Laparoscopic Roux-en-Y Gastric Bypass

Surgical Technique and Perioperative Care

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KEYWORDS

• Obesity • Comorbid conditions • Laparoscopic Roux-en-Y gastric bypass

KEY POINTS

- Obesity is a global epidemic with the number of effected individuals steadily increasing.
- Surgical procedures have been developed to alter the gastrointestinal tract to combat obesity and its associated comorbid conditions.
- Laparoscopic Roux-en-Y gastric bypass is highly effective at reducing excess body weight with substantial efficacy against comorbid conditions and a favorable overall side effect profile.
- There are various techniques for performing the laparoscopic Roux-en-Y gastric bypass.
- Standardized preoperative and postoperative protocols derived from evidence-based recommendations are essential to long-term success.

Video content accompanies this article at http://www.surgical.theclinics.com.

INTRODUCTION

The obesity epidemic, and the prevalence of associated comorbid conditions, is a problem of global proportions sparing no geographic, cultural, or demographic subset. Over the past 60 years, a host of surgical procedures have been developed and refined to anatomically and physiologically alter the gastrointestinal tract to combat obesity. Surgical interventions have proven to be among the most effective therapeutic options in the battle against obesity.

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The gastric bypass procedure was first introduced by Mason in 1967 as a variation of the Bilroth II reconstruction used after antrectomy in the treatment of peptic ulcer disease.[1] Over one-half of a century, numerous modifications led to the elegant minimally invasive procedures we perform today. The most noteworthy include the adoption of the Roux-en-Y configuration reported and advocated by Griffin in 1977[2] and the introduction of the laparoscopic Roux-en-Y gastric bypass (LRYGB) by Wittgrove and associates in 1993.[3]

Over the past 2 decades, the LRYGB has proven to be a highly effective operation against obesity and its associated comorbid conditions, and has a favorable metabolic side effect profile when compared with the more radical biliopancreatic diversion with duodenal switch. Numerous high-quality studies have demonstrated the efficacy and safety of the procedure. It has since become and remains the gold standard operation in the battle against the obesity epidemic.

Several technical variations exist with regard to the formation of the pouch and reconstruction of gastrointestinal continuity. These variations, as well as the evidence based recommendations for the preoperative and postoperative care of patients undergoing this procedure, are the focus of this article.

SURGICAL TECHNIQUE

Preoperative Planning

As with all surgical interventions, a detailed history should be obtained to avoid potential pitfalls. Certain subsets of patients may not be best suited for the LRYGB procedure, including those with a suspected hostile abdomen, multiple comorbid conditions for whom a lengthy operation may be detrimental, and conditions treated with psychotropic medications whose absorption is not amenable to LRYGB. The introduction of the laparoscopic sleeve gastrectomy offers a viable alternative for these patients.

Preoperative patient education is imperative, including a discussion of the risks and benefits, as well as knowledge of the procedure and expected postoperative lifestyle changes. The patient should be counseled on pregnancy avoidance for 12 to 18 months postoperatively, avoidance of nonsteroidal antiinflammatory drugs, smoking cessation indefinitely, and limited alcohol use. The patient should undergo psychosocial–behavioral and registered dietitian evaluation and clearance.[4] Preoperative weight management should be individualized and at the discretion of the surgeon.[5]

Preoperative testing should include blood glucose, lipid panel, comprehensive metabolic panel, hemogram, blood type, and when clinically indicated, endocrine and nutrient deficiency laboratory workup. All patients should have an electrocardiogram and chest radiography performed.[4] Obstructive sleep apnea (OSA) is prevalent in patients suffering from morbid obesity and can lead to cardiovascular disease and death. Testing for OSA and initiation of continuous positive airway pressure therapy should be considered in all patients.[6] Any significant gastrointestinal symptoms should be evaluated by imaging studies, upper gastrointestinal series or esophagogastroduodenoscopy before surgery.[4] In patients with symptomatic gallstones or history of cholecystitis, cholecystectomy is recommended. Concurrent laparoscopic cholecystectomy is acceptable and safe[7–10]; however, it should be kept in mind that treatment of choledocholithiasis is complicated by the anatomic changes associated with the gastric bypass procedure. *Helicobacter pylori* testing should be considered routinely and may be accomplished with esophagogastroduodenoscopy or stool testing.[4] Medical clearance from the patient's primary care physician, and cardiopulmonary or other specialists when indicated, should be obtained.[4]

Preparation and Patient Positioning

Most bariatric patients receive preoperative dosing with low-molecular-weight heparin and intravenous antibiotic prophylaxis.[4] It is ensured that the operating room table used can support adequate weight in the steep reverse Trendelenburg position and that it is equipped with right angle foot boards. After induction of general anesthesia, a Foley catheter is placed. Appropriately sized pneumatic compression devices are placed on both lower extremities. Many bariatric surgeons use split leg positioning, allowing the surgeon to stand in between the patient's legs. A securing strap is placed on both upper legs or across the hips. Extremities are placed in neutral abduction with adequate padding to prevent pressure injuries. The table is positioned with minimal break to open the upper abdomen. Upper body heating blankets are often placed to prevent hypothermia. The abdomen is prepped and draped in standard fashion.

