Laparoscopic Sleeve Gastrectomy

Surgical Technique and Perioperative Care

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KEYWORDS

• Laparoscopic sleeve gastrectomy • Bariatric surgical technique • Perioperative care

KEY POINTS

- Laparoscopic sleeve gastrectomy (LSG) has demonstrated durable long-term weight loss and metabolic improvements in obese patients.
- It has proved a safe procedure with a low complication rate in appropriately selected patients.
- Adherence to key surgical tenets is critical for safe and effective patient outcomes.

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

INTRODUCTION

Bariatric surgery has continued to evolve over the past several decades in terms of technique and indication not only for weight loss but also as an effective treatment of type 2 diabetes mellitus and metabolic syndrome abnormalities in general.[1] The STAMPEDE (The Surgical Therapy and Medications Potentially Eradicate Diabetes Efficiently) trial demonstrated bariatric surgery as superior to the best aggressive medical treatment in terms of durable weight loss and improvement of diabetes.[2] Although LSG is largely viewed as a restrictive procedure created for weight loss in patients with morbid obesity, it also has been beneficial in treating metabolic derangements. It has evolved into an increasingly popular procedure compared with the Roux-en-Y gastric bypass and adjustable gastric banding due to its less complex surgical technique and comparable outcomes to Roux-en-Y gastric bypass with regard to durable weight loss and improvement in metabolic syndrome abnormalities. A laparoscopic adaptation of

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the Magenstrasse and Mill procedure, LSG was initially created as the first step in a 2-part procedure (biliopancreatic diversion with duodenal switch) for supermorbid obese patients in whom traditional bypass surgery was thought too high risk based on their associated comorbidities. The same 2-stage approach has also been studied for Roux-en-Y gastric bypass.[3,4] The goal was to initiate surgical weight loss, thereby improving the patient candidacy for a more complex bypass procedure in the future. The surgery consisted of restrictive gastrectomy, removing up to 80% of the stomach along the greater curvature, with subsequent revision to duodenal switch or Roux-en-Y anatomy after appropriate weight loss had occurred to reduce surgical risk.[5] The sleeve gastrectomy has since been found to have comparable results to other weight loss procedures, including the Roux-en-Y gastric bypass, and has become an increasingly popular option among both surgeons and patients. Advantages of laparoscopic sleeve gastrectomy over the roux-en-Y gastric bypass includes acceptable use in patients with inflammatory bowel disease, patients who are transplant candidates (liver and kidney), and patients with complex prior abdominal surgery or complex abdominal wall hernias. It is also a pylorus-sparing procedure that eliminates the risk of dumping syndrome. Finally, there is no increased risk of marginal ulceration or internal hernias compared with traditional bypass surgery. It is not, however, considered an antireflux procedure. Therefore, Barrett esophagus may be a contraindication. The American Society of Metabolic and Bariatric Surgery has published position statements regarding the use of sleeve gastrectomy as a bariatric procedure, establishing its safety, efficacy, and durability.[6]

An expert consensus statement published in 2012 by Rosenthal and colleagues[7] addressed the key components of surgical technique, indications for surgery, and postoperative management as well as management of complications. This article describes surgical technique for LSG as well as the preoperative work-up and perioperative management of patients undergoing the procedure at the authors' institution.

PREOPERATIVE PLANNING

The preoperative work-up for bariatric surgery typically begins several months prior to the procedure. Most patients in need of bariatric surgery have multiple obesity-related comorbidities, which require cardiopulmonary work-up and clearances, including psychological, nutritional, and sleep study evaluation.

All patients receive extensive preoperative education from a multidisciplinary team specializing in bariatric surgical patients, including bariatric nurse coordinators, dieticians, nutritionists, and exercise physiologists. Standard biochemical blood work is obtained, including complete blood cell count, chemistry panel, liver and thyroid panels, and evaluation for any vitamin deficiencies.

