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Abbreviations:
GBP = gastric bypass
GI = gastrointestinal

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Gastrointestinal Complications of Laparoscopic Roux-en-Y Gastric Bypass Surgery: Clinical and Imaging Findings[1]

PURPOSE: To report the complications and imaging findings in a large group of patients who underwent Roux-en-Y gastric bypass (GBP) surgery.

MATERIALS AND METHODS: Four hundred sixty-three patients were evaluated for upper gastrointestinal (GI) complications following Roux-en-Y GBP surgery. Major complications were those that required surgical or radiologic intervention and minor complications were those that resolved spontaneously. The time from surgery to complication and findings from upper GI series and computed tomography (CT) of the major complications and minor leaks were reviewed.

RESULTS: Forty-four patients had 56 major complications: 23 small-bowel obstructions (14 internal hernias and nine adhesions), 16 major leaks, 15 anastomotic strictures, and two fistulas. There were 13 minor leaks and 18 other complications. Internal hernias were late complications and had a variety of findings at upper GI series and CT. Leaks were early complications and usually originated from the gastrojejunal anastomosis; findings from upper GI series and CT demonstrated extraluminal gas, contrast material, or both. Anastomotic strictures were late complications and were diagnosed at upper GI series with rounded dilation of the pouch and delayed emptying.

CONCLUSION: Upper GI complications that required intervention occurred in 9.5% of patients. CT and upper GI series can depict most major complications.

Morbid obesity is a national health problem in the United States that is constantly increasing in prevalence. During the 30-year interval from 1960 to 1990, the incidence of overweight American adults has increased from 13% to 35% (1,2), and it is estimated that 6% of women and 2% of men in the United states are morbidly obese (3). Obesity is defined as a body mass index of 35 kg/m^2 with comorbidity or 40 kg/m^2 or greater without comorbidity (4). A body mass index of 40 kg/m^2 is roughly equal to 100 pounds over the ideal body weight. It has been shown in several studies (5–7) that the risk of physical disability and early mortality increases with increasing body mass index.

Patients who have failed to achieve or maintain weight loss with supervised programs may be candidates for bariatric surgery (8–10). Bariatric surgery allows considerable weight loss, extended weight maintenance, and control or reversal of some of the obesity-related health problems (11). The Roux-en-Y gastric bypass (GBP) surgery has been shown to result in greater weight loss than other bariatric surgical techniques (12–15). A laparoscopic approach to Roux-en-Y GBP was introduced by Wittgrove et al (16) and became the procedure of choice in North America. This procedure involves the creation of a 15–30-mL gastric pouch that is isolated from the distal stomach (Fig 1). This pouch is anastomosed to a 75- or 150-cm Roux-en-Y limb that is brought to the pouch through the transverse mesocolon in a retrocolic retrogastric position. The Roux-en-Y limb is anastomosed side to side to the distal jejunum and thereby bypasses most of the jejunum.

Imaging in patients after GBP surgery has received little attention in the radiology

literature, with most studies being more than a decade old and with radiographic findings for types of gastric bypass procedures no longer in common use (17–20). There are only a few case reports and small case series in which some complications of GBP surgery at computed tomography (CT) are described (21–23). As the laparoscopic GBP procedure becomes more frequent, it is important for radiologists to understand the frequency and radiographic manifestations of potential complications of this procedure. Our purpose is to report the complications and imaging findings in a large group of patients who underwent GBP surgery.

MATERIALS AND METHODS

We reviewed the computer database at the Center for Minimally Invasive Surgery and identified 463 patients who underwent laparoscopic Roux-en-Y GBP surgery at our institution from July 1997 through November 2000. The electronic medical records and radiology files of these patients were searched (K.M.P.) for gastrointestinal (GI) complications, which were then subdivided into major complications, those that required intervention, and minor complications, those that resolved spontaneously or with conservative treatment. Major complications included small-bowel obstruction, major leaks and abscesses, anastomotic strictures, and gastrogastric and gastrocutaneous fistulas diagnosed at surgery, endoscopy, and/or imaging. Minor complications included contained leaks, marginal ulcers, pancreatitis, esophagitis, splenic abscess, and cholelithisis diagnosed at imaging or clinical studies. The complications were also subdivided into early (<1 month after Roux-en-Y GBP) and late (>1 month after the Roux-en-Y GBP) complications. The time from the laparoscopic Roux-en-Y GBP surgery to the complication and to the resolution or treatment of the complication was evaluated. The study was approved by our institutional review board. Patient informed consent was not required.