Surgical Approach

The standard surgical approach to bariatric Roux-en-Y gastric bypass today is laparoscopic, with primary open procedures being of historic interest only (**Fig. 1**). There are reports of the robotic approach being safe and feasible.[11]

SURGICAL PROCEDURE

Trocar Placement

Accessing the abdominal cavity in the morbidly obese patient can be challenging. Most bariatric surgeons use the established safe technique of placement of a

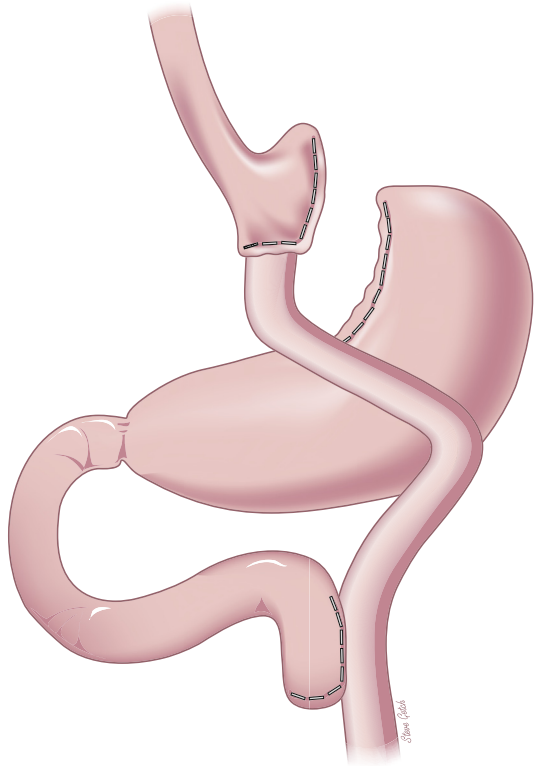

Fig. 1. Roux-en-Y gastric bypass.

bladeless optical view trocar with direct visualization by a 0° laparoscope at Palmer's point, in favor of the periumbilical access location. Pneumoperitoneum is established up to 18 mm Hg. A 30° laparoscope is used to perform a brief diagnostic laparoscopy noting presence or absence of hiatal hernia, adhesive disease, or other abnormalities. Abiding by minimally invasive surgical principles, the 4 remaining trocars are placed in an arc pattern. Minor variations in trocar size and location are determined by patient body habitus, surgical technique, and stapling device to be used.

Creation of the Gastric Pouch

The stomach is decompressed via placement of an orogastric tube, which is then removed along with any esophageal devices. Routine standardized communication with the anesthesia team should be established to ensure all tubes and devices are removed before gastric transection. There are varying modalities for determining pouch size, including placement of a sizing balloon, transection below the second lesser curve vascular bundle, and most commonly measurement from the gastroesophageal junction.[12] Regardless of technique, goal pouch size is 25 to 30 cm^3. The pouch vascular supply depends on the left gastric vessels. Depending on technique used, the pouch is created either vertically based on the lesser curvature, or horizontally based on the greater curvature. In vertical construction, the stomach is retracted caudally to expose the phrenoesophageal ligament and peritoneal reflection at the angle of His. This is incised, exposing the left diaphragmatic crus. Dissection is begun perigastric with sparing of the neurovascular bundle, or at the pars flacida with division of the lesser omentum by an energy device or by a stapling device with buttressing material to prevent bleeding. Access to the lesser sac and posterior stomach is obtained and the stomach is transected horizontally using a linear stapling device. The posterior wall of the stomach is examined and any adhesive attachments are divided. The fundus is retracted laterally to avoid redundancy, resulting in a large pouch. A retracting device is passed posteriorly, medial to the short gastric vessels, and deflected above the angle of His into the previously created space to allow for passage of the stapling device. Linear stapling devices are sequentially fired vertically. Care is taken to remain lateral to the esophageal fat pad to prevent esophageal transection or narrowing.

If a circular stapling device used, the anvil must be placed within the gastric pouch either transoral after pouch creation, or transgastric/abdominal before pouch completion. In transgastric/abdominal construction, the pouch can be created and the end opened to accommodate the anvil and refashioned[13] or, more commonly, a gastrotomy is made before pouch creation to allow passage of the anvil and the pouch is created around the anvil.[14]

Construction of the Roux and Biliopancreatic Limbs

The patient is returned to the supine position to facilitate cephalad retraction of the omentum and transverse colon to identify the ligament of Treitz. The ligament of Treitz is confirmed by identification of the adjacent inferior mesenteric vein. The bowel is run 30 to 50 cm distal to the ligament of Treitz, and transected using a linear stapling device. The proximal transected bowel becomes the biliopancreatic limb, and the distal bowel the Roux limb. The mesentery is further divided by use of an energy device or linear stapling device with buttressing material to allow for further mobility of the Roux limb and decreased tension on the gastrojejunostomy. The Roux limb is measured up to 150 cm distally and aligned with the biliopancreatic limb for creation of the jejunojenostomy. Prospective randomized controlled trials have shown no weight loss benefit to longer Roux limbs in patients with a body mass index (BMI) of less than

50 kg/m^2 but improved control of diabetes mellitus type 2 and hyperlipidemia, and greater weight loss in BMI greater than 50 kg/m^2 is described.[15–17]