Preoperative dietary modifications with evidence of discipline and the ability to sustain moderate weight loss are essential. For some high-risk patients, it is the authors' preference to place patients on a liquid low-calorie diet prior to surgery to enhance weight loss.[8] Preoperative weight loss not only improves obesity-related comorbidities but also improves visualization during surgery by decreasing intra-abdominal adipose tissue and decreasing liver volume. The authors previously described a significant reduction in both visceral and subcutaneous adipose tissue as well as reduction of liver volume after an average of 9 weeks on a low-calorie liquid diet.[9] To foster dietary compliance prior to surgery, patients are counseled in monthly dietary sessions with a certified dietician.

Cardiopulmonary work-up includes an adenosine stress test on patients older than 40 years with a history significant for coronary artery disease and associated risk factors. Patients with congestive heart failure are evaluated with an echocardiogram if no recent study is available. Routine chest radiograph is performed on all patients. Those at high risk for pulmonary complications receive a sleep study and pulmonary function tests and are optimized accordingly with bronchodilators and/or positive pressure airway devices. Perhaps most important are education and insistence on smoking cessation prior to surgery and the continuation of abstinence from nicotine products postoperatively given the significantly increased complication rate associated with smoking.[10]

There is controversy surrounding the necessity for preoperative esophagogastroduodenoscopy (EGD) prior to bariatric surgery. When performed routinely, gastric and esophageal pathology can be found in a significant number of patients, with gastritis, Barrett esophagitis, and hiatal hernias the most common findings.[11] In some patients, especially those undergoing revisional cases, medical and/or surgical therapy may be modified based on EGD findings; therefore, routine preoperative EGD is used.

SURGICAL TECHNIQUE

Many variations exist regarding surgical technique; however, the basic tenets of LSG should be stringently followed. These include pyloric preservation with gastrectomy beginning 2 cm to 6 cm proximal to the pylorus, mobilization of the entire greater curvature with exposure and identification of the left crus and base of the right crus, avoidance of stricture at the gastric incisura, and proper apposition of the anterior and posterior aspects of the stomach when stapling to prevent a corkscrewing effect of the sleeve and avoid a large retained fundic pouch.

The following describes the technique used at the authors' institution. Preoperative antibiotics are administered in accordance with Surgical Care Improvement Project guidelines. A prophylactic dose of subcutaneous heparin is also administered preoperatively. Patients are placed on an operating table in supine position with arms abducted. Sequential compression devices are placed and confirmed to be functioning. All pressure points are padded to prevent deep tissue injury. A footboard is placed under the patients' feet and firmly secured to the bed. The legs and hips are secured with safety straps to prevent bowing or buckling of the knees or ankles. A urinary catheter is placed after induction of general anesthesia.

Pneumoperitoneum to a pressure of 15 mm Hg is achieved through Veress needle technique at Palmer point in the left upper quadrant. The incision is made large enough for placement of a 5-mm port. A laparoscopic camera is introduced and the remainder of the abdomen is inspected for any anatomic abnormalities or iatrogenic injury. Adhesiolysis is performed as necessary. The remaining ports are placed in the following positions: a 12-mm periumbilical port located approximately 15 cm to 17 cm from the xiphoid process; two 5-mm ports placed in the right subcostal position; and a 15-mm port placed in the right upper quadrant. Finally, it is the authors' preference to retract the falciform ligament using a suture passed percutaneously and secured at skin level with a small clamp to better visualize the operative field. A liver retractor is then placed through the most lateral 5 mm right subcostal port and secured to a malleable hands-free device attached to the operating table. Liver retractors may also be placed through a subxiphoid incision; however, caution must be taken to avoid injury to the pericardium, which lies in close proximity.

Once all ports are placed and adequate visualization of the anatomy is achieved, an orogastric tube is placed and the stomach is deflated under direct visualization. The orogastric tube is then removed along with any other foreign devices (esophageal temperature probes and esophageal stethescope). The patient is then placed in steep reverse Trendelenburg position, allowing the transverse colon and small intestine to fall in a caudal direction. Because the stomach is large and extends from foregut to midabdomen, different degrees of Trendelenburg positioning may be used to facilitate better exposure in a large abdomen.

