

# Radiology of the Laparoscopic Roux-en-Y Gastric Bypass Procedure: Conceptualization and Precise Interpretation of Results<sup>1</sup>

## CME FEATURE

See accompanying test at [http://www.rsna.org/education/rg\\_cme.html](http://www.rsna.org/education/rg_cme.html)

## LEARNING OBJECTIVES FOR TEST 3

After reading this article and taking the test, the reader will be able to:

- Discuss the laparoscopic Roux-en-Y gastric bypass procedure.
- Describe the normal radiologic appearance after this procedure.
- Identify complications of the procedure on upper gastrointestinal series or CT images.

## TEACHING POINTS

See last page

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Obesity is an epidemic in the United States. The laparoscopic Roux-en-Y gastric bypass procedure is an effective surgical intervention that can produce dramatic weight loss in morbidly obese patients. Despite the inherent risks, the surgery is increasing in popularity. Radiology plays a crucial role in postoperative evaluation. Upper gastrointestinal (UGI) series and abdominal computed tomography (CT) are the primary radiologic tools used in assessment of possible complications. With knowledge of the normal postoperative appearance, performance of UGI studies and interpretation of the results should be easy. The 24-hour postoperative examination allows reliable detection of anastomotic leaks. Although strictures of the gastrojejunal anastomosis are a common complication, they are often diagnosed and treated with endoscopy. In a thorough examination, one also evaluates for degraded pouch restriction, including a patulous gastrojejunal anastomosis or gastrogastric fistula, as a late cause of weight gain. Knowledge of the postoperative anatomy also assists in detection of internal hernias. CT is invaluable in detection and characterization of small bowel obstructions and internal hernias. CT may allow diagnosis of anastomotic leaks, abscesses, gastrogastric fistulas, and intra-abdominal hematomas. CT-guided percutaneous procedures, such as placement of gastrostomy tubes or drainage of fluid collections, can obviate emergency exploration and may be the only procedural intervention necessary for a cure.

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Abbreviation: UGI = upper gastrointestinal

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## Introduction

Obesity and its health-related complications are epidemics. The association of obesity with type II diabetes, hypertension, hypercholesterolemia, and other complications—the “metabolic syndrome”—is well established, with significant cardiovascular risk (1–5). Annually, 300,000 deaths are attributable to obesity (6). It has been shown that weight reduction, even in modest amounts, is beneficial (7). The National Institutes of Health Consensus Development Panel in 1991 declared that surgical therapy should be considered in patients with morbid obesity (defined as a body mass index > 40 or one > 35 with complications) (8). Obesity surgery is successful in producing weight loss and cost-effective (9), and a decision analysis has shown bypass surgery patients to have a longer survival than patients treated with diet or exercise alone (10).

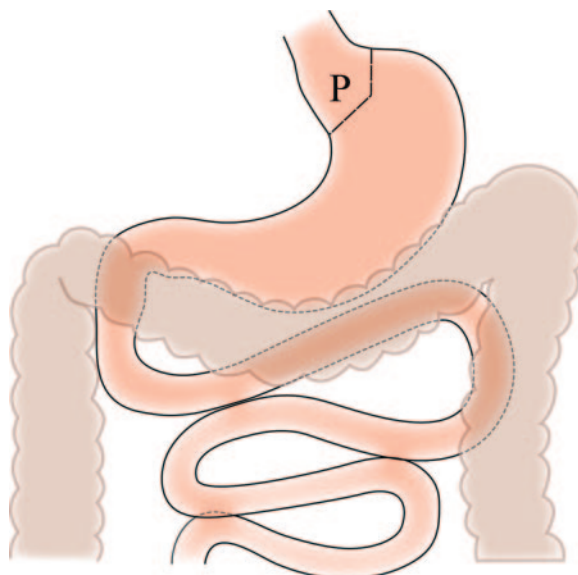
Numerous bariatric surgical procedures exist, the most common being the Roux-en-Y gastric bypass. The laparoscopic approach to the Roux-en-Y gastric bypass is quickly becoming the preferred method due to its decreased hospital stays, faster recovery, and decreased wound complications (11,12). However, the laparoscopic Roux-en-Y gastric bypass procedure is technically difficult to master, with a steep learning curve that increases the risk of complications early in a surgeon's experience (12,13).

Radiologists are crucial in the postoperative assessment of these patients. Many institutions perform routine upper gastrointestinal (UGI) examinations within 24 hours of surgery to evaluate for a life-threatening leak to determine if urgent re-exploration is necessary. In addition, UGI and computed tomographic (CT) examinations are used in the work-up of many other complications, including small bowel obstructions, abscesses, and hematomas. Adequate evaluation requires radiologists to understand the surgical technique, because complex postsurgical anatomy and surgery-specific complications make interpretation difficult.

In this article, we describe and illustrate the laparoscopic Roux-en-Y gastric bypass procedure, depict the normal postoperative findings on both fluoroscopic and CT images, and review the radiologic manifestations of complications.

## Surgical Technique

There are three classifications of surgical therapies for morbid obesity: restrictive, malabsorptive, and combined. Restrictive types create a small gastric pouch to induce weight loss through



**Figure 1.** A gastric pouch (*P*) is created by dividing the stomach primarily along the lesser curvature.

satiety effects. These include vertical banded gastroplasty and adjustable gastric banding, the former creating a fixed pouch size and the latter allowing continuous adjustment. Purely restrictive therapies are generally less complex (ie, technically easier to perform with less potential for serious complications) but may produce less weight loss and have more long-term failures (14).

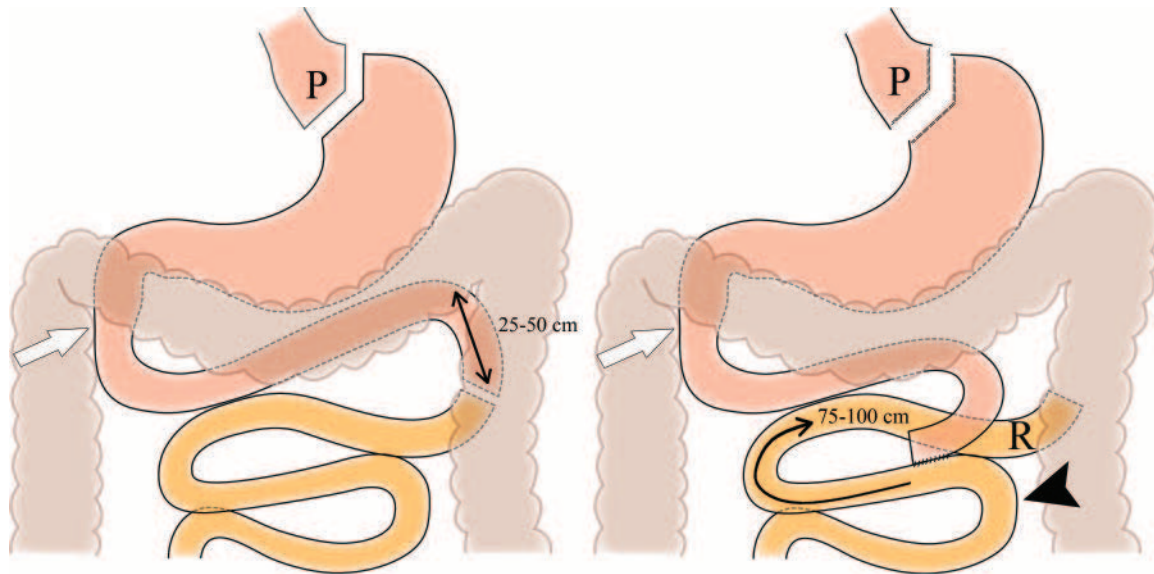
Malabsorptive procedures bypass portions of small bowel, limiting food digestion and absorption to a short segment of ileum (15). These include jejunioileal bypass, biliopancreatic diversion, and the duodenal switch. There is potential for metabolic complications including intermittent diarrhea and steatorrhea due to malabsorption (14,15). In particular, the jejunioileal bypass is no longer performed due to excessive protein and caloric malnutrition, as well as hepatic fibrosis (16).

The gastric bypass technique was introduced by Mason and Ito in 1967 (17). Currently, the Roux-en-Y gastric bypass combines restrictive and malabsorptive properties by creating a small gastric pouch and a Roux limb (18). While variations exist, the Roux-en-Y gastric bypass may be considered the standard of reference for bariatric surgery (14). In 1994, Wittgrove et al (19) described the laparoscopic approach widely employed today.

