# Laparoscopic Sleeve Gastrectomy: The Technique

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**Abstract**

Sleeve gastrectomy is presently the most popular weight loss procedure globally. The only absolute contraindication to this procedure is the presence of Barrett's esophagus. Comprehensive preoperative workup, optimization of comorbidities, and adequate preoperative preparation are of paramount importance. Preoperative patient counseling should focus on caution about variable impact of surgery on symptoms of gastroesophageal reflux, if present. Though technically less complex than the gastric bypass, meticulous technique and avoidance of certain pitfalls are essential to achieve an optimal outcome and minimize serious complications including leaks. It is recommended to adopt an unhurried approach during stapling to avoid narrowing at incisura angularis, twisting of sleeve, and ensure adequate hemostasis at the end of the procedure.

**Keywords**

Sleeve gastrectomy · Bariatric surgery · Obesity surgery · Laparoscopic technique · Operative steps

## Introduction

Bariatric surgery is superior to medical therapy for weight loss, survival, and treatment of comorbidities, especially type 2 diabetes mellitus. Among the various procedures for weight loss, laparoscopic Roux-en-Y gastric bypass (LRYGB) has generally been considered as the gold standard. Laparoscopic sleeve gastrectomy (LSG) originated as a part of the duodenal switch procedure. It was not used as a separate procedure for weight loss, until it was pioneered by Gagner as a first-stage procedure for the two-stage duodenal switch (DS) in super-obese patients, since the risk of operative mortality for these patients undergoing a prolonged procedure was high [1]. The second stage of the surgery is usually carried out in another setting once the patients have lost some weight. However, majority of patients had significant weight loss during this interval, and hence the second stage surgery was deferred or not required. Hence, with some further modifications laparoscopic sleeve gastrectomy was established as an effective stand-alone bariatric procedure.

Level 1 data suggests that mid- or long-term weight loss following LSG is equal to or not inferior to laparoscopic RYGB [2, 3]. LSG reduces ghrelin and leptin levels and hence, apart from the reduced capacity of stomach, one of the important mechanisms of weight loss is decreased appetite and enhanced satiety. It also results in faster gastric emptying resulting in an increase in postprandial GLP-1 [4].

Various advantages of the LSG include its technical simplicity, shorter operative time, and maintenance of normal continuity of bowel, along with preservation of the pylorus [5]. Long-term problems associated with LRYGBP including marginal ulcers, internal hernias, and small bowel obstruction are avoided with LSG. The LSG procedure can later be modified for weight loss failure or new onset reflux to a RYGB, OAGB (one-anastomosis gastric bypass), or single anastomosis duodeno-ileostomy (SADI). The only major disadvantages of the procedure are development of leak along the long gastric staple line, which is often more difficult to treat than the following LRYGB, as well as its variable impact on gastroesophageal reflux (GER).

## Indications and Contraindications

LSG, a multipurpose operation, is suitable for almost all morbidly obese patients fulfilling the National Institutes of Health (NIH) criteria for bariatric surgery [6, 7]. It is specifically indicated for super-obese patients, either as a first stage and recently as a stand-alone option [8, 9]. It is also a suitable option for those with Class I obesity and comorbidities. LSG has surpassed RYGB and is now the most commonly performed procedure worldwide according to the Fifth IFSO Global Registry Report 2019 [10]. LSG is a safer option in high-risk patients and those with poor intraoperative conditions.

Specific contraindications for LSG are few and include the Barrett's esophagus, severe symptomatic GERD, and/or erosive esophagitis. It is generally agreed that LRYGB is superior to LSG in patients with longstanding diabetes especially those requiring insulin. Other general contraindications apply, as for any bariatric surgical procedure, and include the American Society of Anesthesiologists (ASA) grade 4 patients not likely to withstand the surgery, patients with end-stage organ dysfunction of the heart, lungs, or both that are unlikely to improve, and patients with malignancy.

The patients should be counseled specifically about the variable impact of LSG on reflux symptoms and possibility of de novo reflux in future. As with any other procedure, they must understand about the nature of surgery and be willing to accept the risks of surgery. The patient must be motivated enough to comply with long-term dietary changes, lifestyle, and behavior modification.

## Diagnosis and Management

### Workup/Preoperative Evaluation

A comprehensive preoperative workup is necessary for careful selection of patients and risk stratification. A detailed history and physical examination of all patients is mandatory before performing any investigations with special emphasis on comorbid conditions. History should include detailed questioning of reflux symptoms. If the patient complains of suggestive symptoms, details about the nature and frequency of each symptom as well as the requirement of medication should be obtained. An objective assessment of GER symptoms using the available questionnaires is recommended for initial assessment as well as follow-up. An upper gastrointestinal endoscopy is performed in all patients to evaluate the extent of reflux esophagitis, hiatal hernia, gastric and duodenal ulceration, and *Helicobacter pylori* status. Some patients may need 24 h pH studies, esophageal manometry, and esophageal biopsies in associated Barrett's esophagus. Presence of reflux esophagitis is not always a contraindication to sleeve gastrectomy [11–13].

Morbidly obese patients need additional investigations to identify undiagnosed comorbidities. If indicated, the patient may require a consultation from other specialists including cardiologist, pulmonologist, endocrinologist, and gastroenterologist. A multidisciplinary team should be in place

for comprehensive evaluation and decision making.

Morbidly obese patients are known to have a higher prevalence of obstructive sleep apnea (OSA) [14, 15]. History of loud snoring or excessive daytime sleepiness and fatigue should prompt further evaluation for OSA. Evaluation includes baseline oxygen saturation measured by pulse oximeter, room air arterial blood gases (ABG), pulmonary function tests, and polysomnography. Patients with significant OSA should be treated with nasal continuous positive airway pressure preoperatively. Often these patients are at high risk for developing pulmonary complications in the postoperative period, which are occasionally life threatening like acute upper airway obstruction and pneumonia. Presence of OSA preoperatively affects the perioperative outcomes in general.

Patients with morbid obesity have high incidence of nonalcoholic fatty liver disease (NAFLD) including steatohepatitis (NASH). Ultrasound of the abdomen and transient elastography (Fibroscan) are routinely performed in all the patients prior to surgery at author's (SA) center for assessment of liver. Venous Doppler of both lower limbs is performed in all the patients to rule out the stigmata of previous/existing deep vein thrombosis.

A dedicated bariatric nutritionist should be involved early in the workup of these patients.