The patients (380 [82%] women and 83 [18%] men; age range, 27–60 years; mean age, 45 years) weighed 91–196 kg (mean, 130 kg). All patients underwent routine upper GI series as a part of the postoperative follow-up within 24 hours after surgery, with orally administered water-soluble contrast medium (diatrizoate meglumine and sodium [Gastroview]; Mallinckrodt Medical, St Louis, Mo). Patients with signs of peritonitis, infection, or small-bowel obstruction underwent further evaluation with CT. Helical CT scanner (CT HiLight Advantage or CT HiSpeed Advantage; GE Medical Systems, Milwaukee, Wis) was used to image the abdomen and pelvis. Section thickness was 5–7 mm, and scans were obtained with contrast medium administered intravenously, unless the clinical status of the patient did not allow administration of contrast medium. Patients received 150 mL of 60% iodinated contrast medium (iothalamate meglumine [Conray 60] or ioversol [Optiray 350]; Mallinckrodt Medical) administered at a rate of 2–3 mL/sec with a power injector (model OP 100; Medrad, Pittsburgh, Pa). The oral contrast medium was also used routinely.

Imaging reports of all patients were reviewed (A.B., K.M.P.), and patients with major GI complications, minor leaks, or anastomotic strictures in whom imaging findings were available for review were located. The cases of leaks and strictures were retrospectively reviewed by two radiologists (A.B., M.P.F.) with consensus. Imaging evidence of an anastomotic leak was the presence of extraluminal contrast medium. Associated findings included extraluminal fluid or gas. Imaging findings of other minor complications (pancreatitis, cholelithiasis, esophagitis, and splenic abscess) were not reviewed.

We also wanted to determine if we could distinguish between small-bowel obstruction caused by adhesions from that caused by internal hernia on the basis of findings from CT, upper GI series,

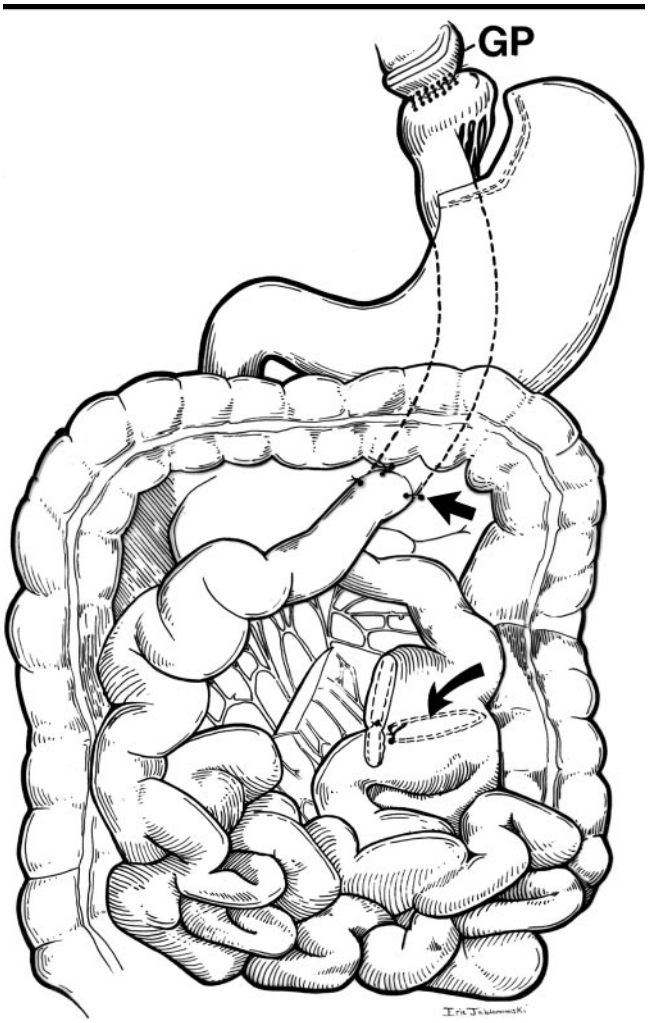


Figure 1. Schematic of the Roux-en-Y GBP procedure. A small gastric pouch *(GP)* is created and anastomosed to a Roux-en-Y limb, which has been passed in a retrocolic retrogastric fashion through a surgical defect (straight arrow) in the transverse mesocolon. The Roux-en-Y limb is anastomosed side to side (curved arrow) with more distal small bowel.

TABLE 1
Minor Gastrointestinal Complications in 31 Patients Following Laparoscopic Roux-en-Y GBP Surgery

Complication	No. of Cases	Percentage of Cases	Time from Surgery to Complications (d)			Outcome
			Early Complications	Late Complications	Range	
Minor leaks*	13	2.8	11	0	1–18 (6)	No intervention
Cholelithiasis	8	1.7	0	8	161–820 (449)	Four cholecystectomies
Pancreatitis	4	0.9	2	2	15–415 (162)	No complications, conservative treatment
Esophagitis	3	0.7	0	3	37–192 (90)	No complications, conservative treatment
Marginal ulcer	2	0.4	0	2	86–105 (96)	Resolved, conservative treatment
Splenic abscess	1	0.2	1	0	15	Antibiotics, conservative treatment

Note.—Numbers in parenthesis are the mean.
* Nine minor leaks were from the gastrojejunal anastomosis; two, from the gastric remnant; and two, from the esophagus.

a. b.

c.