Creation of the Jejunojenostomy

The most common technique used for creation of the jejunojejunostomy anastomosis is a single fire of a linear stapler passed through antimesenteric enterotomies created on the parallel positioned biliopancreatic and Roux limbs with hand sewn closure of the common enterotomy.[12] Other techniques are the double staple, which uses a stapled closure of the common enterotomy, and triple staple involving both proximal and distal firing of the linear stapling device with stapled closure of the common enterotomy (**Figs. 2–7**). For stapled closure of the common enterotomy, sutures can be placed to aid proper positioning within the stapler and full-thickness closure. The triple staple technique was used to prevent stenosis or obstruction at the anastomosis noted with the double staple technique[18] and has been shown to be efficient and safe.[19,20] Completely hand sewn jejunojejunostomy is rarely performed.[12] An antiobstruction stitch, first described by Brolin,[21] is placed between the stapled end of the biliopancreatic limb and the adjacent limb, immediately distal to the anastomosis to prevent the stapled closure of the enteroenterostomy from folding on itself, causing pseudoobstruction. It is common to place a marking stitch and clips at the jejunojenostomy for later radiographic identification. The mesenteric defect is then closed with nonabsorbable suture in running or interrupted fashion.

Gastrojejunal Anastomosis

The most common configuration of the Roux limb is antecolic, antegastric.[12] Retrocolic orientation may reduce tension on the gastrojejunostomy anastomosis, but has been associated with a significant increase in the internal hernia rate.[22] A Penrose drain placed on the Roux limb can aid in retrocolic passage. The transverse colon mesentery, through which the Roux limb passes, is approximated using permanent suture incorporating the Roux limb, ligament of Treitz, and mesentery to prevent herniation. In antecolic passage, right-sided orientation of the Roux limb in the

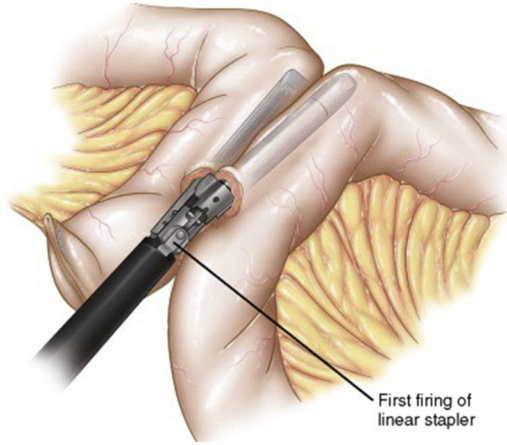

Fig. 2. A white 2.5-mm staple load is used to join together the two loops of bowel. (*From* Zografakis JG, Frantzides CT. Laparoscopic Gastric Bypass with Roux-en-Y Gastrojejunostomy. In: Frantzides CT, Carlson MA, editors. Atlas of Minimally Invasive Surgery. Philadelphia: Elsevier Saunders; 2009. p. 53–66; with permission.)

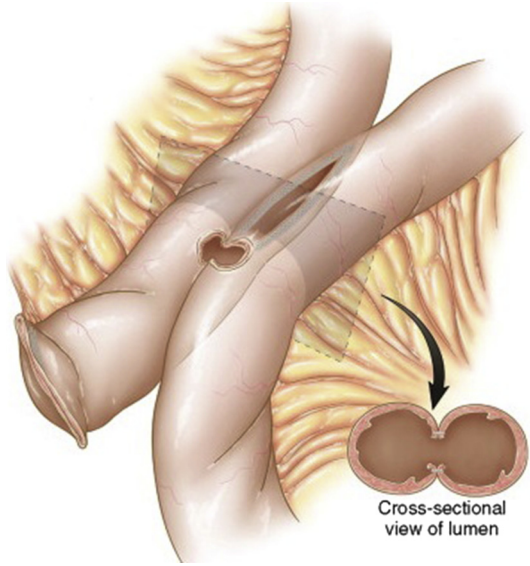

Fig. 3. Defect created after stapler removal. (*From* Zografakis JG, Frantzides CT. Laparoscopic Gastric Bypass with Roux-en-Y Gastrojejunostomy. In: Frantzides CT, Carlson MA, editors. Atlas of Minimally Invasive Surgery. Philadelphia: Elsevier Saunders; 2009. p. 53–66; with permission.)

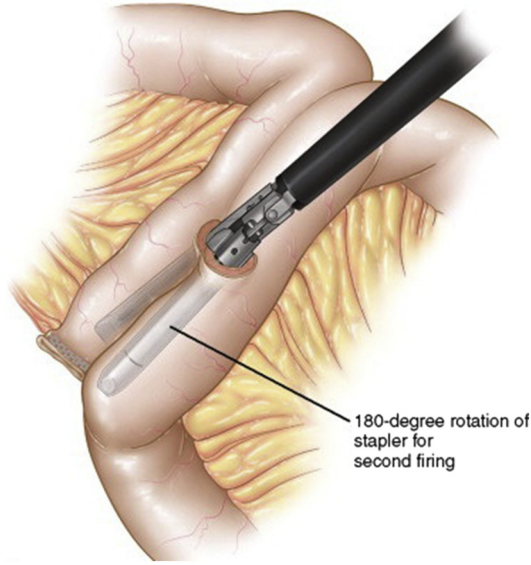

Fig. 4. Second 2.5-mm white staple load is used to create the opposing staple line for the triple-stapling technique. (*From* Zografakis JG, Frantzides CT. Laparoscopic Gastric Bypass with Roux-en-Y Gastrojejunostomy. In: Frantzides CT, Carlson MA, editors. Atlas of Minimally Invasive Surgery. Philadelphia: Elsevier Saunders; 2009. p. 53–66; with permission.)