The dissection is begun by identifying the pylorus and taking down any associated adhesions with an advanced vessel sealing device. The entire greater curvature is then mobilized proximal to the pylorus, taking down the lesser omentum and freeing any attachments to the transverse colon and its mesentery. The greater curvature is mobilized to the angle of His. Great care must be taken when dissecting and sealing the short gastric arteries because they are high risk for intraoperative and postoperative bleeding. The splenic artery should be identified and preserved before proceeding with the dissection.

Dissection of the greater curvature is complete when the left crus can be readily identified and exposed where it meets the base of the right crus. Any hiatal hernias should be addressed at this time and repaired in a posterior fashion.[12] Bioabsorbable mesh is used to reinforce repair of large hiatal hernias. All attachments to the posterior stomach are then taken down. It is critical to identify and preserve the left gastric artery (or any large vessels) to the lesser curvature, because they are the only blood supply to the remaining stomach.

Once dissection is complete, a 36-French blunt-tipped bougie tube is placed and slowly advanced under direct visualization to the level of the pylorus. Non–blunt-tipped bougie tubes should not be used because they are at risk for stapling across the tapered distal aspect, during creation of the sleeve. Controversy exists regarding the proper size of the bougie tube and its relation to durable weight-loss outcomes. The use of a small-caliber tube may increase the risk of stricture, whereas a large tube may not provide an adequate restrictive sensation. The authors caution against the use of any bougie tube smaller than 32 French[13,14] due to increased risk of complications, which include making the sleeve too tight, potentially leading to obstruction especially at the gastric incisura.

Creation of the sleeve begins 3 cm proximal to the pylorus. A consensus article published by Rosenthal and colleagues[7] endorses the first staple load to start between 2 cm and 6 cm proximal to the pylorus. Before firing the stapler, the bougie tube must be visualized passing distal to the stapler along the lesser curvature. The largest available staple height should be used for the initial firing. The staple height may then be decreased for subsequent firings based on the thickness of the gastric tissue, which may vary between patients. If using buttressing material for the staple line, it may be beneficial to use a larger staple height to compensate for the added thickness of the buttressing material. It is critical to expose the stomach such that the anterior and posterior aspects are properly opposed using lateral traction. This prevents a corkscrewing effect of the sleeve as well as avoiding leaving a large posterior fundus. In addition, great care must be taken not to narrow the incisura angularis, leaving at least 2 cm of width to prevent obstruction. The staple line is created cephalad to the angle of His, taking care to avoid injury to the underlying pancreas or any critical vascular structures, such as the left gastric and splenic arteries. It is important to avoid stapling too close to the gastroesophageal junction because it is a vascular watershed area and damage could lead to ischemia and a higher leak rate.

Feared postoperative complications include bleeding and leakage of the staple line; therefore, it is preferred that staple-line reinforcement of some type be used. Controversy exists regarding the method of reinforcement. It is the authors' preference to create a running, inverting Lembert suture the entire length of the staple line. Other methods include a simple oversewing encompassing the staple line and the use of a staple buttressing material at the time of stapler firing. There does not seem to be superiority of any method, but consensus remains that some type of staple-line reinforcement should be used because it confers a lower incidence of bleeding.[7,15–19]

Once the sleeve is created, a leak test is preferable. It may be used by flooding the surgical field with irrigant and insufflating the remaining stomach. Resulting air bubbles denote the presence of a leak and should be addressed appropriately. Methylene blue may also be placed in the stomach and any spillage of blue contents into the peritoneal cavity assess. The authors' preference is to affix the greater curvature mesentery to the sleeve using a running locking suture for further fixation. The excluded stomach is then removed through the 15-mm port site under direct visualization to ensure no gross spillage of gastric contents. Surgical drains are not necessary unless there is high concern for bleeding or leak postoperatively. Drains may be more beneficial when performing revisional surgery, which expectedly has a higher risk of complications. The 15-mm and 12-mm port sites are then closed laparoscopically using a suture passing device under direct visualization. The liver retractor and all remaining ports are then removed and pneumoperitoneum is released.