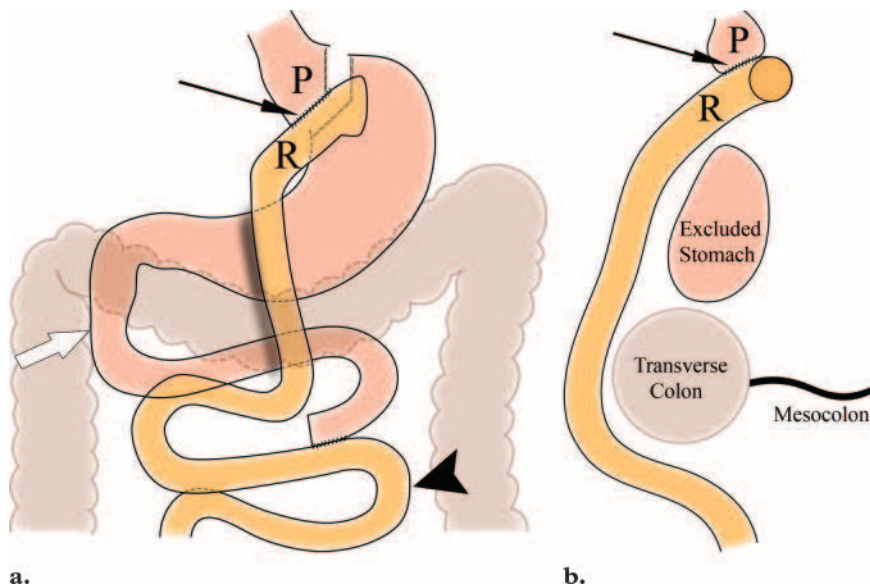
Our current standard laparoscopic Roux-en-Y gastric bypass procedure involves the following: construction of a pouch, Roux limb, and enteroenteric anastomosis; placement of the Roux limb; and creation of the gastrojejunal anastomosis.

### Teaching Point

### Teaching Point



**Figures 2, 3.** (2) The jejunum is divided 25–50 cm distal to the ligament of Treitz. The biliopancreatic limb (arrow) is temporarily excluded from the remainder of the small bowel. *P* = gastric pouch. (3) The Roux limb (*R*) is measured to 75–100 cm and attached to the biliopancreatic limb (arrow) with a side-to-side anastomosis. There are now three distinct portions of small bowel: the biliopancreatic limb, the Roux limb, and the common channel (arrowhead) distal to the anastomosis. *P* = gastric pouch.



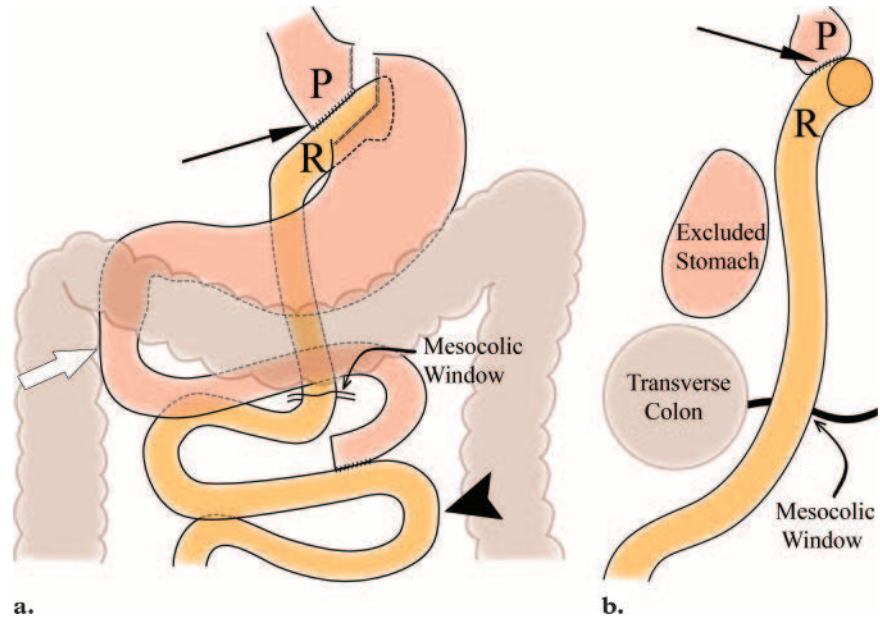
**Figure 4.** Frontal (a) and lateral (b) views show antecolic-antegastric placement of the Roux limb (*R*), which is brought anterior to the transverse colon and stomach. *P* = pouch, black arrow = gastrojejunal anastomosis, white arrow in a = biliopancreatic limb, arrowhead in a = common channel.

At least six trocars are placed into the abdomen, and a 15–20-mL transected gastric pouch is created. A stapler-cutter device divides the stomach into two parts: a small pouch created from the lesser curvature and the much larger excluded stomach (Fig 1).

Then the Roux limb and enteroenteric anastomosis are created. The jejunum is divided 25–50 cm distal to the ligament of Treitz (Fig 2), creating two separate limbs of small bowel: the biliopancreatic limb and the Roux limb (often referred to as the alimentary limb). The Roux limb is measured to 75–100 cm in length and joined to the biliopancreatic limb via a side-to-side anastomosis (Fig 3). Small bowel distal to the anastomosis is called the “common channel.”

The Roux limb may be brought to the stomach along different paths. We prefer an antecolic-antegastric course due to the relative ease compared with retrocolic-retrogastric placement and the advantage of fewer small bowel obstructions (20). The Roux limb is brought up and over the transverse colon, anterior to the excluded stomach, in close approximation to the pouch (Fig 4). The retrocolic-retrogastric path involves tunneling the

**Figure 5.** Frontal (a) and lateral (b) views show retrocolic-retrogastric placement of the Roux limb (*R*), which is tunneled posteriorly through a surgically created defect in the transverse mesocolon. *P* = pouch, black arrow = gastrojejunal anastomosis, white arrow in a = biliopancreatic limb, arrowhead in a = common channel.



Roux limb through a surgically created defect in the transverse mesocolon, behind the excluded stomach, adjacent to the pouch (Fig 5). It is important to recognize that the Roux limb path is variable. Patient anatomic conditions may require any combination of ante- or retrocolic and ante- or retrogastric locations. Knowledge of the path is critical to accurate interpretation of subsequent radiographs.

The final step is creation of the gastrojejunal anastomosis. Three means of joining the pouch with the proximal end of the Roux limb exist: circular stapling, linear stapling with hand-sewn closure, and fully hand-sewn closure. We use a linear stapled and hand-sewn technique. The practical difference for the radiologist is that a circular staple device creates an end-to-end anastomosis, while the partially or fully hand-sewn techniques are end-to-side anastomoses and demonstrate a small blind ending stump of jejunum on postoperative UGI images.

Inspection and intraoperative endoscopy are performed to evaluate the pouch for adequacy of size or evidence of leak. Mesenteric defects are closed prior to trocar removal.

### Normal Anatomy

At our institution, a 24-hour postoperative UGI examination is performed with up to 250 mL of water-soluble contrast material, given via a straw. As the patient swallows, one-per-second rapid-sequence images of the gastrojejunal anastomosis are obtained in the frontal projection, then in shallow oblique projections. If possible, lateral views should be obtained to visualize the area posterior to the anastomosis.

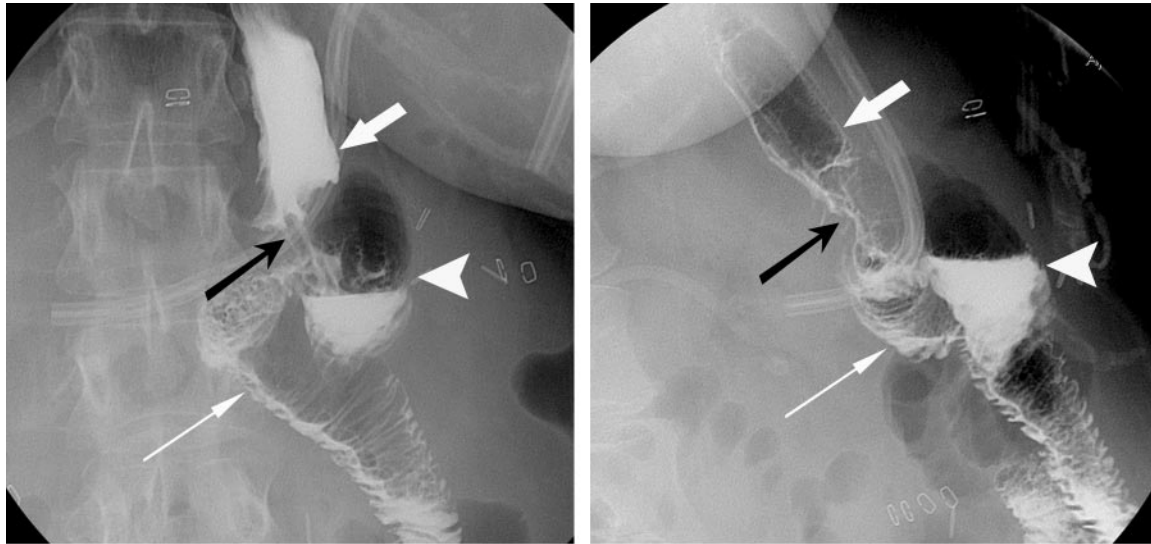
This technique demonstrates the distal esophagus, anastomosis, and Roux limb (Fig 6). A small stump of the Roux limb opacifying with oral contrast material is normally seen in patients with a hand-sewn or partially hand-sewn gastrojejunal anastomosis. In female patients, excessive breast tissue can make evaluation of the anastomosis difficult; having the patient lift her breast allows better visualization (Fig 7).