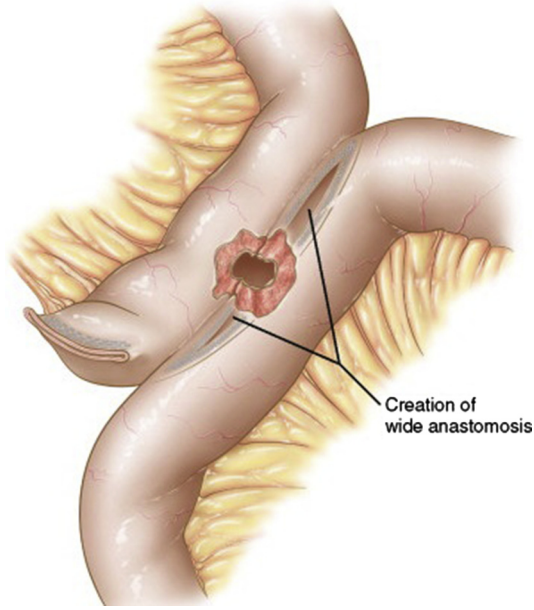

Fig. 5. A curved dissector is used to position the open enterotomy for the third and final firing of the linear stapler. (*From* Zografakis JG, Frantzides CT. Laparoscopic Gastric Bypass with Roux-en-Y Gastrojejunostomy. In: Frantzides CT, Carlson MA, editors. Atlas of Minimally Invasive Surgery. Philadelphia: Elsevier Saunders; 2009. p. 53–66; with permission.)

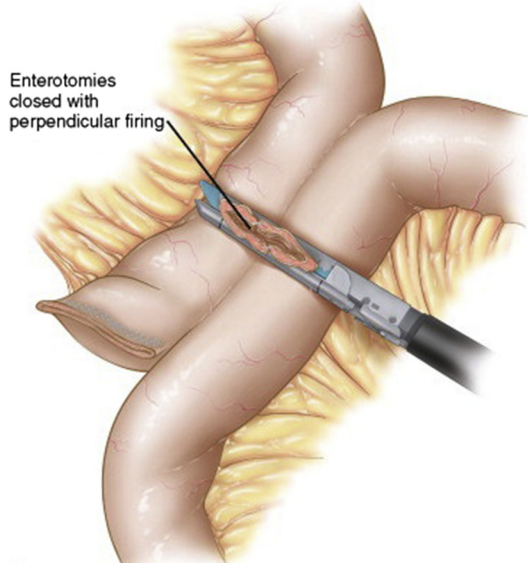

Fig. 6. A white 2.5-mm staple load is used to close the remaining enterotomy and restore bowel continuity. (*From* Zografakis JG, Frantzides CT. Laparoscopic Gastric Bypass with Roux-en-Y Gastrojejunostomy. In: Frantzides CT, Carlson MA, editors. Atlas of Minimally Invasive Surgery. Philadelphia: Elsevier Saunders; 2009. p. 53–66; with permission.)

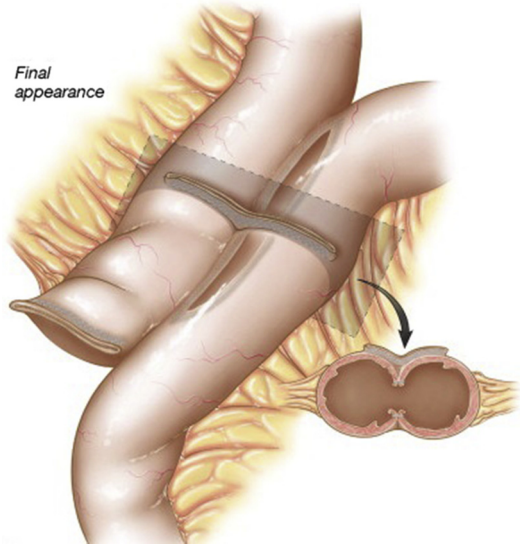

Fig. 7. Perpendicular orientation of staple lines, and completed jejunojejunostomy utilizing the Frantzides-Madan triple-stapling technique. (*From* Zografakis JG, Frantzides CT. Laparoscopic Gastric Bypass with Roux-en-Y Gastrojejunostomy. In: Frantzides CT, Carlson MA, editors. Atlas of Minimally Invasive Surgery. Philadelphia: Elsevier Saunders; 2009. p. 53–66; with permission.)

jejejunojenostomy has been associated with a decreased rate of internal herniation of 0.5% when compared with a left-sided orientation, 9.0%.[23] If antecolic passage of the Roux limb is planned, it is helpful to divide the omentum using an energy device allowing the jejunojenunostomy to be brought anterior to the omentum to reduce tension on the gastrojejunal anastomosis. There are 3 main techniques used to fashion the gastrojejunal anastomosis, including circular stapler, linear stapler, and hand sewing. The most commonly used technique is the circular stapler.[12,24] Variations in each technique exist, but the common sequence is described below.