Figure 2. Images in a 41-year-old woman with transmesocolic internal hernia. **(a)** Transverse CT scan shows a cluster of dilated bowel segments (arrow) that lies dorsal to the bypassed stomach *(S)*. **(b)** Transverse CT scan shows that the mesenteric vessels (arrow) supplying the herniated bowel segments are crowded, twisted, and engorged. **(c)** Image from upper GI series shows a cluster of dilated bowel segments (arrow) in the left upper quadrant.

or both. Of 21 patients with bowel obstruction, two did not undergo upper GI or CT evaluation, and four had imaging findings that were not available for review. The remaining 15 patients included nine patients with internal hernia, who underwent nine upper GI and three CT examinations, and six patients with adhesions, who underwent six upper GI and one CT examination. Findings from these imaging studies were reviewed retrospectively by one investigator (M.P.F.), who was blinded to the clinical diagnosis of the cause of obstruction. Some imaging signs, such as the presence of dilated bowel segments (>2.5 cm) and a transition from dilated to normal or collapsed bowel, were expected to be encountered at both upper GI series and CT for cases of adhesions and internal hernia. Other signs could be evaluated only at CT, such as the recently published (24) signs of internal hernia that include crowding, stretching, and engorgement of mesenteric vessels and displacement of the main mesenteric trunk. We anticipated that other signs that might be more suggestive of adhesions (eg, abrupt angulation of a bowel segment) or internal hernia (eg, a cluster of dilated bowel segments or convergence of afferent and efferent segments at the opening of the hernia) might be encountered at upper GI series or CT.

The reader was asked to assign a confidence scale to the diagnosis. The bowel obstruction was considered to be due to adhesion, unless an internal hernia was diagnosed as "probably" or "definitely" present by using the following five-point scale: 1, not present; 2, probably not present; 3, equivocal; 4, probably present; 5, definitely present.

Findings from 43 upper GI series and 22 CT examinations in patients with GI complications after laparoscopic Roux-en-Y GBP surgery were evaluated. Findings from upper GI series were evaluated on hard-copy images and those from CT, with the picture archiving and retrieval system of our radiology department.

RESULTS

Complications

Major complications.—Of 463 patients, 44 (9.5%) had 56 major GI complications. There were 21 (4.5%) patients with 23 bowel obstructions, 14 (3.0%) patients with 16 major leaks, 15 (3.2%) patients with 15 anastomotic strictures, and one patient each with gastrogastric and gastrocutaneous fistulas. Eight patients had more than one type of complication. By using 1 month as the criterion, there were 24 early and 32 late complications. The time from laparoscopic Roux-en-Y GBP surgery to a major complication ranged from 1 to 825 days (mean, 92 days; median, 15 days). Two (0.4%) patients died of surgical complications: one due to pulmonary embolism and one due to sepsis after repeat surgery for repair of an internal hernia.

The 23 small-bowel obstructions included 14 internal hernias and nine small-bowel adhesions. Thirteen patients had 14 internal hernias (one patient had two internal hernias) that were diagnosed 3–825 days (mean, 235 days; median, 155 days) after Roux-en-Y GBP surgery, with only two hernias diagnosed less than 30 days after surgery. Thirteen (93%) of 14 internal hernias were transmesenteric, with herniation of the small bowel through the mesocolon in 10 cases and through the small-bowel mesentery in three cases. One of the 10 cases had herniation through the mesocolon and small-bowel mesentery. One internal hernia was a Peterson type, with herniation of the small bowel posterior to the Roux-en-Y loop. All patients were treated with surgery, and in none of the patients was volvulus or bowel ischemia detected at the time of surgery.

In eight patients, there were nine cases of small-bowel obstruction due to adhesions. The small-bowel obstruction was diagnosed 3–289 days (mean, 90 days; median, 37 days) after Roux-en-Y GBP surgery, with four of the 10 small-bowel obstructions developing less than 30 days after surgery. Eight of the nine cases required surgery, and one case resolved with conservative treatment. In one case, the bowel was ischemic and required resection.