## Preoperative Preparation

Preoperative preparation involves optimization of risk factors and other routine preoperative preparation applicable to upper gastrointestinal surgery. Preoperative incentive spirometry is encouraged as it improves pulmonary function and ensures good compliance for chest physiotherapy in postoperative period. In patients with severe OSA who are not on any prior treatment, preoperative continuous positive airway pressure (CPAP) application during sleep is initiated at least 5–7 days prior to surgery.

In many patients, a very low-calorie diet is advised for 2 weeks prior to surgery and patients are encouraged to lose some weight prior to surgery to decrease the liver size.

## Operating Room Setup

Operating room setup and instrumentation have been discussed in the chapter, ▶ "Anesthesia Considerations in the Obese Patient for Bariatric Surgery". Briefly, a suitable operating table for heavy patients with facility for steep reverse Trendelenberg position, foot boards, and straps is mandatory. Long instruments, telescopes, and a good self-retaining liver retractor (Nathanson liver retractor [Cook Medical Inc., Brisbane, QLD, Australia]) should be available.

Preoperative antibiotic is given at the time of induction, which is usually a second-generation cephalosporin such as cefuroxime at a dose of 1.5–2 g intravenously.

## Positioning of Patient

Proper positioning and securing the patient to the operating table is important, as this surgery is done in a steep reverse Trendelenberg position. The patient is positioned supine with both arms extended on the arm boards. Patient is positioned in split leg (French) position. Graduated compression stockings and sequential compression device are applied to the lower extremities as prophylaxis for deep venous thrombosis. The patient is secured to the table using footboards, straps, and bandages.

## Operative Steps

Videos 1 and 2 illustrate operative steps in the procedure.

## Creating Pneumoperitoneum

Closed method using Veress needle is author's (SA) preferred method for establishing the pneumoperitoneum. The Veress needle is inserted

in supraumbilical region in most cases. In patients with previous operations, Veress is inserted at Palmer's point, a point two fingers breadth below the subcostal margin in left midclavicular line. Intra-abdominal pressure is maintained between 14 mm and 17 mm. Use of two insufflators is helpful.

In patients where the Veress cannot be inserted safely or has failed, optical entry using a zero-degree telescope is used for insertion of the first port. Open technique at the umbilicus is preferred by the senior author (MG). Open technique at the epigastrium is used in patients with multiple previous laparotomies.

## Port Placement

Port positions, most used when the surgeon is operating from the right side, are shown in Fig. 1. Normally two 12 mm and two 5 mm ports are used. However, in difficult situations extra ports may be required. The first port is inserted in the upper abdomen about 15 cm below the xiphisternum for the camera. A 45° telescope is preferred as it enables an excellent visualization of the angle of His and hiatus. The working ports for the operating surgeon include a 12 mm port placed in right midclavicular line and a 5 mm port in right anterior axillary line. The other 5 mm port is inserted in left midclavicular line for the assisting surgeon. In some patients with severe adhesions in the right upper quadrant of abdomen (for example, previous open cholecystectomy), working ports are placed on the left side of abdomen and operation is carried out with some modification in operative steps.

## Placement of Liver Retractor

A quick diagnostic laparoscopy to identify any inadvertent injury is carried out. If found normal, Nathanson hook liver retractor (Cook Medical Inc., Brisbane, QLD, Australia) is placed through a 5 mm incision in the subxiphoid region to elevate the left lobe of liver (Fig. 2 and Video 3). At this stage, the hiatus is assessed for any laxity or hiatal hernia. In patients with hiatus hernia, the hiatal dissection is performed usually before commencing the original procedure. The crural repair is performed after completion of sleeve gastrectomy (Videos 4 and 5).

## Mobilization of Greater Curvature

A 36 French bougie is inserted under vision at this stage. It helps in decompression of the stomach, and is easier to insert at this stage rather than later when the patient is in steep reverse Trendelenberg position. The bougie is then withdrawn up to the

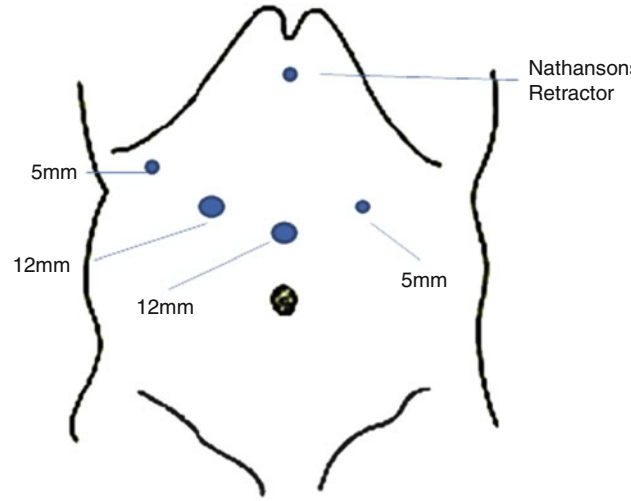


**Fig. 1** Port position

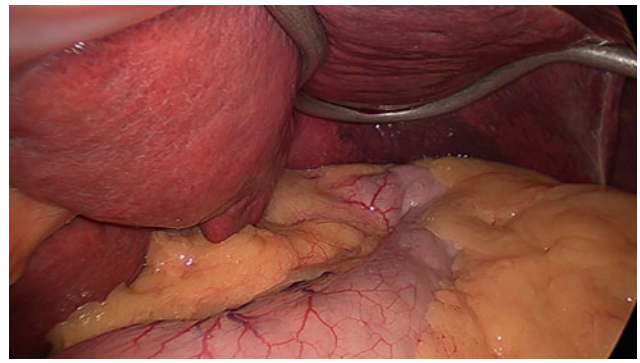

**Fig. 2** Nathansons hook liver retractor placed to elevate the left lobe of liver

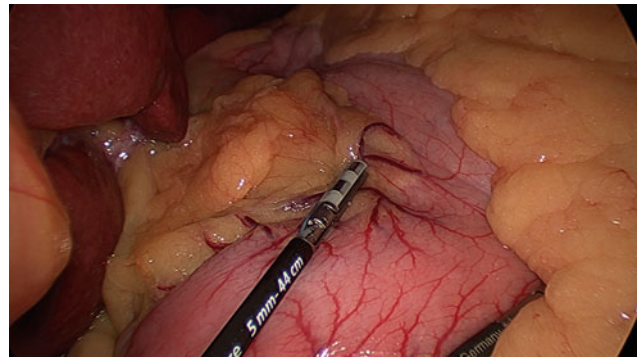


**Fig. 3** Identification of incisura angularis

GE junction. The incisura is identified (Fig. 3). A window is created in the lesser sac at a point on the greater curvature that is almost midway as it is easier to enter the omental bursa at this location (Fig. 4). A 5 mm bipolar vessel sealing device or ultrasonic shears are used. After entering the lesser sac, the omentum is detached from the greater curvature proximally by staying close to the gastric wall. The dissection proceeds cranially and care is taken to avoid any bleeding while taking down short gastric vessels (Fig. 5, Videos 1 and 6).

