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# Sleeve Gastrectomy: Technique, Pearls, and Pitfalls

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## Background

Laparoscopic sleeve gastrectomy, sometimes referred to as longitudinal gastrectomy, was initially introduced as part of the duodenal switch procedure in super obese patients in 1999 [1] and as a stand-alone procedure in 2000 [2]. It is now becoming one of the most popular bariatric procedures based on perceived simplicity of the procedure, significant improvement in comorbidity profile, and evident weight loss. Beginning in 2009 the American Society for Metabolic and Bariatric Surgery endorsed laparoscopic sleeve gastrectomy as a potential first-stage procedure for high-risk morbidly obese patients [3]. At our institution, it is now the most commonly performed bariatric procedure.

The procedure has not been universally standardized to date. At multiple points during the procedure, various technical modifications are employed by different surgeons, including using different surgical staplers, altering the diameter of the bougie, adjusting the size or volume of the sleeve and the distance from the pylorus, or by varying the type or number of stapler cartridges used, In this chapter, we describe the procedure performed at our institution.

## Physiologic Changes

The efficacy of the laparoscopic sleeve gastrectomy leading to sustained weight loss and improvement in comorbidity profile is the result of various mechanisms. First, given the reduction in stomach size and volume, there is decreased alimentary intake [4]. Second, there is a significant drop in the level of the orexigenic hormone, ghrelin, which leads to anorexia. Ghrelin production is significantly reduced following laparoscopic sleeve gastrectomy as the fundus is the principal location of ghrelin function [5]. As a result, patients feel a significant reduction in hunger sensations. Nevertheless, the mechanism of sustained weight loss is most likely multifactorial and yet to be fully elucidated at this time.

## Preoperative Considerations

Laparoscopic sleeve gastrectomy may be performed on those patients who qualify for bariatric surgery (i.e., meet NIH criteria and have satisfied a multi-disciplinary evaluation by a weight loss surgery team). This operation may be offered as an "initial stage" in patients who are at high risk for other more traditional bariatric operations, such as laparoscopic Roux-en-Y gastric bypass or the biliopancreatic diversion with duodenal switch procedure. Laparoscopic sleeve gastrectomy is considered for the following high-risk patients:

- Any patient with a BMI > 60 kg/m$^2$
- Patients with severe android ("apple-shaped") body habitus
- Significant previous intestinal surgery
- Cirrhosis (esophageal/gastric varices or severe hepatic disease may preclude all types of weight loss surgery)
- Inflammatory bowel disease
- Chronic NSAID use

After significant weight loss, these patients may undergo a "second-stage" operation with conversion to either Roux-en-Y gastric bypass or biliopancreatic diversion with duodenal switch. With excellent initial weight loss results and increasing experience with the operation, sleeve gastrectomy is now considered an appropriate stand-alone procedure in average-risk patients.

Special attention in the history and physical should elicit any signs of liver disease and cirrhosis. In diabetic patients, if there is a clinical suspicion of gastroparesis, gastric emptying studies should be considered. Patients with a history of gastroesophageal reflux require preoperative upper endoscopy to diagnose esophageal erosions or hiatal hernia and also to rule out gastric lesions, ulcers, polyps, or *Helicobacter pylori* infection. Barrett's esophagitis may be considered a contraindication to performing sleeve gastrectomy.

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FIG. 1. (**a**, **b**). Patient is positioned split leg on the table as shown above with arms abducted and legs split.

## Clinical Anatomy

The stomach is a well-vascularized organ that has a rich blood supply, which includes the left and right gastric arteries, the left and right gastroepiploic arteries, and the short gastric vessels. This operation involves removal of the majority of the stomach along the greater curve, leaving behind a narrow "sleeve" of stomach based along the lesser curvature with vascularization essentially derived from the left gastric artery. The vagus nerves on the lesser curve of the stomach (Latariet) remain undivided and intact.

The angle of His is given special consideration to ensure the entire left diaphragmatic crus is freed from attachments such that transection of the stomach does not leave a posterior pouch of fundus on the proximal portion of the sleeve. If a hiatal hernia is encountered, reduction (and then hiatal hernia repair) is necessary to ensure complete removal of redundant fundus.