TABLE 2
Upper GI Findings in 13 Patients after Roux-en-Y GBP Surgery and Small-Bowel Obstruction

Upper GI Finding	Internal Hernia	Adhesions
Small-bowel obstruction present	9 (100)	6 (100)
Distended small-bowel segments (>2.5 cm)	9 (100)	6 (100)
Transition between dilated and nondilated small-bowel segments	8 (89)	5 (85)
Abrupt angulation of small-bowel segments	3 (33)	2 (33)
Cluster of small-bowel segments		
Left upper quadrant	5 (56)	2 (33)
Midline	3 (33)	0 (0)
Right upper quadrant	0 (0)	1 (17)
Not seen	1 (11)	3 (50)
Stasis of contrast material in cluster of small-bowel segments	8 (89)	4 (68)
Delayed passage of contrast material through loop cluster of small bowel	8 (89)	4 (68)
Small bowel remains high on the view obtained with the patient in an erect position	6 (67)	1 (17)
Convergence of afferent and efferent limbs of internal hernia	2 (22)	0 (0)
Caudodorsal displacement of transverse colon	2 (22)	1 (17)

Note.—By using our criteria, internal hernia and adhesions were retrospectively diagnosed as definitely or probably present in six (67%) of nine cases and in two (33%) of six cases, respectively. Data in parentheses are percentages.

There were 16 major leaks in 14 patients. Eleven leaks were from the gastrojejunal anastomosis; four, from the gastric remnant, with gastric perforation in two; and one, from small bowel that was involved in an internal hernia. The time from Roux-en-Y GBP surgery to the diagnosis of a leak ranged from 1 to 60 days (mean, 11 days). Fifteen (94%) of the major leaks were early leaks diagnosed less than 30 days after surgery. Four leaks were drained with a pigtail catheter placed percutaneously with CT guidance. Ten major leaks were repaired with a laparoscopic approach and included one of the four leaks initially treated with a CT-guided pigtail catheter. Three leaks were repaired with open laparotomy: one leak from the gastric remnant and two leaks from the gastrojejunal anastomosis in patients who had been operated on for small-bowel obstruction. The time from diagnosis to complete resolution of the five major leaks treated with CT-guided drainage catheter ranged from 40 to 44 days (mean, 42 days).

Fifteen patients had anastomotic strictures. The time from Roux-en-Y GBP surgery to the diagnosis of anastomotic stricture was 9–94 days (mean, 49 days). Two of the strictures were early and 13 were late. All cases were successfully treated with endoscopic balloon dilation, without need for surgery. Only two patients required two dilations.

One of the patients who underwent surgery for a major leak also had a gastrogastric fistula connecting the gastric pouch and distal stomach, which was repaired during surgery. A second patient developed a gastrocutaneous fistula from the distal stomach at the site of the gastrostomy tube and also underwent surgery.

Minor complications.—Of 463 patients, 31 (6.7%) had minor GI complications, which included 13 minor leaks, eight cases of cholelithiasis that was first documented after Roux-en-Y GBP surgery, four cases of pancreatitis, three cases of esophagitis, two marginal ulcers, and one splenic abscess.

The time from surgery to minor complications and the clinical outcome are listed in Table 1.

Imaging Findings

Of the 15 patients with small-bowel obstruction who had imaging studies available for review, all had the obstruction diagnosed at upper GI series (nine with internal hernia, six with adhesions) and CT (three with hernia, one with adhesions). Abrupt angulation of the bowel loop was evident at upper GI series with equal frequency (33%) in patients with hernia (three of nine) or adhesions (two of six). An abnormal cluster of dilated bowel segments was evident at upper GI series in 89% of patients with internal hernia (Fig 2) but was also seen in 30% of cases of adhesions. Convergence of the afferent and efferent bowel segments was detected at upper GI series in only two of nine cases of internal hernia and in no cases of adhesions. These and other ra-

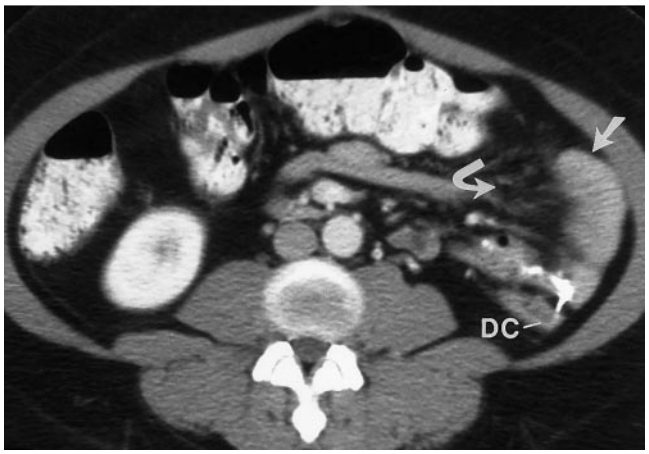


Figure 3. Transverse CT scan in a 46-year-old woman with transmesenteric internal hernia. A cluster of dilated bowel segments (straight arrow) is adjacent to the abdominal wall and displaces the descending colon *(DC)* medially. The mesenteric vessels (curved arrow) are stretched and engorged.

Figure 4. Transverse unenhanced CT scan in a 47-year-old woman with a major leak from gastrojejunal anastomosis. Extraluminal gas and contrast material (arrows) are noted near the anastomosis and around the spleen *(Sp)*.

diographic findings are summarized in Table 2.

