of leaks using partially covered self-expanding metal stents, Polyflex stents, argon plasma coagulation, endoscopic clips, and fibrin glue [77, 78]. Merrifield and colleagues reported successfully treating three patients with leaks endoscopically and concluded that endoscopy may be a feasible, less invasive alternative to surgical repair [77]. A study at the Cleveland Clinic, which used three different types of stents for the management of anastomotic complications after bariatric surgery (a prototype salivary stent, a partially or fully covered self-expanding metal stent, and a silicone-coated polyester stent), demonstrated that endoscopic stent placement successfully resolved anastomotic leaks in 85 % of patients (Fig. 5) [79]. Such novel methods are still currently investigational, and further research is needed to define the role of endoscopy to treat postoperative anastomotic leaks.

Chronic fistulas may be found in the presence of marginal ulcers or as a result of staple line disruption. Staple line dehiscence after SG has been reported at rates ranging from 0.3 to 5 % [80]. Patients with a chronic fistula may present with nausea, emesis, epigastric pain, and weight gain. However, many fistulas may remain subclinical, and the true

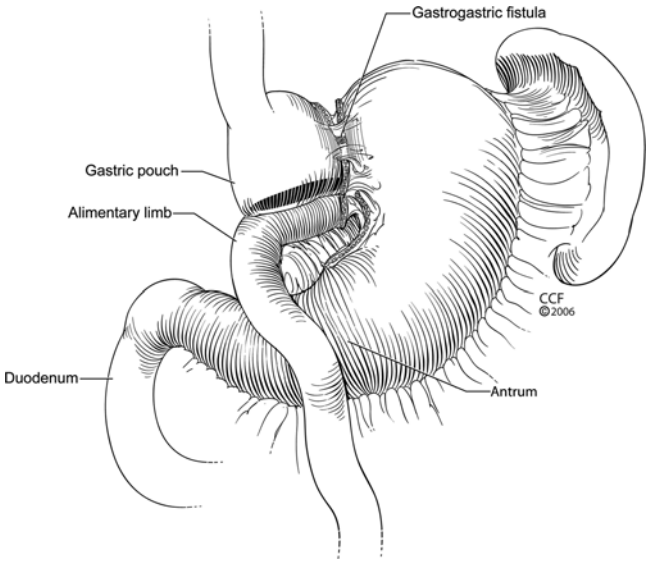

FIG. 6. Gastrogastric fistula after gastric bypass. Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010–2013. All Rights Reserved.

incidence is not entirely known [41]. Fistulas, similar to acute leaks, are typically diagnosed with upper GI series. A large fistula may also be visualized by endoscopy. A gastrogastric fistula is the most common type and is depicted in Fig. 6. Surgery is the mainstay of treatment, but techniques of endoscopic management are being actively investigated [81]. For example, endoscopic treatment of postoperative fistulas has been accomplished with self-expanding stents and endoscopic suturing and clipping [82–85]. Successful closure of gastrocutaneous fistulas after VBG and BPD using endoscopic fibrin sealant injection has also been reported [86]. Although these techniques are feasible, long-term durability is dependent on fistula size, with large fistulas yielding suboptimal results [87].

Band Erosion and Slippage—Band erosion into the gastric lumen can occur after AGB and VBG. Band slippage is another complication that can occur after AGB. The incidence of band erosion after VBG and AGB is uncommon and has been reported at 1–3 % after VBG and 0.9–3.8 % after AGB [88–90]. Band erosion can be asymptomatic or can cause abdominal pain, nausea, emesis, access port site infection, fistula, increased food intake, and GI bleeding. Band slippage may present with weight gain, worsening reflux symptoms, or obstruction. Erosion is best diagnosed endoscopically. Endoscopy can allow for direct visualization of a band eroding through gastric mucosa (Fig. 7), and endoscopic removal techniques for near completely eroded bands have been described [89, 91]. However, surgical repair is usually recommended with excision and replacement or conversion. While band slippage can be demonstrated with endoscopy, it may be best diagnosed with contrast radiography, since findings on upper endoscopy are variable and dependent on the degree and type of slippage encountered. Findings may include an enlarged pouch size, reflux esophagitis, gastritis, or ulcers. Severe cases are potentially life-threatening as they can lead to gastric necrosis [92, 93]; this may be demonstrated endoscopically as mucosal ischemia.