In summary, there are multiple variations of surgical technique for creation of a gastric sleeve. Certain key aspects of the procedure are critical, however, for safe outcomes and durable weight loss. These include complete mobilization of the greater curvature and posterior stomach, visual identification of the left crus and the base of the right crus, avoidance of vascular compromise to the lesser curvature and gastroesophageal junction, proper apposition of the anterior and posterior aspects of the stomach while stapling to avoid corkscrewing and leaving a large posterior fundic pouch, avoidance of narrowing of the incisura angularis, and utilization of staple-line reinforcement.

See **Fig. 1** and Videos 1–14 for a demonstration of the key surgical procedures for creation of a gastric sleeve.

IMMEDIATE POSTOPERATIVE CARE

Consistent and reliable postoperative care with support staff familiar with bariatric patients is essential. Patients are initially kept nothing by mouth after surgery. On postoperative day 1, sips of water are initiated with a goal rate of 30 mL every 30 minutes. If patients can tolerate this diet, they are advanced to a low-sugar phase 1 bariatric diet, as desired, consisting of clear noncarbonated liquids. The oral intake goal is at least 64 mL of fluid per day.

Perhaps the most common postoperative complaint of sleeve gastrectomy patients is severe nausea. Therefore, antiemetics play an important role in the immediate

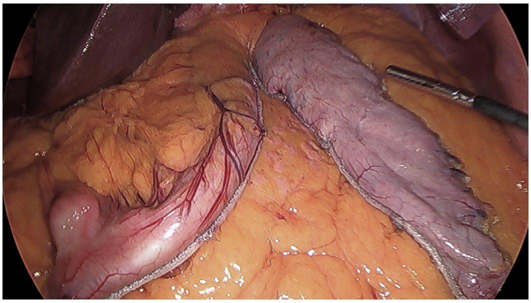

Fig. 1. LSG. (*Courtesy of* Dr Adrian Dan, Akron, Ohio.)

postoperative period to avoid undue stress on the staple line associated with retching and vomiting. It is the authors' preference to schedule 2 alternating antiemetics so that a patient receives 1 agent every 3 hours.

Routine deep vein thrombosis prophylaxis consists of sequential compression device placement and subcutaneous heparin. Maintenance intravenous fluids are administered and adequate urine output is closely monitored. Deep breathing and early ambulation are encouraged. The urinary catheter remains in place the night of surgery and is typically removed on postoperative day 1. Patient-controlled intravenous narcotics are used for pain management. These are discontinued on postoperative day 1 and transitioned to oral narcotic medication. If patients have obstructive sleep apnea and use a continuous positive airway device at home, they may use their machine the night of surgery and thereafter. Patients are typically discharged on postoperative day 2.

After discharge from the hospital, patients are continued on a phase 1 bariatric clear liquid diet for the first 7 days. This is advanced to a bariatric phase 2 pureed high-protein liquid diet for 4 weeks and then finally transitioned to a diet of soft foods. Patients are contacted at home several days after discharge for encouragement, diet reinforcement, and reminders to maintain hydration.

Postoperative patients require regular and frequent follow-up in clinic. They are seen at 1 week, 1 month, 3 months, 6 months, 12 months, 24 months, and then annually after the first year. Clinic visits consist of weight and nutritional monitoring as well as dietary counseling and psychology referral as needed. The importance of long-term follow-up with a surgeon is highly stressed. Ancillary avenues, such as support groups and social media, are also encouraged. Further rehabilitation and recovery consist of aerobic and anaerobic exercise starting 2 weeks postoperatively.

LONG-TERM OUTCOMES

Long-term follow-up has demonstrated durable weight loss and metabolic benefits comparable with Roux-en-Y gastric bypass.[20–23] Type 2 diabetes mellitus and diabetes-associated complications have been shown more effectively treated by bariatric surgery compared with the best medical therapy. The only significant predictor of long-term improvement of type 2 diabetes mellitus was a decrease in body mass index.[2] In addition, survival benefit has been demonstrated among obese patients undergoing bariatric surgery compared with those without surgical intervention. A retrospective cohort study showed a decrease in all-cause mortality at 5 years and 10 years in patients receiving bariatric surgery.[24]