## Operative Steps

1. Anesthesia induction
   (a) The patient is positioned in reverse Trendelenburg, and a ramp is placed behind the patient's upper torso during intubation. The ramp is removed following successful intubation.
   (b) An anesthesia team experienced with the morbidly obese patient population should administer general anesthesia. These patients often have difficult airways and may require a full complement of adjunctive airway techniques, including awake fiberoptic intubation or a McGrath®- type video laryngoscope.
2. Patient positioning
   (a) The patient is positioned supine with both arms abducted and the legs split (Fig. 1). The surgeon stands between the legs with an assistant holding camera on the patient's right and an additional assistant on the patient's left.
   (b) The patient is placed in reverse Trendelenburg position throughout the entire procedure.
   (c) It is important to ensure that nothing is placed in the patient's mouth at any time, including esophageal temperature probe or nasogastric tube, unless specifically instructed by the surgeon.
   (d) A transparent part of the surgical drape over the neck and mouth is a preferred adjunct as the surgeon can then visually confirm that there is nothing in the patient's mouth.
   (e) A Foley catheter is routinely placed for this procedure.
   (f) Patients are administered perioperative antibiotics.
   (g) Surgeons also administer chemical antithrombotic prophylaxis to complement sequential pneumatic compression stockings.
3. Procedure
   (a) Pneumoperitoneum can be established via a variety of established techniques (open, visualizing trocars or Veress needle). We place trocars as shown (Fig. 1): a 15 mm trocar at the umbilicus, a 5 mm trocar in the right upper quadrant, a 5 mm trocar in the epigastrium, a 5 mm trocar in the left upper quadrant, and a 5 mm trocar in the lateral left upper quadrant. The Nathanson® liver retractor is placed via an additional 5 mm incision in the superior epigastrium. If necessary, additional 15 mm stapling trocars can be placed in the right and left upper quadrants.

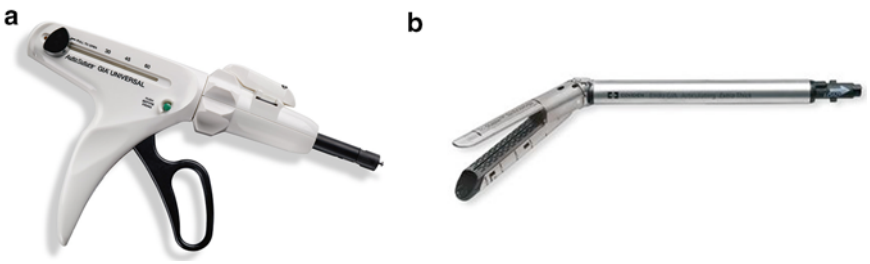


FIG. 2. (**a**, **b**). The Covidien® Endo GIA Universal Stapler is used to perform the laparoscopic sleeve gastrectomy. As shown in the lower figure, we use the Endo GIA™ Black Reload with Tri-Staple™ Technology. Used with permission of Covidien.

(b) If the stomach appears dilated (and difficult to maneuver), a nasogastric tube may be placed to evacuate the stomach. The nasogastric tube should be removed after the stomach has been emptied.

(c) The left lobe of the liver is elevated with the Nathanson® retractor, exposing pars flaccida and the vagus nerves.

(d) Using an ultrasonic scalpel, the gastrocolic omentum is divided off the greater curvature of the stomach, beginning approximately 5–6 cm proximal to the pylorus and proceeding to the angle of His at the hiatal orifice, completely mobilizing the greater curve. The entire fundus is freed posteriorly from the left crus (Fig. 2). Posterior attachments to the pancreas are also divided such that the stomach is only attached via its lesser curvature blood supply. The most efficient maneuver to achieve adequate exposure for the posterior dissection is to retract the posterior aspect of the stomach to the right with a grasper and dissect with the harmonic scalpel beneath the grasper. If present, a hiatal hernia should be reduced to ensure complete mobilization of the fundus; the hernia is then repaired (preferably by posterior apposition of the crus). A large gastric fat pad (seen especially on males) can be resected.

(e) Prior to transection of the stomach, an additional 5 mm port is placed in the midline superior to the 15 mm trocar. The camera is now placed in this position as the 15 mm port in the umbilicus will serve for introduction of the stapling device.

(f) Transection of the stomach begins on the antrum 5–6 cm proximal to the pylorus with a 60 mm long, articulating stapler using Endo GIA™ Black Reload with Tri-Staple™ Technology cartridges. The transection is oriented such that the stomach is not narrowed at the incisura (Fig. 3).