In a completely normal postoperative examination, there is no delay in passage of contrast material into the Roux limb. In our experience, it is not uncommon to have some delay in passage. In the early postoperative state, we presume this delay is due to secondary anastomotic edema (21).

We wait at least 2 weeks before administering barium. Often, we give about one-fifth of a packet of effervescent crystals orally before barium administration. Frontal imaging is followed by oblique imaging, with additional projections used as needed to demonstrate particular abnormalities. After crystal administration, fine mucosal detail of a distended esophagus and pouch is well seen. The contrast material-filled Roux limb should be examined distally, and often the side-to-side enteroenteric anastomosis is well seen.

Contrast-enhanced CT is invaluable in detection of suspected complications. All patients are given oral contrast material before scanning. Unless there is a contraindication, all patients are administered 100 mL of nonionic intravenous contrast material, and thin-section images through the abdomen are obtained.

Knowledge of the employed surgical technique aids in identification of normal structures. The gastrojejunal anastomosis is identified as a high-attenuation suture line in the epigastrium (Fig 8). The Roux limb is followed from its gastrojejunal



**a.** **b.**  
**Figure 6.** Normal findings at 24-hour postoperative UGI examination. Frontal (**a**) and oblique (**b**) images show the normal postoperative appearance of the pouch (thick white arrow), gastrojejunal anastomosis (black arrow), jejunal stump (arrowhead), and proximal Roux limb (thin white arrow).



**a.** **b.**  
**Figure 7.** Displacement of breast tissue. (**a**) Postoperative UGI image obtained in a female patient with pendulous breasts shows underpenetration of the image. (**b**) UGI image obtained after superior displacement of the breast tissue by the patient shows a marked improvement in depiction of the postoperative appearance.

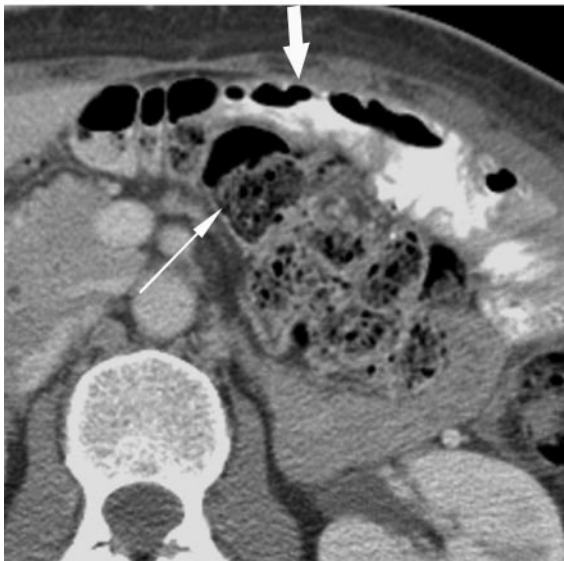


**Figure 8.** Normal gastrojejunal anastomosis. CT scan shows an end-to-side gastrojejunal anastomosis (thin arrow), the gastric pouch (thick arrow), and the excluded stomach (arrowhead).

**Figure 9.** Normal antecolic-antegastric Roux limb. CT scans displayed from cranial (**a**) to caudal (**c**) show the Roux limb (thick arrow in **a** and **b**) anterior to the excluded stomach (arrowhead in **a**) and colon (thin arrow in **b**). Arrows in **c** = sutures of the side-to-side enteroenteric anastomosis.



**a.**



**b.**



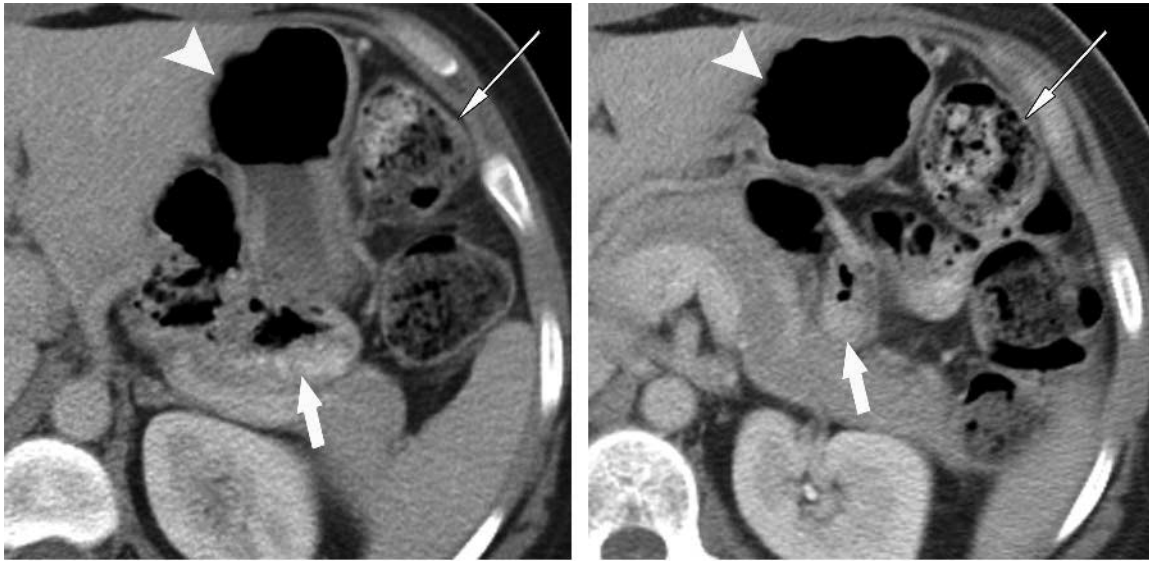
**c.**

anastomosis to its enteroenteric anastomosis. The Roux limb path is variable (Figs 9–11). The mesentery of an antecolic-antegastric Roux limb may produce an impression on the colon and excluded stomach at both CT and UGI series.

The enteroenteric anastomosis is a separate staple line lower in the abdomen (Fig 9). These staples mark the junction of the Roux and biliopancreatic limbs with the common channel; the anastomosis can be a site for small bowel obstruc-

tion. The excluded stomach and biliopancreatic limb are readily identified and followed to the enteroenteric anastomosis. The relative position of the excluded stomach depends on the course of the Roux limb and may be altered if a gastropexy has been performed, in which case it will be adherent to the anterior abdominal wall.

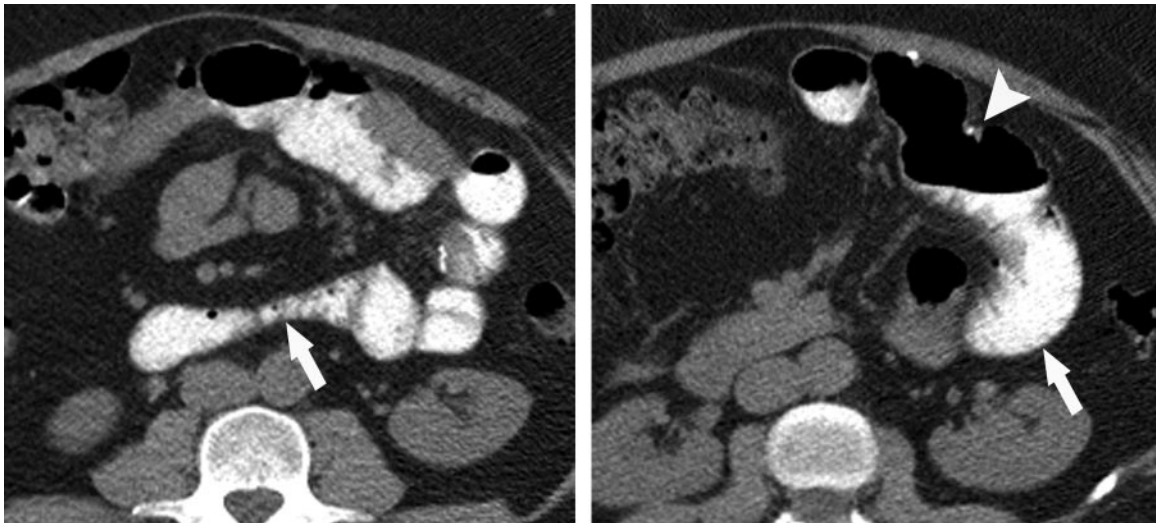
The Roux limb and common channel are usually opacified with oral contrast material. Reflux of contrast material up the biliopancreatic limb is variable but not necessarily abnormal (Fig 12); any distention raises concern about obstruction (22).