Acid Reflux and Gastroesophageal Reflux Disease (GERD)—Symptomatic GERD is frequent in bariatric patients, and obesity itself is a risk factor for GERD. Studies have reported a prevalence of 30–60 % in the severely obese population [94–97]. The effect of bariatric surgery on GERD appears to be variable and is likely dependent on the type of bariatric operation performed. Most studies agree that RYGB has a positive effect on GERD, resulting in a decrease in prevalence, symptoms, and medication use [94, 98–100]. Research has indicated that VBG is either unassociated with any change in reflux postoperatively [101] or associated with a transient decrease and later increase in reflux symptoms [102]. The effect of gastric banding on GERD is inconclusive; some studies report an increase in reflux [101, 103], while others report a decrease [104]. Due to limited data on pre- and postoperative reflux in SG, there is a lack of consensus in regard to the effect this operation has on GERD [65, 105]. Symptoms of GERD after bariatric surgery should be managed like those in patients who did not have bariatric surgery [4]. Flexible upper endoscopy should be reserved for the evaluation of symptoms refractory to medical therapy and to rule out complications and diagnose causes of GERD. Reflux symptoms after AGB can be the result of an excessively tight band or slippage [106]. A contrast study may be helpful to assess the degree of constriction, and endoscopy should be performed if symptoms persist after deflation of the band. Further, for patients who report symptoms of GERD after gastric banding, conversion to RYGB is often recommended as it treats both reflux and weight [107, 108].

Weight Regain or Inadequate Weight Loss—Initial weight loss failures after bariatric surgery or weight regain after an initial postoperative weight loss may be the result of a technical failure. These may include gastrogastric fistula from a staple line dehiscence, a large patulous gastrojejunal anastomosis that fails to restrict food intake, dilatation of the gastric pouch, or band slippage. However, often the cause is related to dietary noncompliance, and thus, preoperative counseling is needed to establish realistic weight loss goals. Endoscopy remains the best way to assess postoperative anatomy [30], and it can also provide a method for management. Endoscopic therapies for weight regain are evolving. Large gastrojejunal anastomoses can be treated with four-quadrant endoscopic injection of sodium morrhuate into the stoma to cause scarring and reduction in stomal size [109]. Novel techniques utilizing endoscopic suturing devices can allow for nonoperative revision of the gastrojejunal anasto-