At UGI series, we diagnosed six (67%) of nine internal hernias and two (33%) of six adhesions. We misdiagnosed two internal hernias as adhesions and one adhesion as internal hernia. The remaining cases were considered equivocal.

At CT, we evaluated three internal herniations: one through a rent in the transverse mesocolon, one through a rent in the small-bowel mesentery, and one posterior to the Roux-en-Y loop (Peterson type). We also evaluated one case of small-bowel obstruction due to adhesions. Distended small-bowel segments with a point of transition from dilated to nondilated small bowel were seen on all four CT scans. The mesenteric vessels were engorged and stretched in all internal hernias and crowded in two of three internal hernias but were normal in one case of adhesions. Internal herniation through the transverse mesocolon was left of midline and posterior to the stomach (Fig 2). Internal herniation through the small-bowel mesentery was adjacent to the left abdominal wall with no overlying omental fat and caused medial displacement of the descending colon (Fig 3). Both of these hernias appeared as clustered masses of small-bowel segments. The Peterson hernia did not demonstrate any specific signs of internal hernia, including clustering of small-bowel segments, except for engorgement and stretching of the mesenteric vessels. At CT, the small bowel demonstrated abrupt angulation in only the case of obstruction due to adhesions. Two of the three internal hernias and one case of adhesions were correctly diagnosed at CT with a high degree of confidence. The Peterson internal hernia was misdiagnosed at CT as due to adhesions, as it was also misdiagnosed at the upper GI series. In one case, bowel ischemia was not specifically diagnosed at imaging.

The 14 patients with major leaks included 12 patients with findings of imaging studies available for review and two patients with findings lost to review. The 12 patients underwent upper GI series; in nine (75%) patients, a leak was identified. Three leaks were discovered during surgery for bowel obstruction and had not been diagnosed at upper GI series. Major leaks were identified at upper GI series as extraluminal collections of contrast material, including opacification of drainage catheters that had been placed near the gastroenteric anastomosis at the time of bypass surgery.

A major leak was identified at CT in seven (64%) of 11 patients on the basis of extraluminal contrast material (Fig 4). Three leaks diagnosed at upper GI series were not diagnosed at CT. Extraluminal gas was seen near the gastrojejunal anastomosis in five (45%) cases, with a moderate amount of free air (with gastric remnant perforation) demonstrated in one case. A small amount of free intraperitoneal fluid was demonstrated in three (27%) cases. All 11 patients with major leaks developed fluid collections (two patients had multiple collections) that ranged from 6 to 11 cm (mean, 9 cm) in diameter. The collections were located adjacent to the gastrojejunal anastomosis ($n = 4$), the perisplenic area ($n = 3$), the left ($n = 2$) and right ($n = 1$) subphrenic areas, the pelvis ($n = 2$), and the lesser sac ($n = 1$). In eight (73%) patients, gas was present within a loculated fluid collection.

Only five patients with anastomotic strictures were evaluated at upper GI series; the rest were evaluated at upper GI endoscopy. All five patients demonstrated delayed passage of contrast material, dilatation of the gastric pouch, and anastomotic narrowing with a diameter of less than 10 mm (Fig 5).

Thirteen patients had a minor leak. In 10 patients, findings from upper GI series were available for review. All minor leaks (100%) were demonstrated at upper GI series, with extraluminal contrast material seen in all cases. All leaks were near the gastrojejunal anastomosis and ranged from smaller than 1 cm to 7 cm (mean, 2.5 cm). In seven of the 10 patients with minor leaks, drainage catheters were placed at surgery, and contrast material was seen filling the catheter in five cases (Fig 6). Three patients underwent CT, which depicted extraluminal contrast material in two cases and a small amount of fluid and gas bubbles adjacent to the gastrojejunal anastomosis in one case (Fig 7). The minor leaks resulted in three fluid collections: two adjacent to the gastrojejunal anastomosis and one in the right subphrenic area. The collections ranged from 4 to 5 cm in diameter

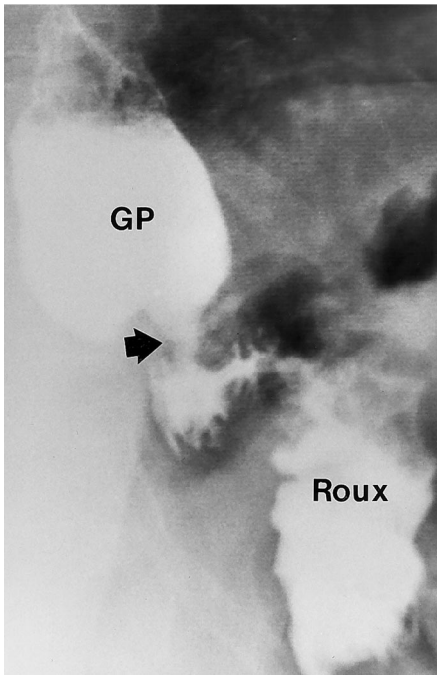


Figure 5. Image from upper GI series in a 52-year-old woman with anastomotic stricture. The gastric pouch *(GP)* is distended and rounded. The opening (arrow) into the Roux-en-Y limb *(Roux)* is narrowed to less than 10 mm. The stricture was dilated successfully with one endoscopic balloon dilation.