## Dissection Near Angle of His

The fundus is completely mobilized by detaching all adhesions. The left crura is exposed completely up to its medial border (Fig. 6 and Video 7). The left phrenoesophageal membrane is an important anatomical landmark that defines the cranio-medial limit of dissection. Anteriorly, the gastroesophageal fat pad is mobilized to guide the correct placement of stapler. Any overzealous dissection near the GE junction is best avoided, to prevent bleeding as well as injury to the esophagus.

Posterior attachments are taken down as the next step (Fig. 7). While taking down posterior attachments, care should be taken to avoid injury to the left gastric artery as it is the main vascular supply for the remnant sleeve of stomach.

Next, the caudal part of greater omentum is taken down, which becomes thicker and vascular closer to the pylorus. Usually, two distinct layers of omentum are encountered in this area, which may need to be taken down individually. Dissection is stopped 3–5 cm away from the pylorus (Fig. 8a, b, Videos 2 and 8). This distance is variable and there are controversies on the amount of antrum to be left behind. In a recent metanalysis it was seen than antral resection is associated with a higher weight loss as compared to antrum preserving group with similar incidence of postoperative leak, bleed, and reflux [16].

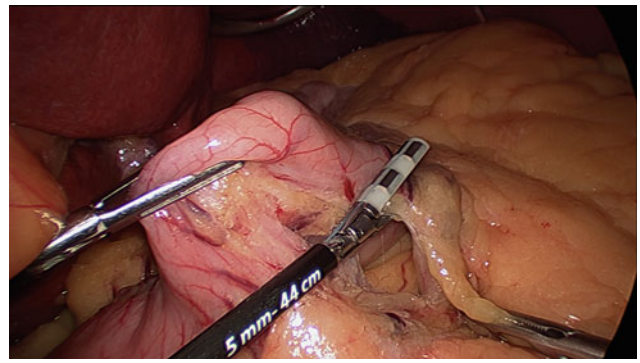


**Fig. 4** Creation of window on greater curvature

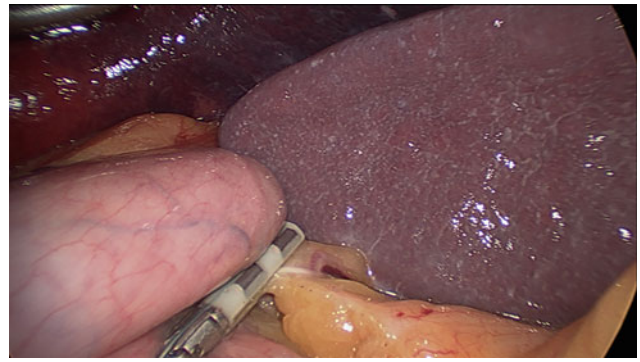

**Fig. 5** Short gastric vessels being taken down close to gastric wall

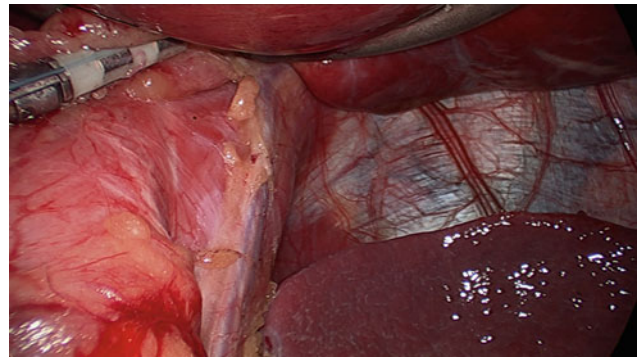

**Fig. 6** Entire left crura exposed

## Creation of Sleeve

First, it is ensured that all the tubes are placed in the stomach except the bougie (e.g., temperature probe and orogastric tube) that has been taken out by the anesthetist. Preplaced bougie is then advanced up to the first part of duodenum under vision, and it is ensured that its alignment is straight. It can be a tricky step sometimes, and atraumatic graspers may be required to guide and push the bougie through the pylorus (Fig. 9a, b and Video 9). Hence, some surgeons prefer to place the bougie after firing the first stapler though it is recommended to place the bougie before start of any stapling. A good communication between anesthetist and surgeon is essential during this step, as forced placement can lead to injury of the esophagus or stomach during this vital step. A gastroscope can also be used instead, to calibrate and guide the creation of sleeve.