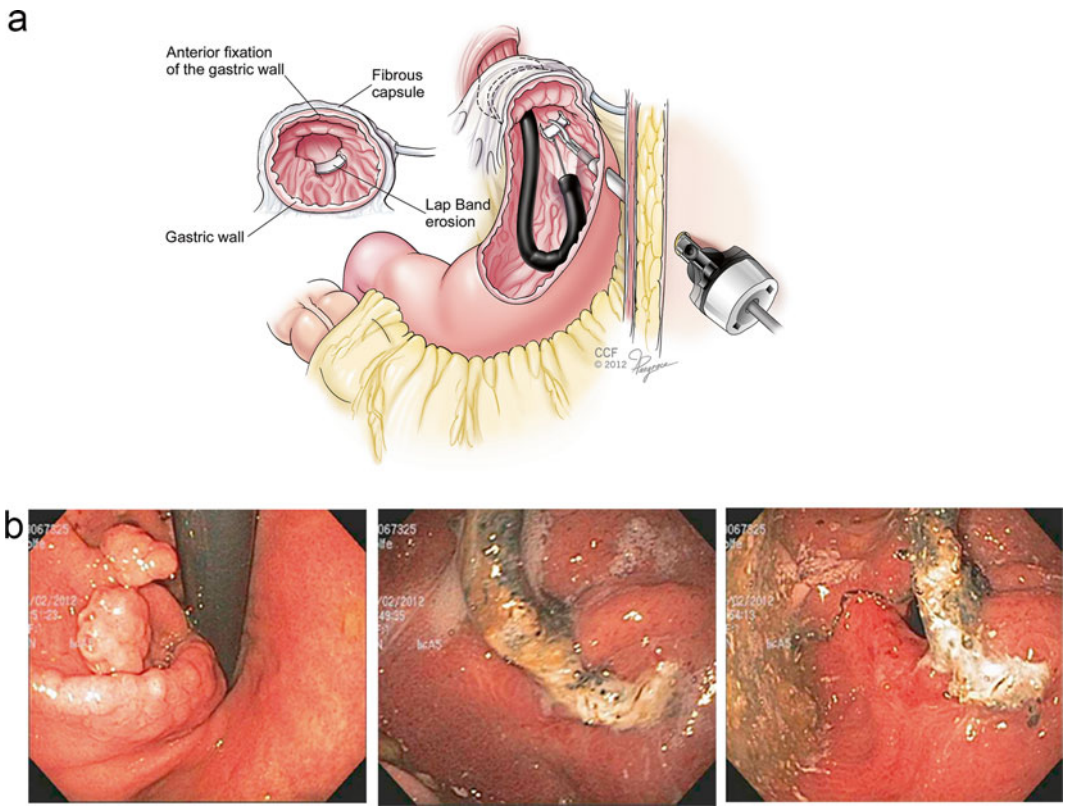

FIG. 7. (**a**) Illustration and (**b**) endoscopic views of band erosion. Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010–2013. All Rights Reserved.

mosis and reduction of pouch size after RYGB. The long-term durability of these endoscopic techniques remains to be demonstrated [110].

Bezoars—Food bezoars can occur in patients after bariatric surgery and are most common after AGB [111, 112]. They form within the first postoperative month, and patients typically present with nausea, emesis, and dysphagia. Bezoars can be diagnosed and effectively treated with upper endoscopy by fragmentation and removal [113]. If an anastomotic stricture or stenosis is discovered with the bezoar, then it should be treated with endoscopic dilation.

Special Considerations—Endoscopic Retrograde Cholangiopancreatography (ERCP) and Transgastric Endoscopy

Pancreaticobiliary disease and specifically gallstone disease are common after bariatric surgery. Studies showed postoperative rates of gallstone detection from 22 to 71 % and cholecystectomy rates from 7 to 41 % in patients who had a prior gastric bypass [114, 115]. The occurrence of choledocholithiasis has not been determined for this patient group. ERCP after AGB, VBG, and SG is relatively straightforward. On the other hand, exclusion of the ampulla after RYGB makes access technically more difficult. Successful biliary cannulation after RYGB depends on factors including the skill of the endoscopist and the lengths of the biliopancreatic and/or Roux limbs. Using varying techniques, both side-viewing and forward-viewing endoscopes have been used successfully. Wright et al. reported on a series of 15 patients in which the papilla was reached and successfully cannulated in 66 %; this was accomplished through the use of various techniques including advancing a duodenoscope over a stiff guide wire that was previously placed with a forward-viewing scope and pulling up a duodenoscope with a wire-guided biliary balloon anchored at the pylorus. Therapeutic maneuvers including sphincterotomy, sphincter of Oddi manometry, stone extraction, and stent placement were also successfully accomplished in this study [116]. Other techniques that may be used to cannulate the biliary system include single- and double-balloon-assisted enteroscopy. These enteroscopes more effectively pleat the small bowel and improve the advancement of the scope through the small intestine. Medical centers with experience in balloon-assisted enteroscopy report an 80 % success rate [117]. The double-balloon enteroscope may also be used to place a retrograde percutaneous endoscopic gastrostomy (PEG) tube in the remnant stomach and then perform an ERCP through the PEG tube [118, 119]. Similar to the factors associated with successful biliary cannulation

mentioned above, the success of reaching the gastric remnant is largely dependent on the length of the Roux limb. Schreiner and associates reviewed the records of post-RYGB bariatric patients who underwent an ERCP and reported that patients with a Roux limb less than 150 cm have a significantly higher rate of therapeutic success. For patients with a Roux limb greater than 150 cm, a laparoscopically assisted ERCP was a better initial option [120].

Although the previously mentioned techniques to access the biliary system and gastric remnant after bariatric surgery have been shown to be effective, they may not be widely replicated due to lack of equipment or expertise. Further, methods such as balloon and overtube endoscopy require the use of front-viewing endoscopes instead of the side-viewing endoscopes typically used for ERCP. Transgastric endoscopy can access the gastric remnant or duodenum through a laparoscopic approach or by placement of a percutaneous gastrostomy tube with radiologic guidance [121–123]. These techniques have been associated with high success rates and low postoperative morbidity [124]. Laparoscopic-assisted transgastric ERCP has been demonstrated to be an effective technique in the treatment of biliary pathology including stone disease, sphincter of Oddi dysfunction, ampullary stenosis, and the diagnosis of and treatment of both benign and malignant strictures [125, 126]. An additional benefit of the laparoscopic transgastric approach is the ability to perform an abdominal exploration to evaluate for any other causes of abdominal pain, such as an internal hernia. The use of laparoscopic transgastric endoscopy through the gastric remnant is safe, reliable, and associated with a high success rate and low complication rate.