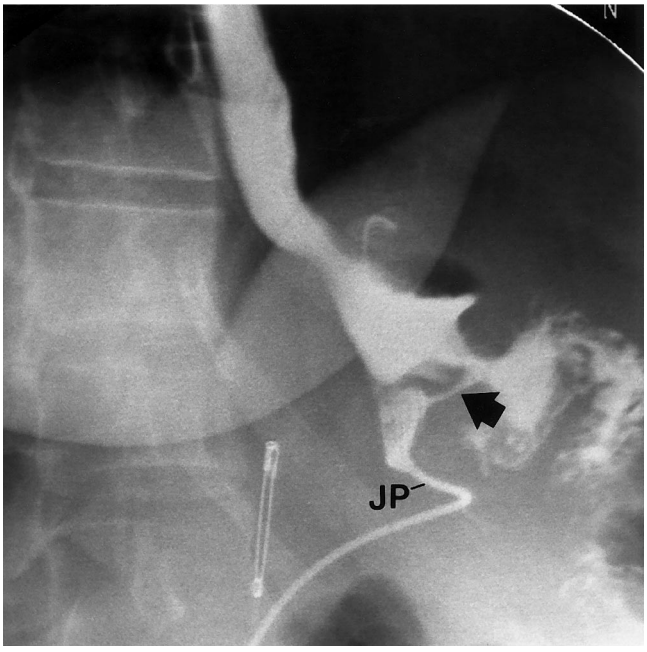


Figure 6. Image from upper GI series in a 46-year-old woman with a minor leak. A small well-controlled leak (arrow) at the gastrojejunal anastomosis is drained with the Jackson-Pratt drainage catheter *(JP)*. The leak resolved after 10 days.

(mean, 4.5 cm). Two of the three collections demonstrated air fluid levels and fluid levels and gas locules, and one collection had an enhancing rim (33%) indicative of abscess formation. All three collections were evaluated at contrast material–enhanced CT.

DISCUSSION

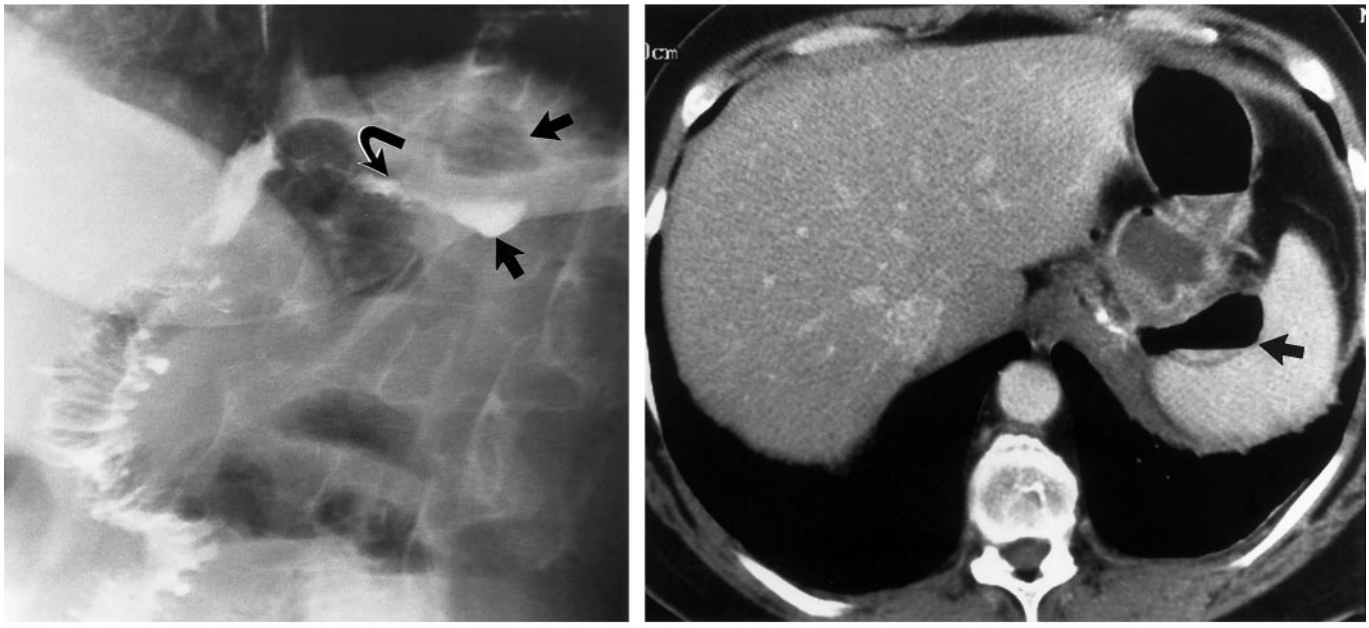
Morbid obesity is a serious risk factor for morbidity and mortality due to its effect on osteoarthritis, hypertension, diabetes, cardiovascular disease, and even some forms of cancer (25). Various surgical procedures have been advocated to induce weight loss when dietary and other interventions have failed. Bariatric surgical procedures are classified into restrictive and combination procedures. Restrictive procedures decrease stomach capacity, while combination procedures include some means of bypassing part of the digestive tract, thus causing decreased absorption of nutrients and calories. The Roux-en-Y GBP has become the most common procedure in North America. The laparoscopic approach offers the potential benefits of reduced perioperative pain, shorter hospital stay, and reduced morbidity in obese patients who are prone to cardiopulmonary and wound-related complications.