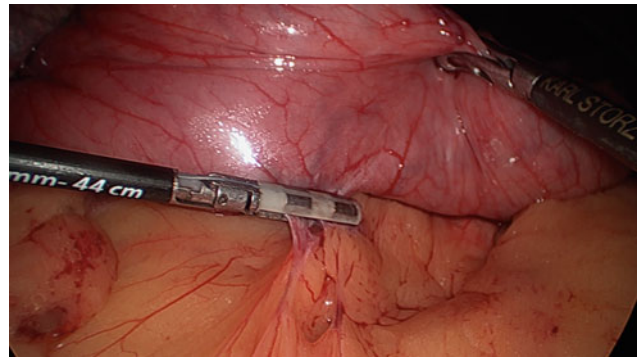


**Fig. 7** Detachment of posterior attachments

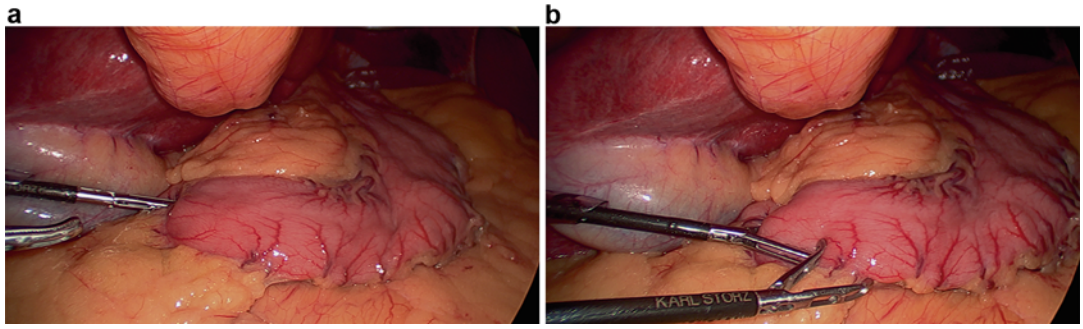


**Fig. 8** (**a**) Dissection is stopped 3–5 cm away from pylorus. (**b**) Measuring the distance from pylorus

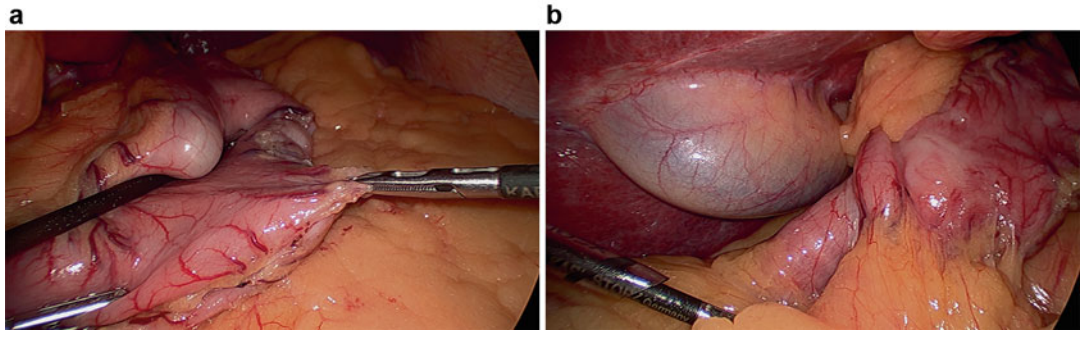


**Fig. 9** (**a**) Atraumatic graspers guiding the placement of bougie. (**b**) Bougie has been pushed through the pylorus to the first part of duodenum

There is a great variation in the size of gastric calibration tube being used to create the sleeve, which ranges from 32 to 60 French. Creating a sleeve using a bougie of smaller size may result in greater effective weight loss, but at the expense of higher stricture and leak rates [17]. However, in a recent metanalysis, use of a thinner bougie (<36 French) was associated with a greater weight loss when compared to the use of >36 French bougie with no significant difference in leak and reflux postoperatively [18]. At author's (SA) center, the sleeve is created over a 38 French bougie. For the first fire, a three-row stapler is placed 3–5 cm away from pylorus. The stapler is inserted through the right 12 mm port, The stapler should be angled away from the incisura (Fig. 10a, b, Videos 4 and 10). Before firing the first staple, the distance of stapler from incisura angularis is reassessed. The

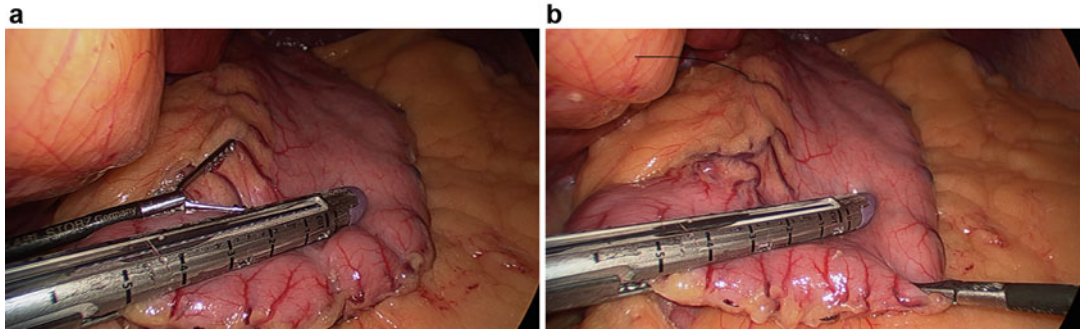


**Fig. 10** (**a**) Measuring the distance from incisura to guide the correct placement of first stapler. (**b**) The first stapler should be angled away from the incisura to prevent narrowing

stapler is placed slightly away from bougie at this point to avoid any narrowing that can result in a leak in the postoperative period. There have been studies suggesting that the chances of leak are less if the diameter of sleeve at the incisura is maintained around 40 French [17, 19]. After ensuring that the stapler is placed correctly, it is generally recommended to wait for about 30 s before firing the stapler.

The sleeve is created by sequential firings of the stapler using the purple cartridges (Fig. 11a, b, Videos 4 and 11). After each placement, the stapler should be rotated to check that the excessive posterior stomach is not left behind (Fig. 12). After each fire, the staple formation should be checked for proper staple formation and any loose staples (Fig. 13) should be removed. Care should be taken to avoid bunching of tissues. While retracting the stomach, the assistant should hold the greater curvature and not the anterior or posterior wall, as it may cause twisting of sleeve. Excessive traction should also be avoided.

The last fire should be properly planned. Again, an articulating instrument such as Goldfinger (Fig. 14) can be used to define the angle of His. The fundus should be retracted appropriately to avoid bunching of tissues. Care should be taken to include whole of the fundus in the resected part, as remnant fundus can lead to poor long-term outcome. The stapler should be angled away from the angle of His to avoid any narrowing at the gastroesophageal (GE) junction or inclusion of esophagus in the stapler (Fig. 15, Video 12). Another important precaution is to avoid the temptation of saving on a cartridge by trying to push the stapler all the way through and cause bunching. It is safer to fire for a lesser distance and use another cartridge if one is unsure whether the entire tissue will fit in the stapler during the last fire.

An alternative approach used by few surgeons involves creation of a small window at 2–3 cm from the pylorus, complete the sectioning of stomach first to create the sleeve, and then do the omentolysis.

## Hemostasis and Reinforcement

The bougie should be withdrawn until the GE junction and systolic blood pressure raised to about 140 mm Hg before checking for bleeding. The stapled end of the sleeve is inspected carefully for any bleeders (Fig. 16a, b). Most often, they can be secured using small clips. Rarely figure of eight sutures may be required to invert the bleeding edge of the stomach.