Future Considerations

Flexible upper endoscopy in bariatric patients currently also includes revisional procedures as well as primary weight loss therapies, in both experimental models and in patients. Such endoscopic interventions require advanced skill sets with novel equipment and methods.

Obesity is a multifactorial disease and the changes that occur after bariatric surgery are numerous. Specifically, mechanical changes in the postbariatric anatomy, such as dilation of an anastomosis or pouch, are thought to contribute to weight regain. Several endoscopic revisional procedures have presented potential solutions. Sclerotherapy is a procedure that uses a traditional endoscope with an injection needle to inject sodium morrhuate around the gastric outlet. About 2 cm^3 per injection (a total of 20 cm^3 per procedure) and about 2–3 sessions are needed to achieve a desired outlet size. Initial studies reported a 75 % weight loss in patients over 6 months compared to 50 % in matched controls [127]. The EndoCinch is another endoscopic technique that was originally developed for fistula repair and gastric pouch reduction. This device guides a needle through a piece of vacuum-acquired tissue within a metal cap and thereby places a stitch. Stoma reduction using the EndoCinch was investigated using a randomized sham control trial; using an average of four sutures per patient, the results of this study demonstrated a 4.7 % weight loss compared to 1.9 % in the sham group [128]. The invention of Incisionless Operating Platform (IOP) allowed the ability to perform serosal tissue plications under direct visualization to adjust dilated pouches and gastric outlets. Plications were made using specialized jaws and nitinol tissue anchors that were deployed through a curved hollow needle. Only initial feasibility studies have been performed for this device [129, 130].

There is significant interest in the development of successful and effective endoscopic techniques and alternatives to surgery for primary weight loss. No such method has been perfected, but three different approaches stand out in the literature—endoscopic gastroplasty, intragastric balloons, and endoluminal sleeves. Endoscopic gastroplasty has been performed using stapling and suturing devices. Suturing devices achieve volume reduction by anterior and posterior gastric wall approximation. Devices that have been used and described in the literature include the EndoCinch, the Endo Stitch, and the OverStitch. Alternatively, with the TOGA system (Satiety Inc.), staples are used to form a gastric sleeve similar to an unsupported VBG [131]. Well-designed studies with long-term follow-up will be needed to determine the outcomes of these techniques. Since the 1980s, intragastric balloons have been used as space-occupying devices for weight loss. They may have value in select high-risk patient groups as a bridge to surgery in those individuals who may have otherwise been nonoperative candidates [132]. There are two available models of the intragastric balloon, the BioEnterics balloon and the Heliosphere BAG, both of which were used in a prospective randomized study that resulted in 27–30 % excess weight loss at 6 months [133]. Long-term studies are lacking, and complications including esophagitis, nausea, emesis, abdominal pain, rupture, and obstruction have been associated with placement of these devices. Placement of these devices is relatively uncomplicated, but knowledge of proper removal is important to minimize the risk to the patient [131]. Currently, these devices remain unapproved by the Food and Drug Administration for use in the United States [134]. Similar to the surgical interventions that alter anatomy and exclude the proximal small bowel, endoscopic insertion of a barrier in the small bowel may replicate this intestinal bypass. Two unique, novel devices are currently under study: the ValenTx endoluminal bypass and the EndoBarrier (GI Dynamics) (Fig. 8). The ValenTx endoluminal bypass is anchored at the esophagogastric junction with a specialized device, and the sleeve extends 120 cm through the stomach and into the mid-jejunum. The impermeable sleeve allows nutrients to bypass the proximal bowel and entice metabolic effects through stimulation of the distal small bowel [131]. The EndoBarrier is similar in concept to the ValenTx endoluminal bypass, but it is a duodenojejunal