Gastrojejunal Anastomosis: Transoral Circular Stapler Technique

Transoral placement of the anvil is achieved via slow passage of an attached orogastric tube with direct laparoscopic visualization until the tip is oriented along the staple line of the gastric pouch at the intended site of anastomosis (Video 1). A small gastrotomy is made using ultrasonic scalpel, hook scissors, or hook cautery device. It is important to place the gastrotomy through the staple line to avoid creation of an ischemic tissue island and prevent subsequent leak. The orogastric tube is advanced out of the gastric pouch, grasped by a blunt instrument, and removed through a trocar with minimal force in coordination with the team member assisting oral passage of the attached anvil. Techniques that can facilitate passage of the anvil are deflation of the endotracheal tube, head flexion, and orienting the smooth part of the anvil toward the hard palate as the orogastric tube is removed from the abdomen pulling the anvil into the gastric pouch. A gentle “corkscrew” motion is used to ensure the anvil does not get caught on the patient’s teeth or interfere with the endotracheal tube.[25] The securing suture is cut, allowing the orogastric tube to be removed and leaving the anvil in place within the gastric pouch, ready for anastomosis.

The Roux limb is brought up to the gastric pouch and run back to the jejunojejunostomy to ensure proper mesenteric orientation and placement of the jejunojejunostomy anterior to the omentum. This maneuver also reduces tension on the anastomosis. Other techniques used to further reduce tension on the gastrojejunostomy are division of the small bowel mesentery, omental division, pouch mobilization, creation of a vertical length pouch, and hitch suture placement at the gastrojejunal anastomosis.

The port site is enlarged to accommodate the end-to-end anastomosis (EEA) stapling device, which is fashioned with a dilating cone and sterile sleeve to decrease trauma and minimize wound infection. The stapling device is then passed into the abdominal cavity. The Roux limb staple line is opened to allow passage of the EEA stapling device. The post is advanced through the antimesenteric side of the jejunum and married to the anvil located in the gastric pouch (**Fig. 8**). The EEA device is closed and deployed. The sterile sleeve is retracted over the end of the device and it is removed from the abdomen. The anastomotic tissue rings are examined for completeness. The anastomosis is completed with closure of the Roux limb with a linear stapling device creating a very short blind or "candy cane" limb. The transected jejunum is placed into a sterile bag and removed. A minimum of 2 absorbable hitch sutures are placed to reinforce the anastomosis and minimize tension. An alternative to the end-to-side gastrojejunostomy described is an end-to-end configuration in which the EEA device is passed through a separate enterotomy created distally on the Roux limb, which is closed later.[26]

Gastrojejunal Anastomosis: Linear Stapler Technique

Linear stapler is the second most common technique for creation of the gastrojejunostomy (**Fig. 9**, Video 2).[12,24] This technique eliminates the need for port site dilation and

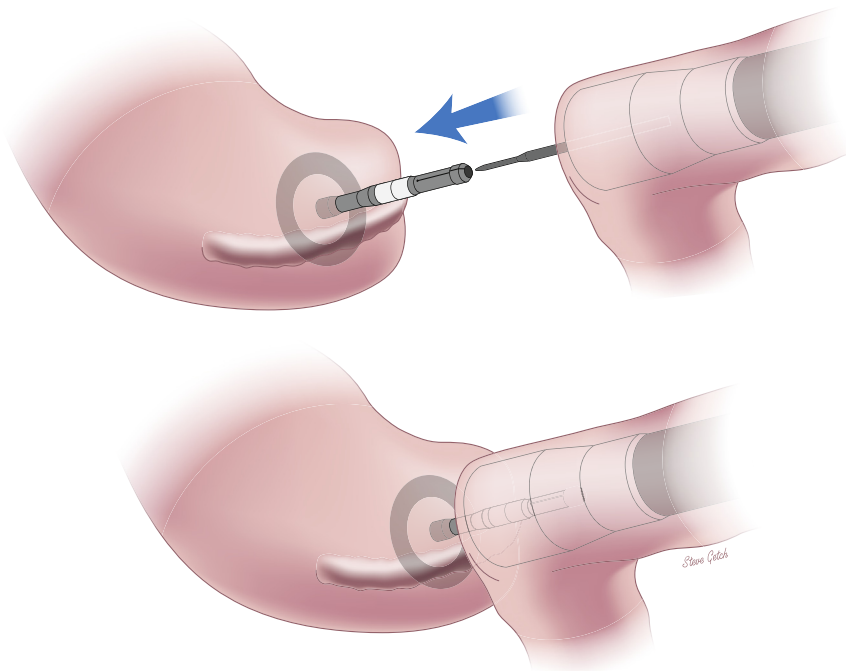

Fig. 8. Circular stapler.

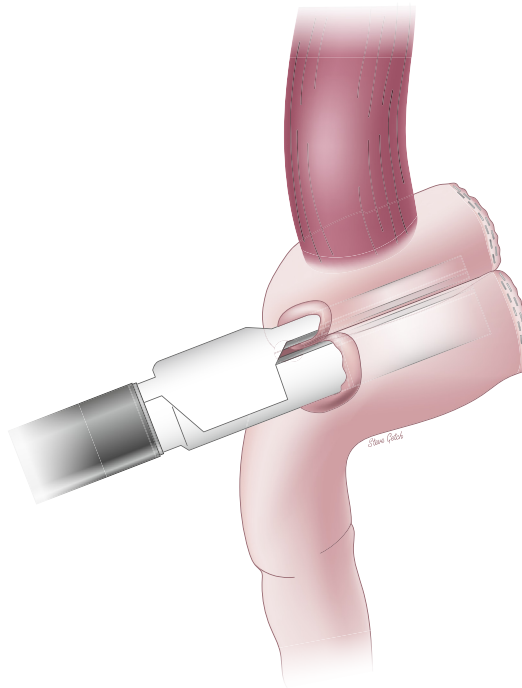

Fig. 9. Linear stapler.