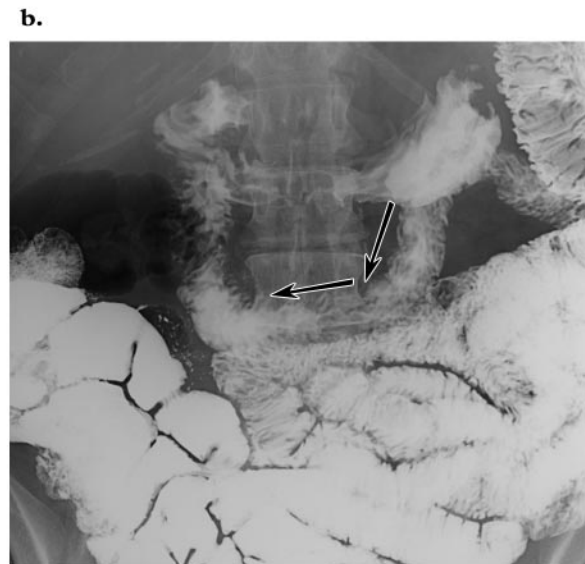
**a.** **b.**  
**Figure 10.** Normal retrocolic-retrogastric Roux limb. CT scans (**a** obtained cranially to **b**) show the Roux limb (thick arrow) posterior to the excluded stomach (arrowhead) and colon (thin arrow).



**a.** **b.**  
**Figure 11.** Normal retrocolic-antegastric Roux limb. CT scans (**a** obtained cranially to **b**) show the Roux limb (thick arrow) anterior to the excluded stomach (arrowhead in **a**) and posterior to the colon (thin arrow).



**a.**  
**Figure 12.** Normal reflux up the biliopancreatic limb. **(a, b)** CT scans **(a)** obtained cranially to **(b)** show wide patency of the enteroenteric anastomosis (arrowhead in **b**) and reflux of contrast material up the biliopancreatic limb (arrow). **(c)** Image from a small bowel series, obtained in another patient, shows reflux of contrast material up the duodenum (arrows), through the pylorus, and into the excluded stomach.

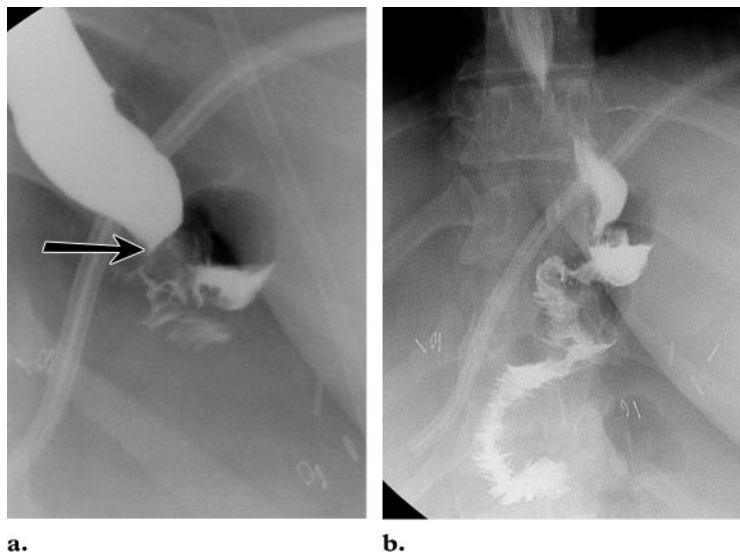


**b.**  
**c.**

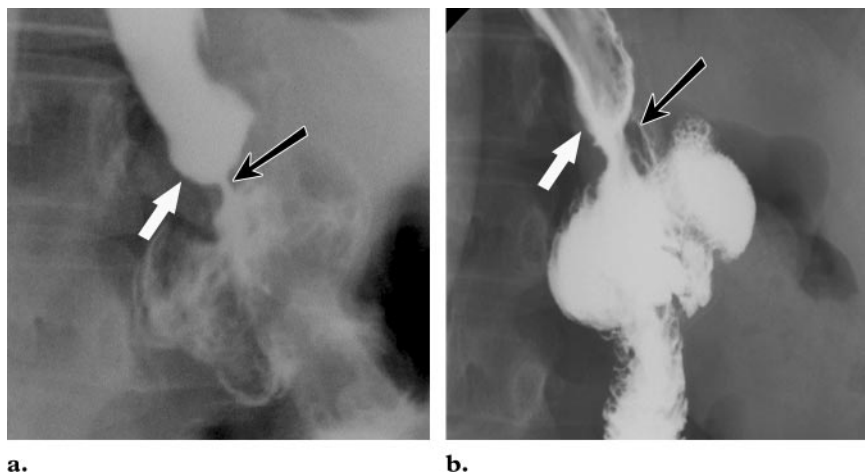
**Figure 13.** Anastomotic leak in a 47-year-old woman 24 hours after surgery. UGI image shows contrast material from a large leak arising from the gastrojejunal anastomosis; the contrast material completely outlines the spleen. Emergent reexploration demonstrated an anastomotic leak, which was repaired.







**Figure 14.** Gastrojejunal edema in a 33-year-old woman who was asymptomatic 24 hours after surgery. **(a)** Routine postoperative UGI image shows a marked delay in passage of contrast material through the narrowed gastrojejunal anastomosis (arrow). **(b)** UGI image obtained after 1 week of conservative management shows resolution of the edema, with rapid passage of contrast material into the Roux limb.



**Figure 15.** Gastrojejunal stricture in a 28-year-old woman with nausea and vomiting 1 month after surgery. **(a)** Image from the initial UGI examination shows tight narrowing of the gastrojejunal anastomosis (black arrow) and a rounded appearance of the gastric pouch (white arrow). **(b)** UGI image obtained 3 months after endoscopy and balloon dilation shows resolution of the anastomotic stricture (black arrow) and of the rounded pouch (white arrow).

## Complications

### Leak

The most ominous complication is a leak from the gastrojejunal anastomosis or the enteroenteric anastomosis, both of which may be life threatening (23,24). Clinical signs and symptoms including fever, tachycardia, abdominal pain, and increasing fluid requirements are nonspecific (23,24); thus, we perform a 24-hour postoperative UGI examination before patients resume their diet. Contrast material outside the confines of the gastric pouch and anastomosis indicates a leak and may be seen on UGI images (Fig 13) or CT scans. Although leaks from the enteroenteric anastomosis are rapidly clinically evident and severe, they are usually not diagnosed radiographically (23). We and others advocate immediate surgical exploration if there is high clinical suspicion of a leak, even if the postoperative UGI images are normal (23,24).

### Anastomotic Narrowing

Gastrojejunal anastomotic strictures are relatively common complications, manifesting with postprandial pain and vomiting (24). We presume that transient holdup in emptying of the esophagus (<1 minute) during immediate postoperative studies is a result of anastomotic edema (21) and treat these patients expectantly. Delayed passage of greater than 1 minute in the immediate postoperative period could be the result of more severe edema or early stricture. These are also managed conservatively, and a follow-up examination in 2 weeks should show improvement if the delay was caused by edema (Fig 14). Persisting pouch distention, with a spherical appearance, and air-fluid–contrast material levels in the pouch and esophagus all suggest a stricture (Fig 15) (25). These are usually diagnosed and treated endoscopically (Fig 16), with balloon dilation a safe and effective means of management (11,26–28).



**Figure 16.** Anastomotic stricture. Image from endoscopy shows a stricture at the anastomosis. Typically the first study performed in patients with symptoms of an anastomotic stricture, endoscopy is both diagnostic and therapeutic. (Courtesy of David L. Burns, MD, Lahey Clinic, Burlington, Mass.)

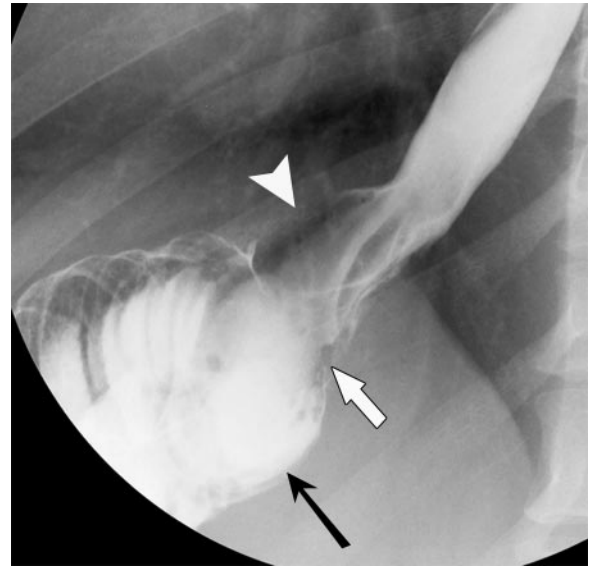
### Degradation of Pouch Restriction

Very rapid passage of contrast material through a patulous anastomosis degrades the restrictive properties of the laparoscopic Roux-en-Y gastric bypass and may cause the patient to feel insatiable and produce weight gain (Fig 17) (18).