The LSG has continued to gain popularity among both patients and surgeons due to its perceived technical simplicity compared with other bariatric surgical procedures. As data regarding patient outcomes after this procedure continue to accrue among institutions, promising results are being published more than 5 years out from surgery. Most publications report a mean percent excess weight loss of 55% or more over this time period.[21,25–29] The authors have published data from 6 years to 8 years postoperatively that demonstrate durable excess weight loss of 46% at 96 months.[30] LSG compares favorably to long-term weight loss data for laparoscopic Roux-en-Y gastric bypass over the same time frame. Improvements of type 2 diabetes mellitus and metabolic syndrome abnormalities are also similar compared with gastric bypass. Data pertaining to the improvement of gastroesophageal reflux disease or new onset of gastroesophageal reflux disease after sleeve gastrectomy continue to evolve, and dedicated objective studies are needed to better delineate this potential outcome.[31] Regarding the most feared complication, overall leak rates are reported between

0.7% and 3.7%, and a majority of these occur at the proximal third of the stomach staple line near the gastroesophageal junction.[32]

SUMMARY

LSG evolved from a staged procedure as part of the biliopancreatic diversion and duodenal switch and has emerged as a sole procedure for sustained weight loss and improvement of metabolic derangements. The surgery continues to gain popularity due to its perceived technical simplicity coupled with promising short-term and long-term data, which suggest results comparable to more established bariatric procedures. Certain key surgical tenets of the LSG are described in this article that are essential for safe and effective outcomes. The sleeve gastrectomy has clearly established itself as a successful stand-alone procedure for the effective treatment of obesity and related diseases.

SUPPLEMENTARY DATA

Supplementary data related to this article are found at http://dx.doi.org/10.1016/j.suc.2016.03.015.

REFERENCES

1. Mattar S, Velcu L, Schauer P. Surgically-induced weight loss significantly improves nonalcholoic fatty liver disease and the metabolic syndrome. Ann Surg 2005;242(4):610–7.
2. Schauer P, Bhatt DL, Kirwan JP, STAMPEDE Investigators. Bariatric surgery versus intensive medical therapy for diabetes - 3 year outcomes. N Engl J Med 2014;370(21):2002–13.
3. Johnston D, Dachtler J, Martin IG. The Magenstrasse and Mill operation for morbid obesity. Obes Surg 2003;13(1):10–6.
4. Cottam D, Qureshi FG, Mattar SG, et al. Laparoscopic sleeve gastrectomy as an initial weight-loss procedure for high-risk patients with morbid obesity. Surg Endosc 2006;20:859–63.
5. Regan JP, Inabnet W, Gagner M, et al. Early experience with two-stage laparoscopic Roux-en-Y gastric bypass as an alternative in the super obese patient. Obes Surg 2003;13(6):861–4.
6. ASMBS Clinical Issues Committee. Updated position statement on sleeve gastrectomy as a bariatric procedure. Surg Obes Relat Dis 2012;8(3):21–6.
7. Rosenthal R, International Sleeve Gastrectomy Expert Panel. International Sleeve Gastrectomy Expert Panel Consensus Statement: best practice guidelines based on experience of >12,000 cases. Surg Obes Relat Dis 2012;8(1):8–19.
8. Edholm D, Kullberg J, Sundbom M. Preoperative 4-Week Low-Calorie Diet Reduces Liver Volume and Intrahepatic Fat, and Facilitates Laparoscopic Gastric Bypass in Morbidly Obese. Obes Surg 2011;21(3):345–50.
9. Collins J, McCloskey C, Eid G. Preoperative weight loss in high-risk superobese bariatric patients: a computed-tomography based analysis. Surg Obes Relat Dis 2011;7(4):480–5.
10. Haskins IN, Amdur R, Vaziri K. The effect of smoking on bariatric surgical outcomes. Surg Endosc 2014;28(11):3074–80.