split leg positioning. It is also associated with decreased operative times and stricture rates. The Roux limb is brought up to the gastric pouch as described previously. The Roux limb is approximated to the end or side of the adjacent gastric pouch using interrupted sutures. Enterotomies are created in the Roux limb and the gastric pouch to accommodate a linear stapling device. The common channel enterotomy is closed using the linear stapler device or hand sewing. Hand sewn closure is commonly completed in running fashion over a bougie, gastric lavage tube, or endoscope to prevent stenosis.[27,28] It is suggested that transverse closure of the common enterotomy, when compared with longitudinal closure, reduces anastomotic stricture.[27]

Gastrojejunal Anastomosis: Hand Sewn Technique

In the hand sewn technique, the Roux limb is approximated to the end or side of the gastric pouch using interrupted or running suture. Enterotomies are made on both the gastric pouch and roux limb to allow for anastomosis. The anastomosis is constructed in 2 layers, a running full-thickness absorbable suture and reinforcement anteriorly with interrupted permanent seromuscular sutures. A 34F to 36F tube is passed through the anastomosis before completion to prevent stenosis.

COMPLICATIONS

There are multiple complications associated with the LRYGB, including but not limited to bleeding, infection, small bowel obstruction secondary to internal or port site herniation, marginal ulceration, anastomotic leak, anastomotic stenosis or stricture, hypopharyngeal or esophageal injury, omental torsion or necrosis, pulmonary embolus, death, development of symptomatic cholelithiasis, inadequate weight loss, nutritional

deficiencies, and symptomatic dumping syndrome. The incidence of specific complications can vary with the technique used.

Anastomotic leak is a dreaded complication most commonly occurring at the gastrojejunal anastomosis site.[29] Rates of anastomotic leak are similar (0.1%–8.3%)[16,30–33] regardless of the technique used, and significantly decreased in newer studies reporting only laparoscopic procedure rates (0%–3%).[26,34–40] Several methods to decrease leak have been attempted, including staple line oversewing, fibrin glue/sealant application, and staple line reinforcements,[41–45] but there is no prospective randomized evidence to suggest any method is effective. Most bariatric surgeons use a form of intraoperative leak testing that allows for immediate repair. Air insufflation via endoscope or orogastric tube and blue dye instillation are 2 commonly used techniques. If a leak is found, it should be repaired and the leak test repeated.[30] Routine drain placement at the gastrojejunal anastomosis is debated with proponents noting ability to diagnosis and control leak,[46,47] and opponents noting no benefit and potential increase in leak rate.[48,49]

Anastomotic stricture/stenosis is a widely studied complication that can occur with any gastrojejunostomy technique. Several large studies and 2 randomized control trials have shown stricture rates for hand sewn, linear stapler, and circular stapler techniques to be 4.1% to 7.7%, 0% to 10.1%, and 1.6% to 17.5%, respectively.[26,50–58] Two metaanalyses of comparative studies between linear stapler and circular stapler anastomoses have shown a statistically significant decreased risk of stricture associated with the linear technique.[59,60] There are 2 circular stapler sizes, 21 and 25 mm, which are associated with different diameters and cross-sectional areas, 12 and 113 mm versus 16 and 201 mm, respectively.[57] Several small comparative studies and 1 randomized control trial have noted an increased rate of symptomatic stenosis associated with use of the 21-mm stapling device when compared with the 25-mm device.[61–64] In patients who develop symptomatic stenosis, there are no differences in interval to stenosis (46–52 days) or number of interventions required between the 2 sizes.[61,62] Endoscopic balloon dilation is safe and effective treatment, and in 82% to 86% of patients only 1 dilation is required.[62,65] One study has shown that circular stapled anastomosis through the staple line versus the posterior gastric pouch decreases stenosis (0.8% vs 5.9%).[40] One randomized controlled trial noted the use of a circular stapler with a 3.5-mm staple height versus 4.8 mm also led to decreased stenosis (3.9% vs 16.0%).[52] Several studies have shown no difference in weight loss associated with the different anastomotic techniques, regardless of stricture occurence.[36,38,50,60–62,66]

Hypopharyngeal perforation and esophageal injury with transoral passage of the anvil are exceedingly rare in the literature, but have been reported.[14,67] The majority of difficulty is associated with passage through the upper esophageal sphincter and may be related to specific anvil characteristics.[28,68] Pretilted anvils for ease of passage and prevention of injury are widely available. A corkscrew action used during passage of the anvil and use of a 21-mm diameter stapler, versus the 25-mm stapler, may also ease placement.[25] Two large series specifically examining transoral passage have reported no injuries.[68,69]

An increased rate of wound infection from 3.6% to 23% has been described with the circular stapler technique, when compared with other techniques.[70]

Use of the circular stapling device requires port site dilation, resulting in trauma and necrosis of subcutaneous fat, as well as passage of the stapling device through the subcutaneous tissues, which can lead to the increased rate of infection. Methods created to combat these issues, including use of a cone-shaped stapler introduction device and sterile sleeve, preoperative chlorhexidine swish and swallow, wound

irrigation, and loose wound closure with permanent monofilament suture, have resulted in reduced infection rates of 1%.[71,72]

Postoperative bowel obstructions can occur secondary to internal hernias, port site herniation, or pseudoobstruction of the biliopancreatic limb prevented by placement of the Brolin antiobstruction stitch previously described.