Staple line reinforcement (SLR) has been used to decrease bleeding and leaks. There are various methods for reinforcement of staple line such as oversewing, placing omental flap, using buttressing material over stapler, and spraying fibrin glue along the staple line. A number of buttressing materials are commercially available to reduce the rate of bleeding from the staple line. These include glycolide trimethylene carbonate copolymer (Videos 2 and 4) (Gore Seamguard, W.L. Gore and Associates), bovine pericardium strips

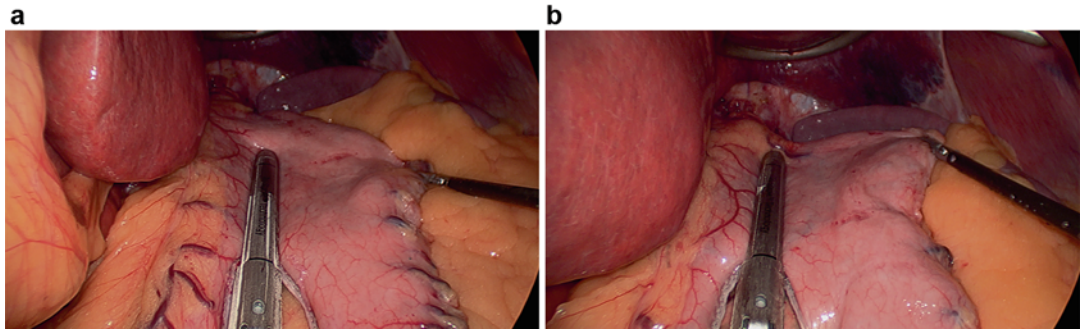


**Fig. 11** (**a**, **b**) Creation of gastric sleeve using sequential firings of the stapler

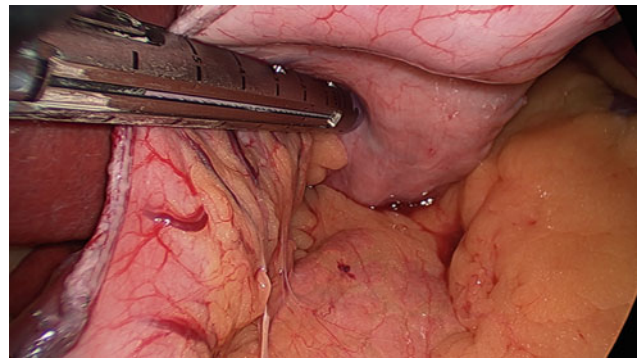

**Fig. 12** Rotating the stapler to check that excessive posterior stomach is not left behind

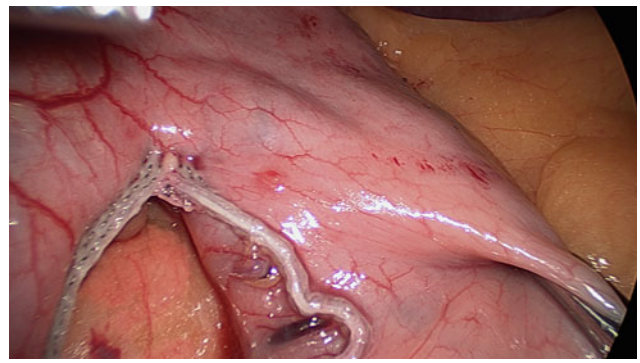

**Fig. 13** Checking for proper staple formation and loose staples at the crotch

(Synovis Surgical Innovations), or porcine small intestinal submucosa (Surgisis Biodesign, Cook Medical) [20]. At author's (SA) institution reinforcement using Gore Seamguard (Fig. 17a, b) is used in some selected patients such as super-super-obese patients, patients on anticoagulants, and patients with portal hypertension. The role of staple line reinforcement is discussed later in the chapter.

## Leak Test and Organ Retrieval

Leak test can be done by air insufflation or by instilling methylene blue dye. The leak test is performed by instilling 50–100 ml of methylene blue dye in the created sleeve through the bougie (Fig. 18 and Video 13). Some surgeons may like to omit the leak test based on the presumption that

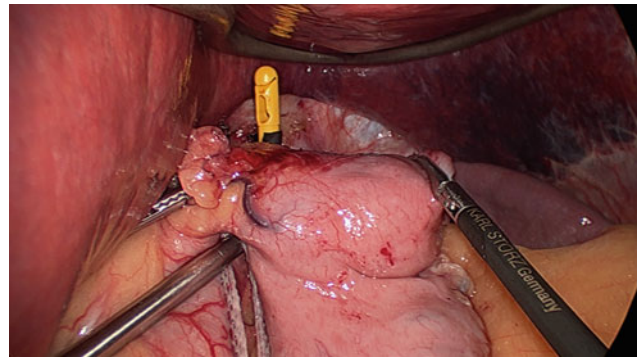

**Fig. 14** Using articulating instrument/Goldfinger to define the angle of His

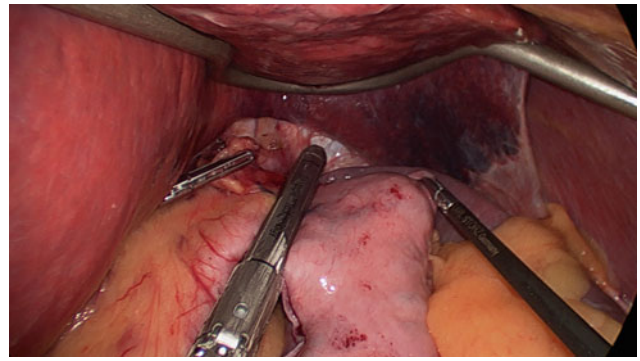

**Fig. 15** The stapler should be angled away from the angle of His to avoid injury to esophagus

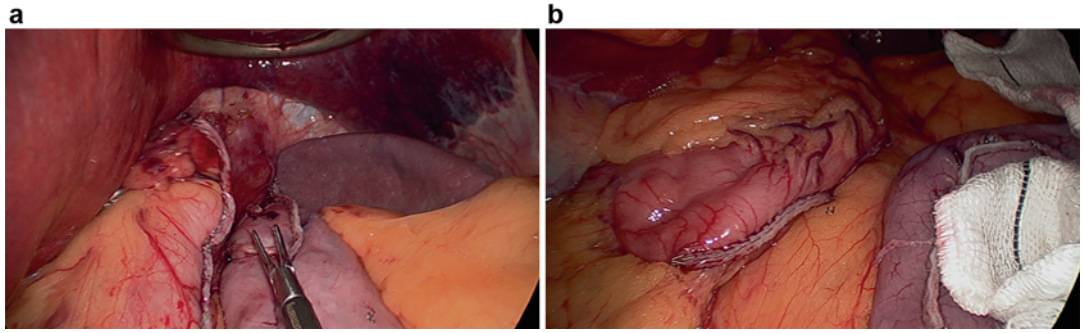


**Fig. 16** (**a**) Completed sleeve (**b**) The stapled end of the sleeve should be inspected carefully for bleeders

the staple line appears good. Some studies show no benefit of routine intraoperative leak test, however there is almost no harm in doing the leak test [21, 22]. The authors recommended to perform the leak test in all cases [23].