11. Schigt A, Coblijn U, van Wagensveld B. Is esophagogastroduodenoscopy before Roux-en-Y gastric bypass or sleeve gastrectomy mandatory? Surg Obes Relat Dis 2014;10(3):411–7.
12. Boules M, Corcelles R, Kroh M. The incidence of hiatal hernia and technical feasibility of repair during bariatric surgery. Surgery 2015;158(4):911–8.
13. Cal P, Deluca L, Fernandez E. Laparoscopic sleeve gastrectomy with 27 versus 39 Fr bougie calibration: a randomized controlled trial. Surg Endosc 2016;30(5):1812–5.
14. Parikh M, Gagner M, Pomp A. Laparoscopic sleeve gastrectomy: does bougie size affect mean %EWL? Short-term outcomes. Surg Obes Relat Dis 2008;4(4):528–33.
15. Rogula T, Khorgami Z, Schauer P. Comparison of Reinforcement Techniques Using Suture on Staple-Line in Sleeve Gastrectomy. Obes Surg 2015;25(11):2219–24.
16. Aydin M, Aras O, Memisoglu K. Staple line reinforcement methods in laparoscopic sleeve gastrectomy: comparison of burst pressures and leaks. JSLS 2015;19(3) [pii:e2015.00040].
17. Chen B, Kiriakopoulos A, Frezza EE. Reinforcement does not necessarily reduce the rate of staple line leaks after sleeve gastrectomy. A review of the literature and clinical experiences. Obes Surg 2009;19(2):166–72.
18. Lauti M, Gormack S, MacCormick A. What does the excised stomach from sleeve gastrectomy tell us? Obes Surg 2015;26(4):839–42.
19. Galloro G, Ruggiero S, Manta R. Staple-line leak after sleeve gastrectomy in obese patients: a hot topic in bariatric surgery. World J Gastrointest Surg 2015;7(9):843–6.
20. Vidal J, Ibarzabal A, Romero F, et al. Type 2 diabetes mellitus and the metabolic syndrome following sleeve gastrectomy in severely obese subjects. Obes Surg 2008;18:1077–82.
21. Bohdjalian A, Langer FB, Prager G. Sleeve gastrectomy as sole and definitive bariatric procedure: 5-year results for weight loss and ghrelin. Obes Surg 2010;20(5):535–40.
22. Fischer L, Hildebrandt C, Muller-Stich B. Excessive weight loss after sleeve gastrectomy: a systematic review. Obes Surg 2012;22(5):721–31.
23. Adams TD, Gress RE, Hunt SC. Long-term mortality after gastric bypass surgery. N Engl J Med 2007;57(8):753–61.
24. Arterburn D, Olsen M, Smith V, et al. Association between bariatric surgery and long-term survival. JAMA 2015;313(1):62–70.
25. Hauser D, Titchner R, Wilson M, et al. Long-term outcomes of laparoscopic Roux-en-Y gastric bypass in US Veterans. Obes Surg 2010;20(3):283–9.
26. Sarela A, Dexter S, McMahon M. Long-term follow-up after laparoscopic sleeve gastrectomy: 8-9 year results. Surg Obes Relat Dis 2012;8(6):679–84.
27. Himpens J. Adjustable gastric banding, sleeve gastrectomy and Roux-en-Y gastric bypass by laparoscopy: long term outcomes and laparoscopic solutions in case of failure (doctoral dissertation). 2013. Retrieved from Maastricht University database.
28. Baltasar A, Serra C, Ferri L. Laparoscopic sleeve gastrectomy: a multi-purpose bariatric operation. Obes Surg 2005;15(8):1124–8.
29. Himpens J, Dobbeleir J, Peeters G. Long-term results of laparoscopic sleeve gastrectomy for obesity. Ann Surg 2010;252:319–24.

30. Eid G, Brethauer S, Mattar SG, et al. Laparoscopic Sleeve Gastrectomy for Super Obese Patients Forty-eight Percent Excess Weight Loss After 6 to 8 Years With 93% Follow-Up. Ann Surg 2012;256(2):262–5.
31. Chiu S, Birch DW, Shi X, et al. Effect of sleeve gastrectomy on gastroesophageal reflux disease: a systematic review. Surg Obes Relat Dis 2011;7:510–5.
32. Marquez M, Ayza M, Poujoulet R. Gastric leak after laparoscopic sleeve gastrectomy. Obes Surg 2010;20(9):1306–11.