There are 3 common sites of internal herniation: the classic mesojejunal site, transmesocolic associated with retrocolic Roux limb passage, and in the potential space between the Roux limb and the transverse mesocolon, also known as Petersen's hernia. Closure of the mesenteric defect is routine for most surgeons performing gastric bypass today. Nonclosure and loss of mesenteric fat owing to postoperative weight loss[73] can lead to mesojejunal herniation, the most common type.[74] Internal hernias are a significant cause of late complications (0.4%–14.4%),[75] and the most frequent cause of late small bowel obstruction after LRYGB.[22,31,76] They often present with vague symptoms and computed tomography scanning has low sensitivity for diagnosis, but may show the classic finding of a "swirl sign" in the mesentery.[74] This finding can lead to delayed diagnosis, bowel strangulation, anastomotic dehiscence, gastric remnant dilation, and death.[77]

Port site herniation, including Richter's type hernia, can also present with vague symptoms leading to delays in diagnosis, bowel necrosis, and death. The incidence reported in most studies is less than 2%.[78,79] A cumulative review counterintuitively found a significantly increased incidence of herniation in LRYGB patients at sites where closure was attempted, from 0.36% to 1.1%.[78] The reason for this is unknown. There is currently no evidence to support routine fascial closure, but closure should be attempted at the umbilicus and at any enlarged or dilated sites, such as that created to accommodate the circular stapler. This is usually accomplished with an 0-absorbable suture and suture passing device under laparoscopic visualization.

IMMEDIATE POSTOPERATIVE CARE

Patients are transferred to the recovery area under observation of the operating surgeon and anesthesia team. Nursing staff should be trained in postoperative bariatric care and recognition of potential postoperative complications. Patients remain nil per os throughout postoperative day 0. Adequate hydration is ensured with intravenous crystalloid and monitoring of urine outputs. Most patients can be transferred to a surgical unit, but those with history of OSA, cardiac conditions, respiratory difficulties, or complicated cases will require telemetry monitoring or rarely intensive care.

Immediate postoperative laboratory studies should include blood counts and electrolyte levels, as well as a creatine phosphokinase level in any patient suffering from super morbid obesity (BMI >50 kg/m^3 or >400 lb) or with prolonged operating room times. Creatine phosphokinase levels should be reevaluated on postoperative day 1. Early identification of rhabdomyolysis allows for early intervention, decreasing renal damage.[80] Routine metabolic panels, magnesium level, and complete blood counts are obtained daily, unless increased frequency is indicated. Blood glucose level should be assessed immediately postoperatively and serially in all diabetic patients. Antidiabetic medications will require individualized adjustment postoperatively with glucose management with a short-acting insulin analogue while inpatient.[4]

Pain management is most commonly achieved with intravenous opioids while nil per os, with transition to oral opioids when diet is initiated and continuation of intravenous form for breakthrough pain. Intravenous acetaminophen and ketorolac may be considered in addition to narcotic management. Ice packs, abdominal binders, and nerve blockades may also assist in achieving adequate pain control. Inadequate

pain control can lead to patient dissatisfaction, tachycardia, shallow respirations, immobility, increased complications, and increased duration of stay.

Aggressive postoperative pulmonary toilet can decrease complications and should be initiated immediately upon arrival to the floor.[81] This should include incentive spirometer use, deep breathing, coughing, and evaluation by a respiratory therapist. For patients diagnosed with OSA and preoperative use of continuous positive airway pressure, continuous positive airway pressure should be ordered postoperatively and the patient should bring their own mask to ensure proper fit.[6] Continuous pulse oximetry in OSA patients may reduce the risk of complications.[82]

The risk of venous thromboembolism and pulmonary embolus in average risk bariatric patients is less than 1%,[83–87] but risk continues for several weeks postoperatively[88,89] and remains a leading cause of preventable postoperative death.[90] Patients with a BMI of greater than 55 kg/m^2, immobility, venous stasis, pulmonary hypertension, obesity hypoventilation syndrome, hypercoagulable state, and history of venous thromboembolism, characteristics of most bariatric patients, are at high risk for venous thromboembolism.[91] Mechanical prophylaxis in combination with early ambulation alone may be sufficient[87,92] and is recommended for all patients.[4,91] Most bariatric programs use mechanical prophylaxis in combination with chemoprophylaxis initiated within 24 hours of surgery.[4,91] Based on available data, low-molecular-weight heparin is superior to unfractionated heparin for chemoprophylaxis.[84,91] Extended prophylaxis beyond the hospitalization period may be considered in high-risk patients. Inferior vena cava filters are associated with multiple complications, including death. Their use should only be considered when potential benefits outweigh these risks and always in conjunction with mechanical and chemoprophylaxis.[4,91]

Routine or selective upper gastrointestinal series soluble contrast study can be performed to evaluate the integrity and patency of both the gastrojejunostomy and jejunojejunostomy, identified by the surgically placed clips. Routine testing has been associated with a positive and negative predictive value for suspected leak of 67% and 99%, respectively,[93] and may lead to findings other than leak or stricture, such as dilation of the gastric remnant, trocar site hernia or internal hernia causing early postoperative obstruction, which may change postoperative care.[94] Despite these findings, there is increasing evidence to support selective testing.[95–98]

Postoperatively, a bariatric clear liquid diet, consisting of sugar-free liquids with minimal gastrointestinal residue and no carbonation or caffeine to avoid pouch irritation, is initiated. The use of straws is discouraged. Fluid intake recording is encouraged to ensure adequate hydration. Postoperative counseling on diet initiation and advancement, adequate hydration, and vitamin and mineral supplementation by a registered dietitian should be completed.[4]

Incisions and drains, when present, are examined daily while inpatient. Nursing staff and patients are educated on signs of wound infection and drain care.