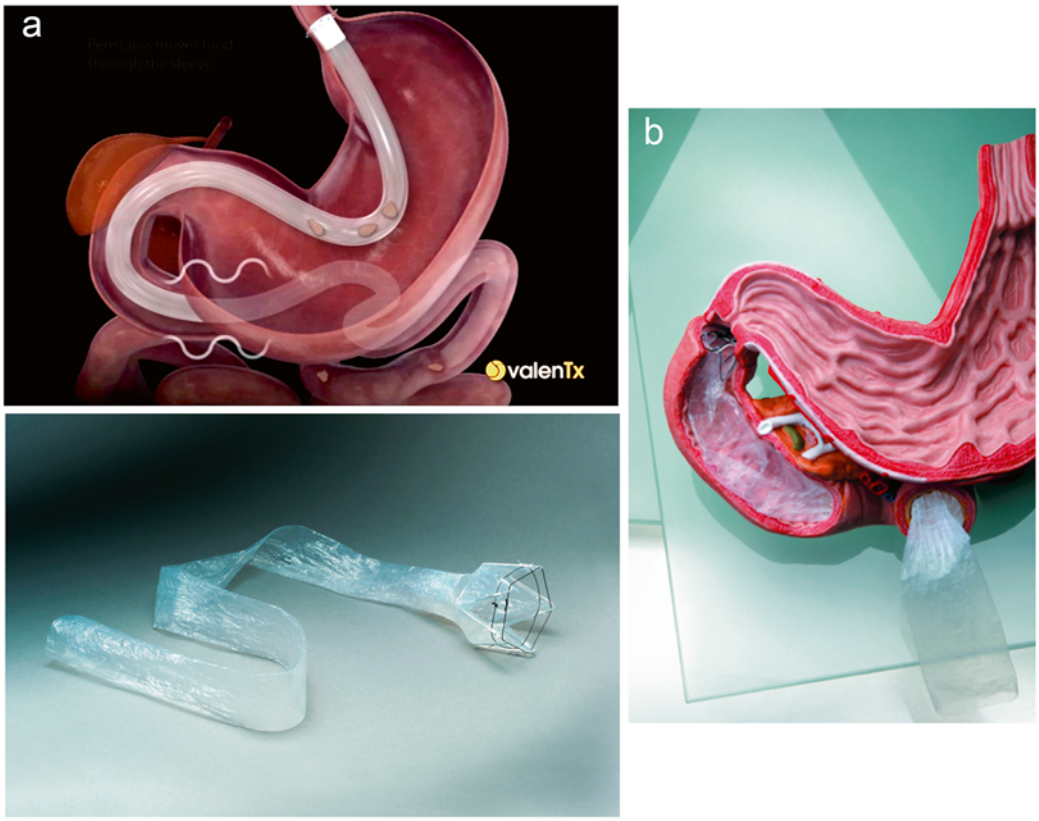

FIG. 8. (**a**) ValenTx endoluminal bypass (courtesy of ValenTx, with permission). (**b**) GI Dynamics EndoBarrier (courtesy of GI Dynamics, with permission).

bypass sleeve that anchors in the duodenal bulb by a self-expanding cuff and extends a polyethylene sleeve 60 cm into the small bowel. It does not need additional equipment for anchoring at the proximal end and is easily removable with a removal loop. A short-term study by Schouten et al. evaluated 26 patients after the placement of the EndoBarrier and demonstrated a 19 % excess weight loss in 3 months along with a reduction in hemoglobin A1C and glucose control medications [135]. However, complications of migration, stent obstruction, and upper GI bleeding have been reported with these novel devices [136], and further studies are presently underway to clarify their safety and efficacy. As was the case with the intragastric balloons, the endoluminal sleeves are not approved for use within the United States at this time.

Conclusions

As bariatric surgery evolves and new techniques are developed, perioperative management of such patients becomes very important. Flexible upper endoscopy can be a helpful tool in the armamentarium for the diagnosis and treatment of bariatric patients in all stages of their care. It has wide applications in the preoperative setting, but routine use is not yet observed. On the other hand, the routine use of intraoperative endoscopy is well documented in the medical literature. In addition, the use of flexible upper endoscopy has been validated throughout medical literature for the evaluation of postoperative patients and has both diagnostic and therapeutic potential. Such widespread advantages of flexible endoscopy should encourage bariatric surgeons to develop and refine their endoscopic skills and proficiencies (Video 1).

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