Another potential cause of weight gain is a gastrogastric fistula. Although uncommon, a fistulous tract arising from the pouch may opacify the excluded stomach on UGI images or CT scans and is thought to be a result of the patient over-eating (29). An example of a gastrogastric fistula at UGI examination, performed in a patient who underwent an open gastric bypass procedure, is shown in Figure 18. A fistulous tract from the pouch to the jejunal stump (Fig 19) also acts as a functional increase in gastroenteric communication and may also induce weight gain.

### Ulcer

Prospective radiographic diagnosis of an ulcer is difficult. In our experience, despite clear evidence of ulcers at endoscopy, UGI images or CT scans may be negative. Clinical symptoms of anastomotic or poststomal ulcers include dyspepsia,



**Figure 17.** Widened gastrojejunal anastomosis in a 37-year-old woman with lack of satiety and suboptimal weight loss 1 year after surgery. Image from a double-contrast UGI study (prone drinking view) shows mild dilatation of the pouch (arrowhead) and a widened gastrojejunal anastomosis (white arrow) with rapid passage of contrast material into the Roux limb (black arrow). These findings were confirmed at surgery, and the bypass was revised.

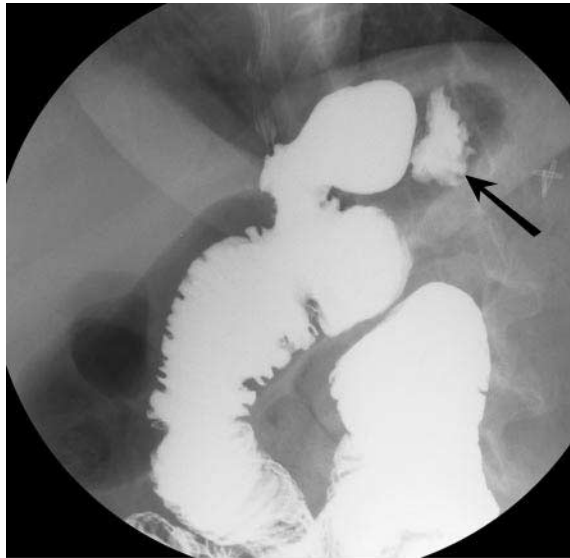
retrosternal pain, and vomiting (24). Ulcerative symptoms require only endoscopic evaluation for diagnosis (Fig 20) and are treated medically. Untreated ulcers can lead to stomal stenosis from scarring and fibrosis (24).

### Small Bowel Obstruction

Small bowel obstructions are more frequent after laparoscopic gastric bypass than after open procedures (30). Most obstructions after laparoscopic Roux-en-Y gastric bypass are secondary to internal hernias, with fewer obstructions from postoperative adhesions or other causes (20). Small bowel obstructions may occur anywhere and produce varied radiographic appearances.

Obstructions of the excluded stomach and biliopancreatic limb may be due to stenoses at the enteroenteric anastomosis, kinking at the anastomosis, or internal hernias. CT demonstrates distention of the entire biliopancreatic limb, particularly the excluded stomach (Fig 21a, 21b). Biliopancreatic limb obstructions are true closed-loop

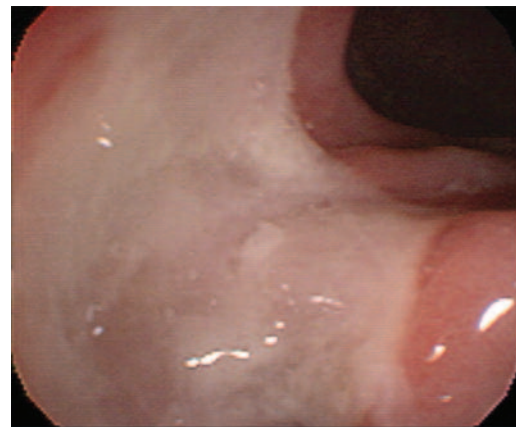
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a.

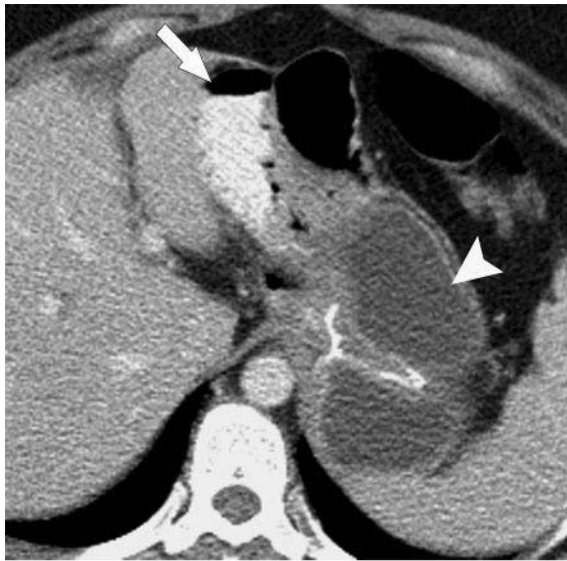
b.

**Figure 18.** Gastrogastric fistula in a 47-year-old woman with insatiable appetite and weight gain 4 years after open Roux-en-Y gastric bypass. (a) UGI image shows contrast material opacifying the fundus (arrow) of the excluded stomach. (b) Image from the CT equivalent of a UGI examination shows oral contrast material (arrow) in the fundus of the excluded stomach. Note that no contrast material is seen in the body of the stomach; thus, this appearance does not represent normal reflux up the biliopancreatic limb.

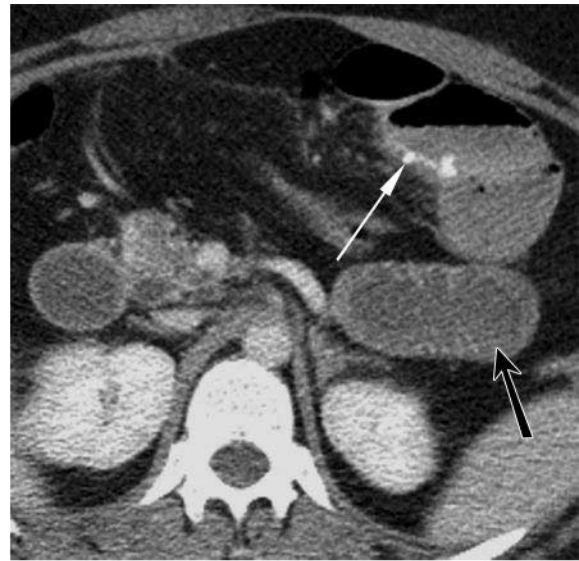


**Figure 19.** Pouch-to-stump fistula in a 50-year-old woman with abdominal pain 1½ years after surgery. UGI image shows a fistula (thin white arrow) between the pouch (black arrow) and jejunal stump (thick white arrow). The symptoms were not attributed to the fistula, and subsequent laparoscopy for evaluation of the pain revealed a previously undetected internal hernia.

**Figure 20.** Anastomotic ulcer. Image from endoscopy shows a large, white, fibrin-coated ulcer at the anastomosis. Ulcers can be difficult to diagnose with radiography. In general, they are diagnosed with endoscopy. (Courtesy of David L. Burns, MD, Lahey Clinic, Burlington, Mass.)



21a.



21b.



21c.

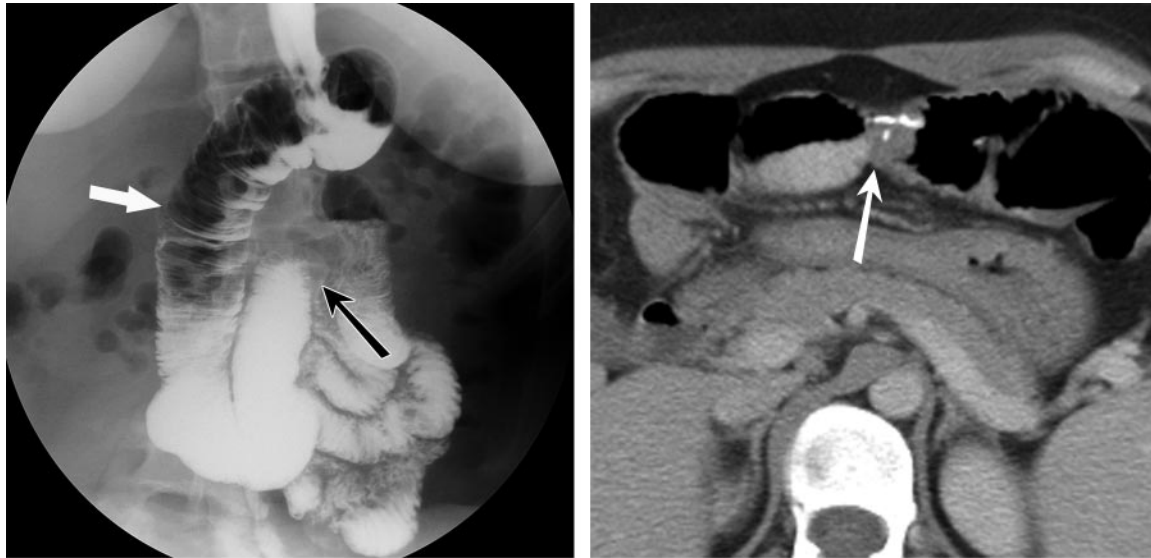


22.