Patients are generally discharged postoperative day 1 to 3. Patients and caretakers should be educated by the bariatric nurse case manager and registered dietitian on dietary and activity restrictions, wound and drain care if applicable, signs and symptoms of complications including anastomotic leak and venous thromboembolism, and home medications. They should be counseled on the avoidance of caffeine, nonsteroidal antiinflammatory drugs, alcohol, and nicotine exposure. Comorbid conditions may improve rapidly and patients are counseled to follow closely with their primary care physicians.

Recently, emphasis has been placed on adherence to Enhanced Recovery After Bariatric Surgery protocols. Enhanced Recovery After Bariatric Surgery interventions include shortened preoperative fasts, intraoperative humidification, early mobilization

and feeding, avoidance of fluid overload, incentive spirometry, and use of prokinetics and laxatives. Short-term studies show Enhanced Recovery After Bariatric Surgery protocol adherence to be feasible and safe, and results in shortened duration of hospital stay and low 30-day readmission rates.[99]

LONG-TERM CARE AND FOLLOW-UP

The first patient follow-up is usually at 5 to 7 days postoperatively, which allows for drain removal if applicable; assessment of wounds, medications, and overall condition; and reinforcement of dietary progression, vitamin supplementation, and activity restrictions. Dietary progression generally proceeds from bariatric clear liquids to full liquids, pureed, and finally regular maintenance. Concentrated carbohydrates are eliminated to prevent dumping. Dietary protein intake should be 1.5 g/kg ideal body weight per day. Vitamin supplementation includes multivitamins plus minerals, calcium and vitamin D, thiamine, folic acid, iron, zinc, selenium, and copper as needed to maintain normal levels. Subsequent follow-up appointments should be scheduled at 1, 3, 6, and 12 months postoperatively and include weight loss and exercise monitoring, dietitian counseling/supplementation monitoring, evaluation of the need for support group participation or psychiatric follow-up, review of medications and comorbid conditions, and laboratory testing. Exercise is encouraged at 4 weeks postoperatively and should include aerobic activity and strength training 2 to 3 times per week.[100] It is currently recommended that a compete blood count and iron be checked at each visit, vitamin B_{12} every 3 to 6 months, lipids every 6 to 12 months, and calcium, folic acid, vitamin D, and intact parathyroid hormone be checked regularly. A 24-hour urinary calcium excretion test should be considered at 6 months. Copper, zinc, selenium, and thiamine levels should be checked if indicated clinically. Patients should be referred for bone density testing at 2 years postoperatively. Referral for body contouring surgery should be offered.[4]

Rapid weight loss after a gastric bypass procedure may lead to symptomatic gallstone formation that may require surgical intervention in 7% to 41% of patients.[101–103] This incidence may be reduced to 2% with the use of ursodiol 600 mg daily for 6 months postoperatively.[104] Marginal ulceration occurs with an incidence of 1% to 16%[105] and is more common in patients with *H pylori* infection.[106] The incidence is significantly reduced with prophylactic proton pump inhibitor therapy[105–108] with a suggested duration of 90 days[108] and preoperative *H pylori* eradication.

CLINICAL RESULTS IN THE LITERATURE

LRYGB performed at specialty centers by fellowship-trained bariatric surgeons has excellent outcomes with short durations of hospital stay and low readmission rates. The 30-day mortality rate is 0.3% and major complication rate is 4.3%.[109] The LRYGB is highly effective with regards to excess weight loss when compared with other contemporary procedures.[110,111] The average excess weight loss following LRYGB is 56% to 66% with average maintenance of 50% excess weight loss at 5 years.[112] Morbid obesity increases the risk of premature death[113,114] and the risk of morbid obesity outweighs the risks of bariatric surgery.[115,116] Furthermore, several studies show improvement in life expectancy after bariatric surgery.[115,117–119] Several randomized control trials, metaanalyses, and outcomes studies have shown improvement or resolution in type 2 diabetes, hypertension, hyperlipidemia, and OSA, as well as improved outcomes when compared with medical interventions.[110–112,119–122] Bariatric surgery, including LRYGB, is also associated with improvement of obesity-related cardiac dysfunction,[123] polycystic ovarian syndrome and resolution of associated infertility,[124] gastroesophageal reflux disease, and osteoarthritis. Outcomes are improved at centers

with comprehensive programs including bariatricians, dietitians, psychologists, and bariatric nurse case managers, which facilitates long-term follow-up and support.

SUMMARY

The LRYGB is the gold standard metabolic/bariatric procedure used today to combat the growing morbid obesity epidemic. This procedure is highly effective at reducing excess body weight and has substantial efficacy against the multiple comorbid conditions associated with obesity. There are varying techniques for procedure performance, as described. The most common technique today is a circular stapled gastrojejunal anastomosis with antecolic Roux limb and stapled jejunojenostomy with hand sewn common enterotomy closure. Complications are associated to varying degrees with technique used. It is important to be aware of these complications and be prepared for expeditious management. Regardless of the technique used, the LRYGB performed at specialty centers by fellowship trained surgeons with adherence to evidence-based care protocols for perioperative care has excellent outcomes.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.suc.2016.03.003.

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