The specimen is retrieved from the right 12 mm port after dilating it (Fig. 19). Use of a retrieval bag is not recommended. A Jackson Pratt 14 French flat drain is placed near sleeve through left port (Fig. 20). The right 12 mm port is closed using transfascial sutures using an endoclosure device. Subcuticular monocryl stitches and dermabond are used for skin approximation.

## Postoperative Care

Patients are monitored overnight in a high-dependency unit. Early ambulation of patients, sequential pneumatic compression device, and

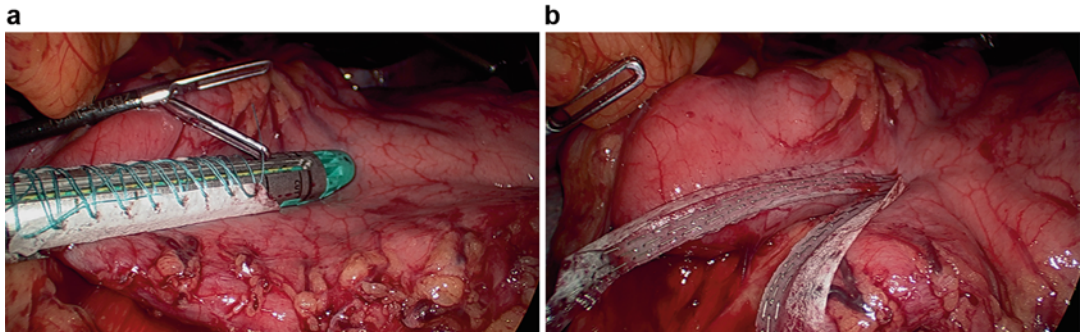


**Fig. 17** (**a**, **b**) Reinforcement using Gore Seamguard

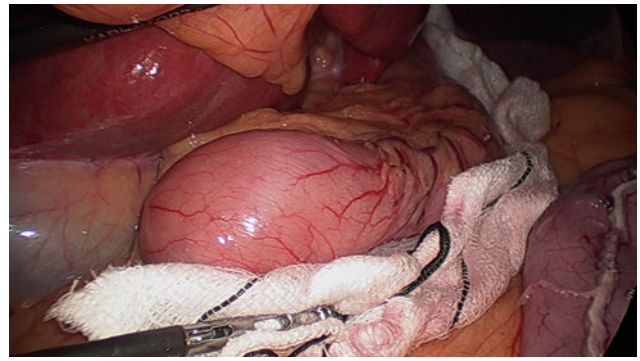

**Fig. 18** Leak test being done by instilling methylene blue dye

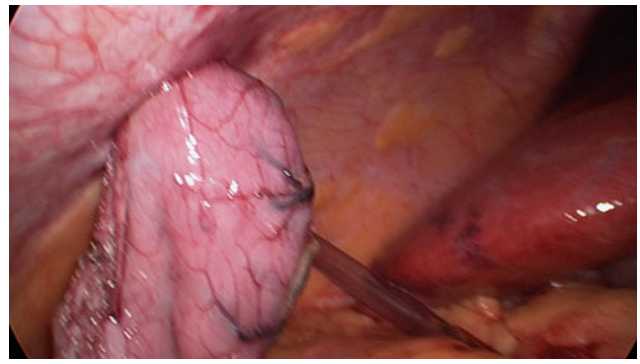

**Fig. 19** Retrieval of specimen from right 12 mm port

subcutaneous heparin are used for DVT prophylaxis. Patients are ambulated as early as possible, often after 4–6 h of surgery. Incentive spirometry and deep breathing exercises are encouraged to prevent atelectasis. Patients are permitted to sip clear liquids after 24 h. A dye study is done after surgery, although some surgeons may prefer performing a routine gastrografin test before allowing oral intake.

Patients are discharged on the second or third postoperative day if they are afebrile, ambulatory, tolerate oral liquid diet, and do not require oral analgesics. Some centers discharge the next day, and with certain selection criteria the same day.

## Complications

A detailed discussion of the complications is outside the scope of this chapter and can be found elsewhere. A few important complications are discussed below.

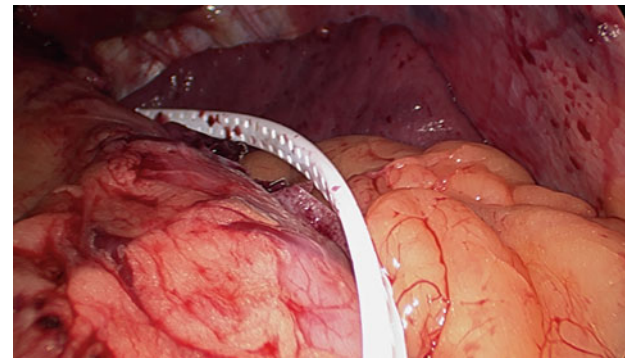

**Fig. 20** Jackson Pratt drain placed near sleeve through left port

## Hemorrhage

Traditionally, the incidence of hemorrhage after LSG has been varying from 1–6% [24]. The recent studies suggest the average incidence to be around 2% [25, 26]. The hemorrhage can be extraluminal or intraluminal. The causes of extraluminal hemorrhage are bleeding from the staple line, omental vessel, spleen injury, liver laceration, or trocar sites. Intraluminal bleeding is uncommon, and is a result of staple line bleed. Patients with extraluminal hemorrhage usually experience tachycardia, sudden hypotension, and sanguineous drain output, with a drop in hematocrit. Patients are resuscitated and serial monitoring of pulse rate, blood pressure, and hematocrit is done. An urgent re-laparoscopy or laparotomy should be done if bleeding results in hypotension, especially within 12 h after LSG. Most patients can be managed conservatively if they are hemodynamically stable. Anticoagulants should always be discontinued in such cases.

## Leak

The most dreaded complication after sleeve gastrectomy is a leak from the staple line with an incidence of 1–2% [25]. Leak can be classified as early or late, depending upon the time interval of presentation after surgery. Early leak is defined as a leak that is diagnosed within 3 days after surgery. Late leaks are those diagnosed a week after surgery. The presentation of leak is often varied ranging from absence of symptoms to diffuse peritonitis. The earliest signs of leak are tachycardia, agitation, tachypnea, and fever. Pulse rate is the single most reliable parameter to diagnose an early leak in obese patients. Any tachycardia or fever warrants further evaluation by contrast-enhanced computer tomography of the abdomen and/or gastrografin study to diagnose the leak. If the leak is diagnosed or suspected within 48–72 h, re-laparoscopy is done. At the time of re-laparoscopy, the leak is repaired with peritoneal lavage and placement of one or more drains. A feeding jejunostomy should always be done at this stage. After 72 h, repair of leak is not recommended because of the extensive inflammatory changes. If the patient presents with a leak after this narrow therapeutic window and is stable, conservative management is an excellent alternative to surgery, and includes image-guided drainage of infected collections, parenteral antibiotics, and naso-jejunal feeding. Use of stents is controversial. However, if the patient has toxemia and has signs and symptoms of diffuse peritonitis, prompt re-laparoscopy/laparotomy is mandatory. The important point is to avoid any delay in the management of such patients. The sepsis should be drained at the earliest, after the diagnosis.