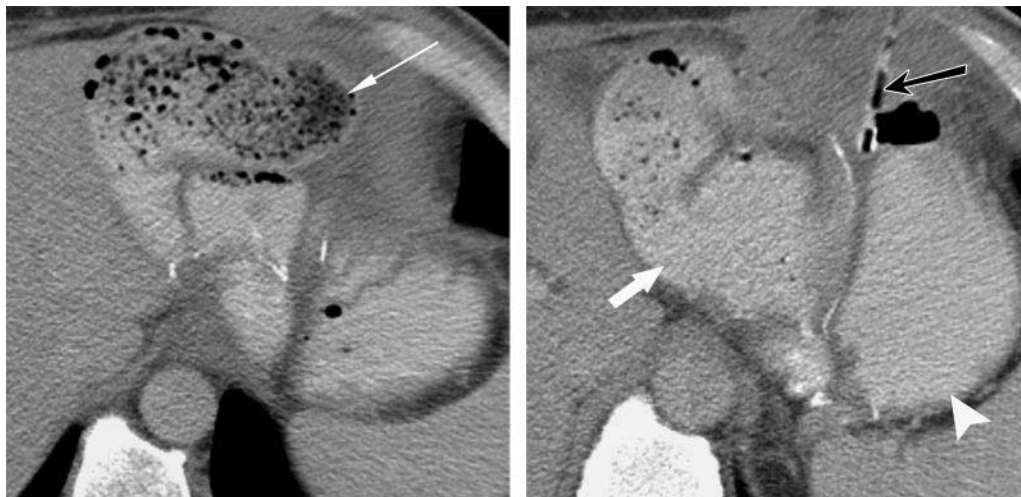
**Figures 21, 22.** (21) Obstruction of the biliopancreatic limb in a 38-year-old woman with abdominal pain 1 week after surgery. (a, b) CT scans (a obtained cranially to b) show a nondistended, contrast material–filled antegastric Roux limb (arrow in a) but a distended, fluid-filled excluded stomach (arrowhead in a) and biliopancreatic limb (black arrow in b). The enteroenteric anastomosis (white arrow in b) was obstructed, presumably as a result of edema, and was subsequently decompressed with a percutaneous gastrostomy. (c) Follow-up CT scan obtained after percutaneous gastrostomy (arrow) shows a decompressed excluded stomach (arrowhead). The biliopancreatic limb obstruction due to enteroenteric anastomotic edema resolved without complication. (22) Perforation of the excluded stomach in a 28-year-old woman with tachycardia 1 day after surgery. CT scan of the thorax, obtained to evaluate for a pulmonary embolus, shows excessive free intraperitoneal fluid and air (arrow) without extraluminal contrast material. Arrowheads = enhancing, crescentic, atelectatic lung. Surgery revealed perforation of the excluded stomach adjacent to the suture line.

obstructions; although all patients should eventually undergo surgical exploration to exclude an internal hernia, a temporizing percutaneous gastrostomy (Fig 21c) converts an emergent surgery into an elective one. Lack of early recognition and treatment can result in perforation of the ex-

cluded stomach or cause a leak due to tension at the gastrojejunostomy (24). Radiologists should be aware that perforation could occur even in the presence of a normal appearance at UGI examination. Perforation of the excluded stomach may be seen as free intraperitoneal air or fluid in the absence of extraluminal oral contrast material at CT (Fig 22).



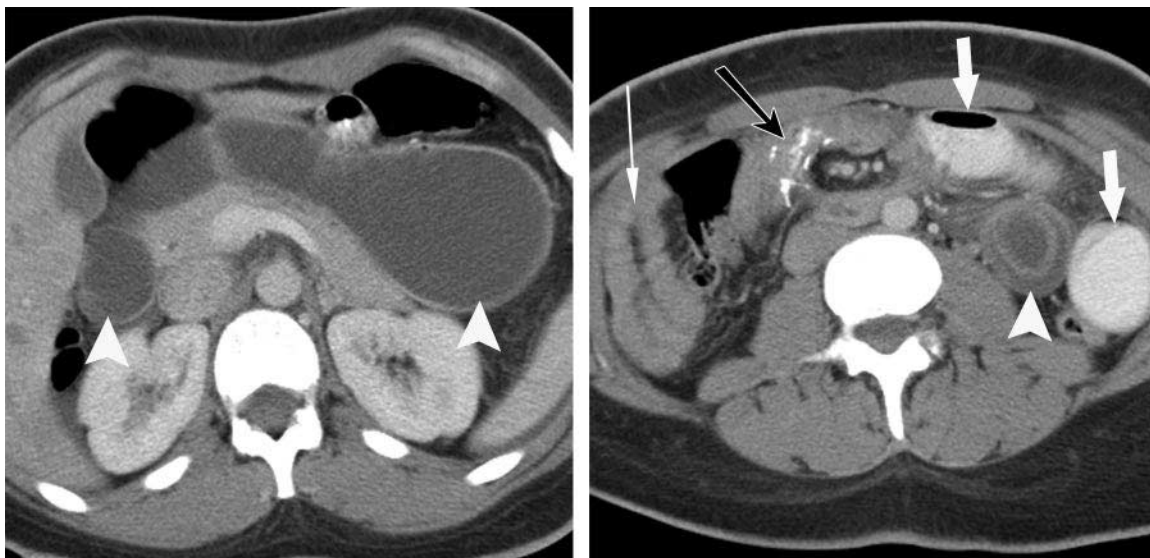
**a.** **b.**  
**Figure 23.** Edema at the enteroenteric anastomosis in a 24-year-old woman with abdominal pain, nausea, and dehydration 5 days after surgery. **(a)** UGI image shows a distended Roux limb (white arrow) and an apparent transition point (black arrow) at the enteroenteric anastomosis. **(b)** CT scan shows narrowing at the enteroenteric anastomosis (arrow). The findings were believed to be a result of anastomotic edema, and the symptoms resolved with conservative management.



**a.** **b.**  
**Figure 24.** Obstruction of the Roux limb by a bezoar in a 47-year-old man with nausea and vomiting 8 months after surgery. CT scans (**a** obtained cranially to **b**) show a bezoar (arrow in **a**) in the Roux limb with upstream dilatation (white arrow in **b**). The excluded stomach (arrowhead in **b**) was enhanced with contrast material via a previously placed gastrostomy tube (black arrow in **b**). The symptoms resolved with conservative management.

Roux limb obstructions may be secondary to adhesions, strictures, kinking, internal hernias, or occasionally bezoars or intussusceptions (13,31, 32). Early obstructions may be secondary to anastomotic edema (24). Obstructions may also occur due to scarring at the mesocolic window of a retrocolic Roux limb (20,33). Patients with Roux

limb obstructions typically present with nausea and vomiting, and radiologic evidence of obstruction may be detected at UGI examination or CT (Figs 23, 24).



a.

b.

**Figure 25.** Anastomotic obstruction from an internal hernia in a 23-year-old woman with pain, nausea, and vomiting 10 months after surgery. CT scans (**a** obtained cranially to **b**) show a dilated, fluid-filled excluded stomach and biliopancreatic limb (arrowheads) with a distended, contrast material-filled Roux limb (thick white arrows in **b**) and decompressed, clustered distal small bowel loops (thin white arrow in **b**). This appearance is consistent with obstruction at the anastomosis or in the common channel. Laparoscopy revealed an internal hernia at a small bowel mesenteric defect (black arrow in **b**).

Obstructions at or distal to the anastomosis may be a result of strictures, internal hernias, or adhesions and typically distend both the Roux limb and excluded segments (Fig 25).

### Internal Hernia

Internal hernias occur through defects in the small bowel mesentery or transverse mesocolon or through a potential space posterior to the Roux limb termed the *Peterson space*. Although current techniques employ closure of all defects, potential gaps may expand during weight loss, creating avenues for an internal hernia (31).