While the potential benefits of laparoscopic Roux-en-Y GBP are evident, there has been relatively little assessment of the actual prevalence of morbidity and mortality as a result of this procedure, and even less is known about the role and effect of imaging studies in the diagnosis of complications of the operation.

We found that 9.5% of the patients in this series had major GI complications as a result of Roux-en-Y GBP, with a mortality rate of 0.4%. An additional 6.7% had minor complications, while others had morbidities such as wound and respiratory infections, which were not evaluated.

The most serious GI complication of Roux-en-Y GBP is leakage of enteric contents, which may result in sepsis and death if not diagnosed promptly. The leakage usually occurs within the first 10 days of surgery and is difficult to diagnose clinically. The leaks may be related to a surgical technique or noncompliance of the patient with premature ingestion of food or fluids in the early postoperative period. Of 463 patients in our study, 14 (3.0%) had major leaks and 13 (2.8%) had minor leaks, a rate that is comparable with the rate of 1.0%–5.6% reported by others (26–31). The most common site of the leak is the gastrojejunal anastomosis, which accounted for 69% of the major leaks and all of the minor leaks in our series. Leaks from the hypopharynx, esophagus, bypassed stomach, and small bowel are much less common (32).

We found upper GI series to be reliable in helping to diagnose leaks, and we routinely perform upper GI series by using water-soluble contrast medium within 24 hours of surgery and may repeat the study later if a leak is depicted or if it is suspected clinically. In our experience, it may be difficult to recognize a small leak at the initial postoperative upper GI series only to have it diagnosed a few days later with repeat upper GI series. We detected 75% of the major leaks and 100% of the minor leaks, with results that are considerably better than those reported by Buckwalter and Herbst (33) and Fakhry et al (34), who detected only 50% and 43% of leaks, respectively. It may be difficult to recognize a small leak at upper GI series, in part, due to technical factors. The extreme size of patients often strains the limits of the radiographic equipment to penetrate the patient with adequate radiographic contrast discrimination, and fluoroscopic monitoring of the upper GI procedure is sometimes impossible. Some well-controlled leaks are evident only on the basis of opacification of the drainage catheter,



a. b.

Figure 7. Images in a 60-year-old woman with a minor anastomotic leak. **(a)** Oblique image from upper GI series with the patient in an upright position demonstrates a leak (curved arrow) from the anastomosis and a rounded collection (straight arrows) with an air-fluid level. **(b)** Transverse CT scan demonstrates a loculated collection (arrow) with an air-fluid level. The leak and fluid collection resolved without treatment within 10 days.

which is often placed near the anastomosis at the time of surgery.

CT plays a complementary role to the upper GI series in helping to diagnose leaks. We diagnosed 64% of the major and 67% of the minor leaks with CT, which included two patients with large fluid collections due to anastomotic leaks that were not evident at upper GI series. All patients with leaks had loculated fluid collections demonstrated at CT, and most had extraluminal gas as well. The most common locations were near the anastomosis and in the left upper quadrant, including perisplenic space. Minor leaks resulted in smaller fluid collections than did major leaks. CT-guided placement of a pigtail drainage catheter was effective in obviating repeat surgery in three of four cases in which it was used.

Other investigators (33,34) reported surgically proven anastomotic leaks and abscesses that were missed at upper GI series. Because sepsis and bowel obstruction are potential manifestations of an anastomotic leak, we recommend CT examination in all patients with unexplained fever, pain, and abdominal distention following Roux-en-Y GBP.