## Stricture

The incidence of symptomatic stenosis is approximately 1% in patients undergoing sleeve gastrectomy [27]. The presentation of stricture may be either acute or chronic. The most common site of stricture is incisura angularis that may be due to

luminal narrowing or kink. The stricture manifesting in an acute setting is mainly due to tissue edema and settles with conservative management, which comprises of keeping the patient off any oral intake along with administration of intravenous fluids. Alternatively, chronic stricture needs multiple endoscopic balloon dilatations. Patients with persistent stricture who do not respond to endoscopic dilatation often require surgical intervention, mostly conversions to LRYGBP.

### Reflux

The relationship between LSG and gastroesophageal reflux is not clear and regarding whether LSG increases or decreases the symptoms of GE reflux is debatable [28]. There is a significant decrease in objective symptom scores, as well as endoscopic grade of esophagitis, despite a dramatic increase in scintigraphic reflux [29]. Additionally, a routine check for hiatal hernia during surgery and concomitant hiatal hernia repair decreases the incidence of postoperative reflux.

### Nutritional Deficiency

The incidence of nutritional deficiency following LSG is comparatively lower than LRYGBP. However, nutritional surveillance is important during follow-up for early detection and management of nutritional deficiencies. The deficiencies commonly seen after LSG are thiamine, vitamin B12, vitamin D3, zinc, and folic acid.

## Special Considerations

### Banded LSG (BLSG)

Despite the increasing popularity of SG among bariatric patients, there remains a paucity of data on long-term weight loss after SG procedure. The success of SG in promoting weight loss is limited by an increase in the size of gastric reservoir due to dilatation of the pouch in the long term [30]. LSG is now a stand-alone bariatric surgical procedure, and a significant number of the patients require a reoperation for weight loss failure. This is more likely to occur in super-obese patients [31]. Banded SG (BSG) procedure has been proposed as a modification of SG, based on encouraging long-term weight loss results reported with the banded RYGB procedures (Fig. 21).

Placement of band over the sleeve can help prevent weight regain as shown in one study which reported no increase in BMI for 97.9% patients in BSG group as compared to 80.3% patients in NBSG group [32]. It can also enhance the initial weight loss. Results of a randomized controlled trial found that the %EWL at 3 years was 62% in nonbanded group and 74% in banded group [33]. Similarly, another trial found higher % EBMIL in the banded group (103% vs 83%) [34]. The higher weight loss with the use of band comes at a cost of some complications. Studies over medium-/long-term follow-up report late and minor complications (vomiting/functional stenosis/requirement for ring enlargement/removal) to have a much higher frequency than major ring-related complications (such as ring migration following erosion or slippage from initial site) [32]. The rates at which these complications occur vary, with ring erosion and slippage being reported in 0.9–7% and 1.5% of patients, respectively [35, 36]. Banded patients are also likely to have a higher frequency of episodes of dysphagia and regurgitation [32, 33]. More data is required before band can be recommended as a measure to prevent weight regain. The pros and cons of banding should be discussed with the patients prior to surgery.

## Role of Antral Resection

LSG has conventionally been done as an antral preserving procedure, with division of stomach starting at around 5 cm from the pylorus. This approach was advocated in view of the importance of preserving the physiological emptying mechanism of stomach. An intact emptying mechanism would ideally decrease the intraluminal pressures, and thus reduce the risk of staple link

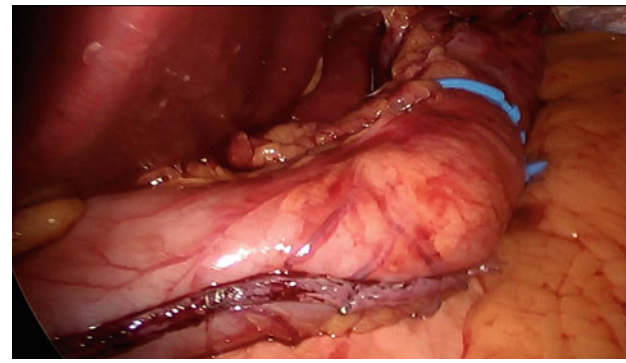

**Fig. 21** Intraoperative image of banded sleeve gastrectomy

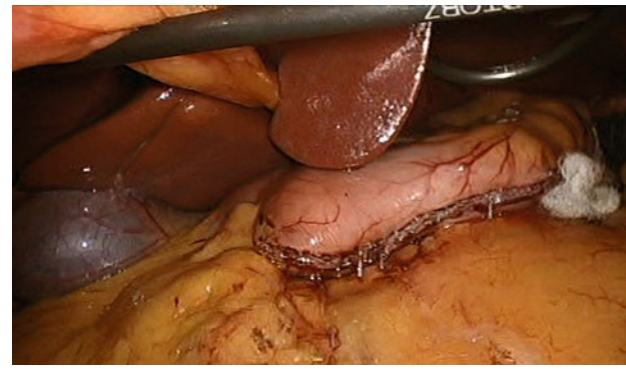

**Fig. 22** Intraoperative image of antrum resecting sleeve gastrectomy

leak and GERD. However, multiple studies over the past decade have shown no statistically significant difference in gastro-oesophageal reflux, vomiting, or staple line leaks between antral preserving (AP-LSG) and antral resecting (AR-LSG) procedures. In comparison to AP-LSG, AR-LSG (Fig. 22) procedures (division of stomach within 2 cm of pylorus) have been associated with greater percentage of excess weight loss (%EWL) in medium-term follow-up studies [37, 38]. Contrary to the initial arguments against AR-LSG that feared disrupting physiological functions of stomach, recent advances in literature now suggest lower incidence of reflux symptoms in AR-LSG, than in AP-LSG [39].