Defects in the transverse mesocolon often involve the Roux limb and can be seen as a redundant portion of the Roux limb extending into the defect (31). Signs of internal hernia into a small bowel mesenteric defect include a cluster of small bowel loops pressed against the anterior abdominal wall with crowding and engorgement of mesenteric vessels at CT (25). There is often an abrupt mesenteric twist, producing dramatic edema both radiographically and intraoperatively,

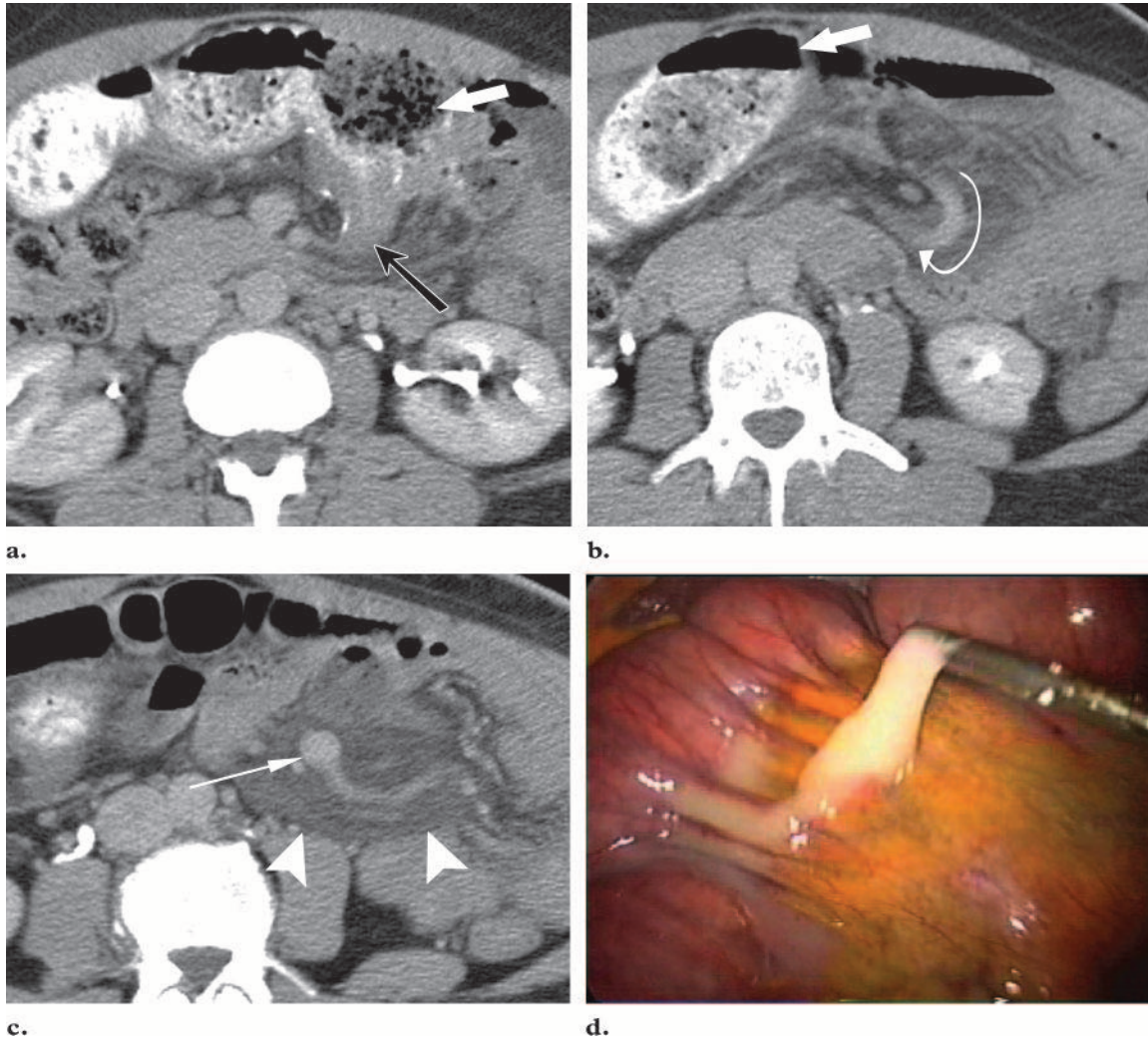
as lymphatic obstruction is superimposed on venous obstruction (Fig 26). Bezoars may also be seen in obstructed Roux limbs. Internal hernias may also result in dramatic closed-loop obstructions to short segments of small bowel (Fig 27), increasing the concern for small bowel perforation or infarction. Peterson space hernias are difficult to recognize prospectively and are often not diagnosed until surgical exploration (25).

**Delay in diagnosis of any type of internal hernia may be devastating and cause ischemia or death (34,35).** In one series, 20% of patients with symptomatic internal hernias had normal preoperative imaging findings, and surgical exploration should be considered in any patient with unexplained abdominal pain (35).

### Hemorrhage and Hematoma

Staple line bleeding can produce postoperative hemorrhage and hematoma (36). On CT scans, hematomas are demonstrated as high-attenuation material (60–80 HU) (22). These often occur adjacent to the gastrojejunostomy, with hematoma in the lesser sac, adjacent to or within the excluded stomach (Fig 28). Patients in unstable condition may require urgent surgical control.

**Teaching Point**



**Figure 26.** Internal hernia at a small bowel mesenteric defect in a 51-year-old woman with abdominal pain 10 months after surgery. (a–c) CT scans displayed from cranial (a) to caudal (c) show distention of the Roux loop with a bezoar (white arrow in a, straight arrow in b); narrowing at the enteroenteric anastomosis (black arrow in a); an abrupt twist in the small bowel mesentery (curved arrow in b); edema of the small bowel mesentery (arrowheads in c); and venous engorgement (arrow in c). (d) Photograph obtained during laparoscopy shows engorged vessels and mesentery with a lymph fluid coagulum. An internal hernia at the small bowel mesenteric anastomosis caused a closed-loop obstruction and volvulus.



**Figure 27.** Closed-loop obstruction and internal hernia at the mesocolic window in a 43-year-old man with severe abdominal pain 2 years after surgery. Coronal thick-section average intensity projection image from contrast-enhanced CT shows a closed-loop obstruction of a short segment of the small bowel (arrow). Surgery revealed an internal hernia at the mesocolic window of a retrocolic and antegastric Roux limb with volvulus and closed-loop small bowel obstruction.

### Abscess

Abscess formation is usually the result of intestinal perforation (25,31). CT is the primary means for abscess evaluation, depicting fluid collections, generally in the left upper quadrant (25). As with abscesses elsewhere, these demonstrate rim enhancement and often contain both gas and fluid (Fig 29). Orally administered contrast material within the collection is diagnostic of an abscess from an anastomotic leak (22). CT-guided percutaneous drainage, with appropriate antibiotic coverage, is the primary means of treatment.

### Wound Complications

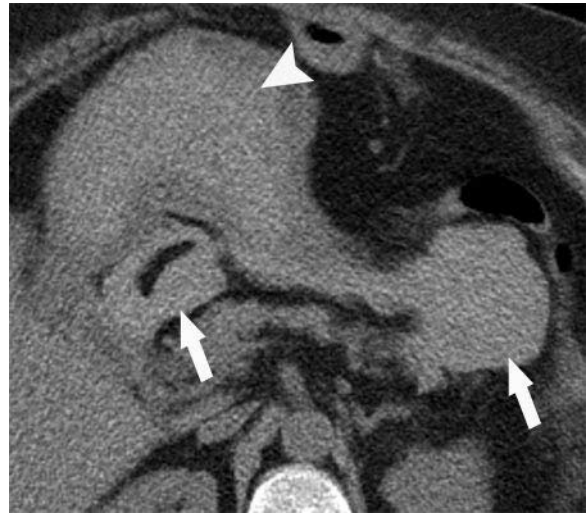
Although one advantage of the laparoscopic Roux-en-Y gastric bypass is the decreased prevalence of wound complications, these still occur (36). Mild stranding or bubbles of gas may normally be seen in closed trocar defects, but larger fluid collections should raise suspicion of an abscess. Although less likely than with the open technique, abdominal wall trocar hernias do occur and may be detected at CT (22).

### Conclusions

The laparoscopic Roux-en-Y gastric bypass procedure is an effective and safe means of producing dramatic long-term weight loss in morbidly obese individuals. As the number of bariatric operations performed in the United States continues to rise (37), it is crucial that radiologists understand the normal postoperative anatomy and recognize complications.

With knowledge of the normal postoperative appearance, UGI examinations should be easily performed and the results interpreted. The 24-hour postoperative examination is reliable for detection of leaks (31). Although gastrojejunal anastomotic strictures are one of the most common complications with laparoscopic Roux-en-Y gastric bypass (30), they are often diagnosed and treated at endoscopy. A thorough examination also evaluates for degraded pouch restriction, including a patulous gastrojejunal anastomosis or gastrogastric fistula, as a late cause of weight gain. An understanding of postoperative anatomy also assists in detection of internal hernias.

CT is invaluable in detection and characterization of small bowel obstructions and internal hernias. The interpreting radiologist should be able to identify the position of the Roux limb, the location of the excluded stomach and biliopancreatic limb, and the location of the enteroenteric anastomosis.



**Figure 28.** Hematoma in a 61-year-old woman with oliguria and a falling hematocrit 1 day after surgery. Nonenhanced CT scan shows high-attenuation material in the excluded stomach (arrowhead) and lesser sac (arrows). Surgery revealed 500 mL of intragastric blood and 150 mL in the lesser sac. No site of bleeding was found.