(g) After the first staple firing, a 40 F Maloney or Hurst-type bougie is placed by the anesthesia team and directed towards the pylorus along the lesser curvature. The surgeon can guide proper placement of the bougie using graspers.

(h) The remainder of the stomach transection is performed aligning the bougie against the lesser curvature to guide the resection as it proceeds towards the angle of His. Seamguard® (W.L. Gore & Associates, Inc., Flagstaff, AZ) is used for each firing after the initial of the stapling device. The Endo GIA™ Black Reload with Tri-Staple™ Technology (Covidien) cartridge can be used for the entire resection with the addition of commercially available buttress materials. Alternatively, 3.5 mm-height (blue) staples can be used in the thinner, more proximal portions of the stomach. Generally, 4–5 cartridges are necessary to complete the sleeve.

(i) The bougie is withdrawn once the sleeve is complete. A nasogastric tube is advanced into the stomach and a methylene blue leak test is performed. The pylorus is occluded using a previously fired stapling device or grasper to compress the area. If there are any areas

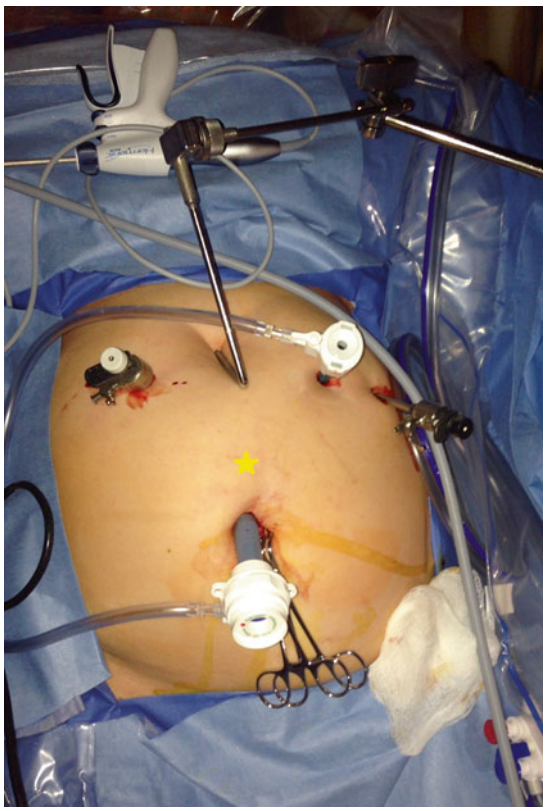

FIG. 3. The image depicts the standard port placement for a laparoscopic sleeve gastrectomy. The star demarcates where an additional 5 mm port is introduced when performing the hiatal dissection.

FIG. 4. The upper GI series representative image demonstrates no evidence of contrast extravasation on postoperative day 1.

of leakage, then additional absorbable sutures can be placed to reinforce the area and the leak test can be repeated.

(j) Hemostasis can be achieved along the staple line with interrupted absorbable sutures in a simple interrupted fashion or figure of eight stitches.

(k) The initial staple line without Seamguard® (W.L. Gore & Associates, Inc., Flagstaff, AZ) is oversewn with an absorbable suture to ensure adequate hemostasis.

(l) We routinely perform an omentopexy of the staple line to avoid torsion or twisting of the stomach at any point. We perform this omentopexy with 4–5 separated sutures spaced out along the entire staple line.

(m) The specimen is removed using a large Endo Catch bag via the 15 mm umbilical port and the fascia at this site is then closed. We do not routinely leave drains following a laparoscopic sleeve gastrectomy.

## Postoperative Care

Patients are monitored in an appropriate setting in the post-anesthesia care unit (PACU) before transfer to the floor. All patients routinely received intravenous patient-controlled analgesia (IV PCA), and chemical antithrombotic prophylaxis is routinely administered. An upper gastrointestinal series using water-soluble contrast may be obtained on the first postoperative day to exclude leaks and evaluate gastric function and anatomy (Fig. 4). Clinical manifestations of a leak include tachycardia or dyspnea postoperatively, significant fever, oliguria, or signs of peritoneal irritation.

Patients are advanced to a bariatric clear liquid diet and progressed to pureed food on the second day. The IV PCA and Foley catheters are routinely removed on the first postoperative day. Patients are given liquid or crushed narcotic tablets dissolved in liquids. Patients are also routinely started on proton-pump inhibitors. The dietician routinely sees all patients postoperatively and reinforces dietetic modifications. Patients are usually discharged home on the second postoperative day. Solid foods are avoided for at a minimum 2 weeks postoperatively, and during that time period, patients are maintained on a pureed diet (including liquid protein supplements).