These findings may be attributed to differential increase in gastric emptying time. It has been seen that the gastric emptying was faster in AR-LSG. However, in diabetic patients, the distance of gastric resection margin from pylorus does not influence gastric emptying time. Altered vagal functionality and lack of significant perioperative change in GLP-1 levels might be the possible reasons for similar gastric emptying times in diabetic patients [37]. At the author's center (SA) the weight loss and complication rates were found to be similar in both the groups at 1 year in a randomized study comparing the two procedures. In a metanalysis, it was seen that the %EWL was similar in both the groups at 1 year and higher in the AR group at 2 years (SMD 0.95) [16]. The advantage of AR-LSG over AP-LSG for weight loss increases over time, and this gradual increase may be attributed to the lower residual sleeve volume in AR-LSG.

## Hiatal Hernia (HH) Repair

The impact of SG on gastroesophageal reflux is variable. While some authors report an improvement in reflux symptoms [40], others have reported worsening of GERD post-LSG, or development of a de novo reflux complaint [41, 42]. Faster gastric emptying, reduced reservoir function of stomach, decreased acid production, and lowering of intra-abdominal pressure because of

significant weight loss may be some of the reasons contributing to improvement of gastroesophageal reflux following SG. On the other hand, worsening of GERD might occur due to the presence of hiatal hernia (increased prevalence in morbidly obese patients), increased intraluminal pressure secondary to decreased capacity of stomach, or sectioning of sling fibers during SG [29, 43]. Though RYGB is still considered as the gold standard for bariatric patients complaining of GERD, SG coupled with hiatal hernia repair (HHR) may also be offered as an alternate therapeutic choice in patients with HH. A meta-analysis by Mahawar et al. [44] analyzed 17 studies describing simultaneous SG with HHR, and only one of them reported poor results following this approach. Aggressive approach to any intraoperatively detected HH (obvious or subtle) can decrease the incidence of de novo reflux. The authors advocate a concomitant hiatal hernia repair (if present) in patients undergoing sleeve gastrectomy. There are various approaches to HHR. The most advocated approach, however, remains the posterior crural approximation as it restores the normal anti-reflux gastroesophageal angle. This should be preceded by sufficient dissection to ensure adequate intra-abdominal length of esophagus. Drawing on the results of mesh repairs for inguinoscrotal and ventral hernias, use of prosthetic mesh for large hiatal hernias may be advocated for. While mesh does decrease the chances of recurrence of hiatal hernias, the possibilities of intraoperative injuries to surrounding structures and mesh erosion as a disastrous long-term complication need to be taken into consideration [45]. Thus, the decision on mesh placement in HHR hinges between a collateral increase in risk of long-term complications with mesh repair, and the risk of recurrence of hernia if repair is performed without mesh placement. Currently, there still exists a paucity of long-term data on this assessment. Another recent modality in addressing hiatal hernias has been Nissen's sleeve operation. As the name suggests, Nissen's sleeve (N-SG) involves creation of a short gastric valve (usually about 3 cm) for the purpose of decreasing acid reflux, prior to stapling the greater curvature of stomach. Care needs to be taken to ensure that a gastric fundus as small and functional as possible is left behind. Though N-SG is a technically more demanding procedure, it appears to provide patients with better control of reflux symptoms, while maintaining other beneficial impacts of conventional SG [46].

## Staple Line Reinforcement (SLR) in LSG

The long length of the staple line in sleeve gastrectomy makes it prone to intraoperative and immediate postoperative complications including bleed and leak. These complications, though rare, may have disastrous sequelae such as fistulas, sepsis, increased recovery times, and/or mortality. SLR can be performed by oversewing the staple line or buttressing it. Buttressing material can be either synthetic (glycolide copolymer) or biologic (bovine pericardium). In a large database of 1,89,173 patients of sleeve gastrectomy, it was seen that the bleeding rates were slightly lower when SLR was performed [47]. Although statistically insignificant, the leak rates were lower in the group without SLR. After propensity score matching to adjust for the various demographic features and comorbidities, the bleeding rates were still lower following SLR while the leak rates were similar in both groups. In a recent metanalysis, SLR was found to significantly reduce the risk of bleeding from the staple line from 5% with no SLR to 2.4% with oversewing and 1–2% with buttressing [48]. However, buttressing and oversewing can be associated with ischemia, deformation of the sleeve, increased operative time, stenosis, and stricture [49]. Considering these facts, the benefits of SLR on prevention of leak is controversial. In a systematic review of 40,653 patients, the leak rates were found to be 0.73% with absorbable polymer membrane (APM), 1.21% with oversewing, 1.89% with no SLR, and 2.73% with bovine pericardium (BP). Leak rates were similar when tissue seal and no SLR were compared [50]. Considering the equivocal evidence as well as the prohibitive cost, use of reinforcement adjuncts becomes a matter of surgeon's own experience as well as affordability.

## Follow-Up

Patients are called for follow-up at regular intervals. The first follow-up visit is usually a week after surgery. Subsequent visits are scheduled at 1 month, 3 months, and at quarterly intervals thereafter, in the first year. After the first year, a half-yearly follow-up is recommended for the next 2 years, and annually thereafter. As stated earlier, nutritional monitoring is an important aspect of follow-up. Importance of dietary compliance and physical activity should be stressed at each visit. Regular support group meetings are an important component of an effective weight loss program.

## Summary

The LSG has already been established as a safe and effective primary weight loss procedure. Its popularity has risen exponentially to the extent that it is being investigated as a metabolic procedure in patients having class I obesity with type 2 diabetes. Despite some technical variations, the basic steps of surgery remain the same and have been continually standardized in the last decade resulting in improved outcomes. Surgeons should perform the procedure in the same standardized manner and avoid the tendency to do unnecessary steps like omentopexy if the sleeve looks uniform with the entire staple line placed laterally. A meticulous approach with attention to various nuances and concomitant repair of HH is of utmost importance to minimize complications and achieve the best long-term results.

## Key Learning Points

- Although LSG is technically less complex than LRYGBP, there are several points of technique which should be adhered to in every patient and the following points are noteworthy:
- Attention should be paid to the compression time of the stapler (as advised by the manufacturer) and tendency to finish the procedure fast should be avoided.
- Special attention is required during the first and the last stapler firings to avoid excessive narrowing.
- Avoid rotation of sleeve by ensuring equal traction on both walls of stomach and avoiding excessive traction.
- Caution should be exercised to avoid including too much tissue into the stapler to preclude bunching of tissues.
- There is no substitute for good hemostasis. The entire staple line should be inspected for bleeding after withdrawing the bougie up to the GE junction. Staple line hematoma can be a factor leading to a leak.
- Hiatus should be inspected carefully and if present, hiatal hernia should be repaired.
- Routine use of steps including staple line reinforcement, omentopexy, and placement of band over sleeve cannot be recommended.

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