**Figure 29.** Abscess in a 49-year-old woman with fever and abdominal pain 18 days after surgery. CT scan shows a large abscess (arrow) posterior to the excluded stomach. Percutaneous drainage produced infected bloody fluid.

CT may allow diagnosis of anastomotic leaks, abscesses, gastrogastric fistulas, and intraabdominal hematomas. CT-guided percutaneous procedures, such as placement of gastrostomy tubes or drainage of fluid collections, can obviate emergent exploration and may be the only procedural intervention necessary for cure.

Although complication rates may decline as surgeons' skill and experience increase, the ever-increasing use of the laparoscopic Roux-en-Y gastric bypass requires all radiologists to be familiar with this procedure and its complications.



## References

- Burton BT, Foster WR. Health implications of obesity: an NIH Consensus Development Conference. *J Am Diet Assoc* 1985;85:1117-1121.
- Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW Jr. Body-mass index and mortality in a prospective cohort of U.S. adults. *N Engl J Med* 1999;341:1097-1105.
- Adachi H, Goetz FC, Jacobs DR, et al. The role of obesity in the association of cardiovascular risk factors and glucose intolerance in small Japanese and North American communities. *Diabetes Res Clin Pract* 2000;49:41-51.
- Rimm EB, Stampfer MJ, Giovannucci E, et al. Body size and fat distribution as predictors of coronary heart disease among middle-aged and older US men. *Am J Epidemiol* 1995;141:1117-1127.
- Fang J, Wylie-Rosett J, Cohen HW, Kaplan RC, Alderman MH. Exercise, body mass index, caloric intake, and cardiovascular mortality. *Am J Prev Med* 2003;25:283-289.
- Allison DB, Fontaine KR, Manson JE, Stevens J, VanItallie TB. Annual deaths attributable to obesity in the United States. *JAMA* 1999;282:1530-1538.
- Van Gaal LF, Wauters MA, De Leeuw IH. The beneficial effects of modest weight loss on cardiovascular risk factors. *Int J Obes Relat Metab Disord* 1997;21(suppl 1):S5-S9.
- Consensus Development Conference Panel. NIH conference: gastrointestinal surgery for severe obesity. *Ann Intern Med* 1991;115:956-961.
- Martin LF, Tan TL, Horn JR, et al. Comparison of the costs associated with medical and surgical treatment of obesity. *Surgery* 1995;118:599-606; discussion 606-607.
- Patterson EJ, Urbach DR, Swanstrom LL. A comparison of diet and exercise therapy versus laparoscopic Roux-en-Y gastric bypass surgery for morbid obesity: a decision analysis model. *J Am Coll Surg* 2003;196:379-384.
- Nguyen NT, Goldman C, Rosenquist CJ, et al. Laparoscopic versus open gastric bypass: a randomized study of outcomes, quality of life, and costs. *Ann Surg* 2001;234:279-289; discussion 289-291.
- Lujan JA, Frutos MD, Hernandez Q, et al. Laparoscopic versus open gastric bypass in the treatment of morbid obesity: a randomized prospective study. *Ann Surg* 2004;239:433-437.
- Suter M, Giusti V, Heraief E, Zysset F, Calmes JM. Laparoscopic Roux-en-Y gastric bypass: initial 2-year experience. *Surg Endosc* 2003;17:603-609.
- Schauer PR. Open and laparoscopic surgical modalities for the management of obesity. *J Gastrointest Surg* 2003;7:468-475.
- Miller K, Hell E. Laparoscopic surgical concepts of morbid obesity. *Langenbecks Arch Surg* 2003;388:375-384.
- Hocking MP, Davis GL, Franzini DA, Woodward ER. Long-term consequences after jejunioileal bypass for morbid obesity. *Dig Dis Sci* 1998;43:2493-2499.
- Mason EE, Ito C. Gastric bypass in obesity. *Surg Clin North Am* 1967;47:1345-1351.
- Fobi MA, Lee H, Holness R, Cabinda D. Gastric bypass operation for obesity. *World J Surg* 1998;22:925-935.
- Wittgrove AC, Clark GW, Tremblay LJ. Laparoscopic gastric bypass, Roux-en-Y: preliminary report of five cases. *Obes Surg* 1994;4:353-357.
- Champion JK, Williams M. Small bowel obstruction and internal hernias after laparoscopic Roux-en-Y gastric bypass. *Obes Surg* 2003;13:596-600.
- Koehler RE, Halverson JD. Radiographic abnormalities after gastric bypass. *AJR Am J Roentgenol* 1982;138:267-270.
- Yu J, Turner MA, Cho SR, et al. Normal anatomy and complications after gastric bypass surgery: helical CT findings. *Radiology* 2004;231:753-760.
- Marshall JS, Srivastava A, Gupta SK, Rossi TR, DeBord JR. Roux-en-Y gastric bypass leak complications. *Arch Surg* 2003;138:520-523; discussion 523-524.
- Byrne TK. Complications of surgery for obesity. *Surg Clin North Am* 2001;81:1181-1193.
- Blachar A, Federle MP. Gastrointestinal complications of laparoscopic Roux-en-Y gastric bypass surgery in patients who are morbidly obese: findings on radiography and CT. *AJR Am J Roentgenol* 2002;179:1437-1442.
- Sanyal AJ, Sugerma HJ, Kellum JM, Engle KM, Wolfe L. Stomal complications of gastric bypass: incidence and outcome of therapy. *Am J Gastroenterol* 1992;87:1165-1169.
- Sataloff DM, Lieber CP, Seinige UL. Strictures following gastric stapling for morbid obesity: results of endoscopic dilatation. *Am Surg* 1990;56:167-174.
- Ahmad J, Martin J, Ikramuddin S, Schauer P, Slivka A. Endoscopic balloon dilation of gastroenteric anastomotic stricture after laparoscopic gastric bypass. *Endoscopy* 2003;35:725-728.
- Goodman P, Halpert RD. Radiological evaluation of gastric stapling procedures for morbid obesity. *Crit Rev Diagn Imaging* 1991;32:37-67.
- Podnos YD, Jimenez JC, Wilson SE, Stevens CM, Nguyen NT. Complications after laparoscopic gastric bypass: a review of 3464 cases. *Arch Surg* 2003;138:957-961.
- Blachar A, Federle MP, Pealer KM, Ikramuddin S, Schauer PR. Gastrointestinal complications of laparoscopic Roux-en-Y gastric bypass surgery: clinical and imaging findings. *Radiology* 2002;223:625-632.
- Bocker J, Vasile J, Zager J, Goodman E. Intussusception: an uncommon cause of postoperative small bowel obstruction after gastric bypass. *Obes Surg* 2004;14:116-119.
- Nguyen NT, Huerta S, Gelfand D, Stevens CM, Jim J. Bowel obstruction after laparoscopic Roux-en-Y gastric bypass. *Obes Surg* 2004;14:190-196.
- Filip JE, Mattar SG, Bowers SP, Smith CD. Internal hernia formation after laparoscopic Roux-en-Y gastric bypass for morbid obesity. *Am Surg* 2002;68:640-643.
- Higa KD, Ho T, Boone KB. Internal hernias after laparoscopic Roux-en-Y gastric bypass: incidence, treatment and prevention. *Obes Surg* 2003;13:350-354.
- Schauer PR, Ikramuddin S, Gourash W, Ramanathan R, Luketich J. Outcomes after laparoscopic Roux-en-Y gastric bypass for morbid obesity. *Ann Surg* 2000;232:515-529.
- Steinbrook R. Surgery for severe obesity. *N Engl J Med* 2004;350:1075-1079.

## Radiology of the Laparoscopic Roux-en-Y Gastric Bypass Procedure: Conceptualization and Precise Interpretation of Results

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### Page 1356

Numerous bariatric surgical procedures exist, the most common being the Roux-en-Y gastric bypass. The laparoscopic approach to the Roux-en-Y gastric bypass is quickly becoming the preferred method due to its decreased hospital stays, faster recovery, and decreased wound complications (11,12).

### Page 1356

Currently, the Roux-en-Y gastric bypass combines restrictive and malabsorptive properties by creating a small gastric pouch and a Roux limb (18). While variations exist, the Roux-en-Y gastric bypass may be considered the standard of reference for bariatric surgery (14).

### Page 1363

The most ominous complication is a leak from the gastrojejunal anastomosis or the enteroenteric anastomosis, both of which may be life threatening (23,24).

### Page 1364

Small bowel obstructions are more frequent after laparoscopic gastric bypass than after open procedures (30). Most obstructions after laparoscopic Roux-en-Y gastric bypass are secondary to internal hernias, with fewer obstructions from postoperative adhesions or other causes (20).

### Page 1368

Delay in diagnosis of any type of internal hernia may be devastating and cause ischemia or death (34,35). In one series, 20% of patients with symptomatic internal hernias had normal preoperative imaging findings, and surgical exploration should be considered in any patient with unexplained abdominal pain (35).