Small-bowel obstruction following laparoscopic Roux-en-Y GBP is most commonly the result of adhesions or internal hernias, although intussusception has also been reported rarely (35). Internal hernias are very rare in the general population; however, following Roux-en-Y GBP or liver transplantation during which a Roux-en-Y anastomosis is constructed, these hernias are much more common and are likely to be underdiagnosed (24,36,37). In our study, 2.8% of patients developed internal hernias. The results correspond well to those of another study (26), in which a 2.5% rate was reported. Sixty-one percent of small-bowel obstructions in our study were caused by internal hernias. This may be attributed to both the lower frequency of adhesions typical of laparoscopic procedures and the relatively high frequency of internal hernias in this patient population. A possible predisposing factor for developing internal hernia in these patients may be the rapid massive weight reduction, which results in decreased intraperitoneal fat that may enlarge the mesenteric defect. Patients who present with signs of small-bowel obstruction following Roux-en-Y GBP surgery should be evaluated carefully, with a high index of suspicion for internal hernias. In our study, adhesions were more common than internal hernias within the 1st month after surgery, while 93% of internal hernias occurred more than 1 month (mean, 235 days) after surgery.

Radiographic and CT signs can be helpful in distinguishing obstruction due to adhesions from that due to internal hernia. However, as noted in Table 2, there was considerable overlap in the findings from upper GI series in patients with adhesions and those with internal hernias. While a confident diagnosis of partial small-bowel obstruction can be made in nearly all cases by using upper GI series criteria, the specific cause may not be evident. Findings that favor a diagnosis of internal hernia include a cluster of dilated bowel segments in the left upper or middle abdomen, which remain relatively fixed in this high position on views obtained with the patient in an erect position.

Recent reports (24,36,37) have demonstrated that CT scans can depict findings that allow an accurate diagnosis of internal hernia in the clinical setting of a prior liver transplantation. We tried to apply these same criteria for the diagnosis of internal hernia in patients after Roux-en-Y GBP. Unfortunately, only three patients with internal hernias underwent CT, and each patient had a different type of hernia. Three types or sites of internal hernia have been reported after laparoscopic Roux-en-Y GBP (15), the most common being transmesenteric, in which the small bowel herniates through the surgical defect in the transverse mesocolon. The herniated bowel is usually the Roux-en-Y loop itself. In our patient with this type of

hernia, we recognized at upper GI series and CT a cluster of dilated bowel segments in the expected position of the Roux-en-Y loop, which is dorsal to the stomach and transverse colon. Because the cluster of bowel segments lies in a retrogastric location, it may simulate a left paraduodenal hernia. Paraduodenal hernias at CT and upper GI series have also been reported recently (24).

In our series, there were 10 cases of herniation of bowel through the mesocolon and three cases of herniation through a surgical defect in the small-bowel mesentery. We obtained one CT scan in a patient with a transmesenteric hernia through the defect in the small-bowel mesentery. This type of hernia was similar to that encountered in a patient with liver transplantation and shared many of the reported CT signs (24,36,37), which included a large cluster of dilated bowel segments pressed against the anterior abdominal wall causing central displacement of the colon and crowding and engorgement of the mesenteric blood vessels. This hernia was also diagnosed with confidence at CT and upper GI series. The third type of internal hernia is known to surgeons as a Peterson type and occurs when the small bowel herniates behind the Roux-en-Y loop before it passes through the defect in the transverse mesocolon. We were unable to diagnose this hernia in one patient at upper GI and CT examinations, although CT depicted partial bowel obstruction and some crowding of mesenteric vessels.

While our experience is limited, we believe that a combination of clinical and imaging criteria may help to distinguish bowel obstruction due to adhesions from that due to internal hernia. Those due to internal hernia tend to occur much longer after surgery and are more likely to show CT signs of a cluster of dilated bowel segments either in a retrogastric (transmesocolic) or peripheral abdominal (transmesenteric) location accompanied by crowding, distortion, and engorgement of mesenteric vessels.

Stenosis at gastrojejunostomy may be the result of relative ischemia and is reported to occur in 1%–27% of patients following Rouex-en-Y GBP surgery (15, 26,30,34,38). Our rate of 3.2% compares well with that in other studies. Anastomotic stricture can be diagnosed at upper GI series, as well as at endoscopy. Findings from the upper GI series show a delayed passage of the contrast material through the anastomosis, as well as the actual degree of stenosis. In our institution, patients were examined more commonly with endoscopy, which is also therapeutic in some cases. Although it was reported (38) that late strictures are difficult to treat nonsurgically, we treated successfully all of the strictures with endoscopic balloon dilation, even those that were diagnosed months after surgery.

Because our study is retrospective, we cannot prove that patients with negative findings at upper GI series or CT did not have surgical complications nor that all patients with imaging evidence of complications have surgical confirmation.

In conclusion, more than 10% of patients who undergo laparoscopic Roux-en-Y GBP have GI complications. CT and upper GI series play important and complementary roles in the diagnosis of the most common complications, including bowel obstruction, leak, and anastomotic stricture.

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