## Pearls and Pitfalls

Identification of a hiatal hernia is crucial to the procedure. Complete mobilization of the fundus should be performed prior to transection to avoid missing a hiatal hernia. We always dissect the phrenoesophageal membrane and inspect the great curve of the stomach for the presence of a hiatal hernia. If identified, the dissection should proceed posteriorly to achieve appropriate approximation and closure of the crura to repair the hernia (Table 1).

Care must be taken when stapling the antrum as this tissue may be relatively thick which can cause stapler misfire or tissue fracturing. If staple line reinforcement products (buttress) are used, it may be prudent to forego them in the antral area.

When the stomach resection begins, it is extremely important to have the anesthesiologist hold the bougie in place throughout the procedure. Failure to do so may result in inadvertently pushing the bougie in a cephalic direction and unintended transection of the bougie or the stomach.

The final staple firing should veer slightly away from the gastroesophageal junction so that the esophagus is avoided. The thinner esophageal wall and absence of serosa make it vulnerable to inadequate stapler closure, which may contribute to the development of a leak.

Carefully inspect the entire gastric staple line upon completion to ensure all staples are well formed and oversew portions as necessary, especially at the junction of stapler firings.

Patients may experience significant reflux, nausea, and dysphagia, which can usually be managed with appropriate medications (ondansetron, metoclopramide, hyoscyamine sulfate) postoperatively.

## Complications

The most common complications following a laparoscopic sleeve gastrectomy include leaks, strictures, bleeding, and gastroesophageal reflux disease. In most cases these complications can be successfully treated without revisional bariatric surgery, although in extreme cases additional surgical intervention is required.

Table 1. Advantages and disadvantages over other bariatric procedures

| Advantages | Disadvantages |
|---|---|
| Maintains gastrointestinal continuity | Long staple line at risk for leak |
| Avoidance of implantable material | Long staple line at risk for bleeding |
| Avoidance of malabsorption | Typically less weight loss than bypass procedures |
| Convertibility to other procedures | |

Based on a recent systematic review, the leak rate is anywhere between 2 and 3 % [6]. In the same review, staple line reinforcement did not affect the incidence of leaks. Leaks are usually diagnosed on upper gastrointestinal series. Postoperative patients with no abnormalities on upper gastrointestinal series, but with tachycardia and fever, require immediate operative intervention for exploration. Leaks can be classified based on timing of presentation [7]. Early leaks occur within the first 1–6 weeks. Late leaks occur after 6 weeks while chronic leaks occur after 12 weeks. Most early leaks can be adequately treated with a stent in stable patients. Leaks that fail to close following exclusion with a stent after 30 days have a very low likelihood of sealing. Unstable patients with contained or uncontained leaks require immediate operative intervention. Stenting is less likely to be successful in chronic leaks; typically these patients need operative re-intervention as often these leaks are exacerbated by a high intraluminal pressure created by a relative stenosis at the incisura. Options include bringing a Roux limb up to the leak site or conversion of the sleeve gastrectomy to a Roux-en-Y gastric bypass.

Strictures are another complication that can occur following laparoscopic sleeve gastrectomy. The incisura angularis is the site at greatest risk for stricture formation. Strictures occurring within the first 6 weeks following surgery tend to be symptomatic. The initial treatment of a stricture is simple observation if patients are minimally symptomatic. The next step can be endoscopic dilation. If that fails after 6 weeks, a seromyotomy is a surgical option [8]. The last resort is conversion of the sleeve gastrectomy to a Roux-en-Y reconstruction.

Bleeding can occur anywhere along the staple line. It is generally accepted to reinforce staple lines by oversewing the staple line or buttressing the staple line. Based on a recent review, the overall postoperative bleeding rate is between 1 and 3 % [9]. In the same review, the use of reinforcement did not significantly change the incidence of bleeding (Table 2) (Video. 1).

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Table 2. Postoperative complications

| Postoperative complications |
|---|
| Acute leak (within 7 days) |
| Early leak (within 1–6 weeks) |
| Late leak (after 6 weeks) |
| Chronic leak (after 12 weeks) |
| Stricture |
| Bleeding |
| New-onset gastroesophageal disease |

AP: Is a consultant, speaker and receives honoraria from W L Gore & Associates and also Covidien

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