Chapter 9
Laparoscopic Sleeve Gastrectomy

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9.1 Introduction

Obesity is endemic in the United States [1]. As of 2016, 39.8% of all adults in the United States were considered obese [2]. Currently, the only long-term durable treatment for obesity is bariatric surgery [1, 3]. In 1999, the vertical sleeve gastrectomy (SG) was performed as the first part of the bilio-pancreatic diversion (BPD) and duodenal switch (DS) [4]. Interestingly, many patients who underwent SG as a staged procedure were noted to have lost enough weight that the BPD-DS did not need to be performed [4]. Therefore, by 2000, SG was being performed as a stand-alone bariatric procedure [1]. Since that time, the laparoscopic SG has gained popularity over the Roux-en-Y gastric bypass (RYGB) due to its technical ease, lower associated morbidity and mortality rates, and effective co-morbidity resolution [1, 5, 6]. Currently, the laparoscopic SG is the most commonly performed bariatric operation in the United States [1, 4]. Herein, we detail our approach to patient selection for laparoscopic SG, the important technical steps of the laparoscopic SG, as well as the postoperative care and long-term follow-up of patients who have undergone a laparoscopic SG.

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9.2 Clinical Presentation

In 1991, the National Institutes of Health (NIH) published consensus guidelines for gastrointestinal surgery for severe obesity. These guidelines stated that adult patients who were believed to have a low probability of weight loss success with nonsurgical interventions with a body mass index (BMI) >40 kg/m^2 or those with a BMI ≥ 35 kg/m^2 with at least one obesity-associated comorbidity, such as obstructive sleep apnea, Pickwickian syndrome, type 2 diabetes mellitus (DM), or osteoarthritis, could be considered for bariatric surgery [7]. Since these initial patient guidelines were published, bariatric surgery has been expanded to include teenage patients who meet similar criteria [8]. Nevertheless, for the purposes of this chapter, we will discuss adult bariatric surgery patients only.

9.3 Preoperative Evaluation and Patient Selection

There are both institutional requirements and patient selection criteria for bariatric surgery. With respect to institution requirements, it is important to understand the history of bariatric surgery. Prior to the development of designated bariatric accredited centers, the mortality rate following bariatric surgery was reported to be as high as 9% [9]. In response to this unacceptably high rate of mortality, designated bariatric accredited centers were proposed [9–11]. This recommendation was proposed by both the American College of Surgeons and the American Society for Metabolic and Bariatric Surgery [11]. In order for an institution to be designated as an accredited bariatric center, there is a minimum number of stapled bariatric cases required that must be performed per year as well as requirements for navigating patients through the bariatric surgery process, including a bariatric surgery medical director as well as specialized nursing staff and bariatric equipment. Currently, close to 90% of all bariatric procedures in the United States are performed at bariatric accredited centers, which includes a robust review process of all morbidities and mortalities experienced by bariatric surgery patients with an emphasis on improving the quality of care delivered to bariatric surgery patients at these accredited centers [12].

Once clinical indications and institutional criteria for bariatric surgery have been met, it is important that bariatric providers follow a multidisciplinary approach, including medical, psychological and dietary counseling prior to considering surgery. When patients are deemed to be surgical candidates, a personalized approach is important when considering what type of bariatric operation to recommend. Ultimately, the type of bariatric procedure (RYGB versus SG) that a patient undergoes is based on a combination of both personal preferences and patient-specific factors. We believe that the long-term success of any bariatric surgery is based on a comprehensive and personalized informed consent process.

First and foremost, it is important to remember that SG is a restrictive procedure only, while the RYGB is both a restrictive and malabsorptive procedure [4].

Therefore, in patients with a BMI > 40 kg/m^2 without the specific comorbidities that we will discuss below who need assistance with portion control only, a laparoscopic SG is a reasonable procedure to offer to a bariatric patient. The determination of RYGB versus SG becomes more complicated as a patient's BMI increases, in patients who have had extensive previous abdominal surgery, and in those patients with specific medical comorbidities. For patients with very high BMIs (≥60 kg/m^2) and/or for patients with extensive previous abdominal surgery, one must consider the ability of the mesentery of the small intestine to reach the gastric pouch without undue tension or disruption of the blood supply to the alimentary limb [13]. For women of child-bearing age who wish to become pregnant following bariatric surgery, we often recommend SG rather than RYGB due to an increased risk of vitamin and nutrient deficiencies following RYGB [14]. Furthermore, while not common, the diagnosis of acute, post-bariatric surgery pathology, such as marginal ulcer perforation or internal hernia formation, can be challenging in the pregnant patient. Finally, patients with either gastroesophageal reflux (GERD) or type-2 DM warrant special consideration when determining the most appropriate bariatric procedure. For patients with already established GERD, the creation of a gastric sleeve can worsen GERD symptoms and lead to esophagitis [15]. We perform preoperative upper endoscopy to screen patients for esophagitis. Furthermore, while bariatric surgery in general has been associated with better glycemic control versus intensive medical therapy for type-2 DM, RYGB has been shown to have higher rates of type-2 DM remission over the long-term [16]. For these reasons, we strongly encourage patients with either GERD or type 2-DM to undergo RYGB and for patients with significant GERD-related pathology, including Barrett's esophagus or severe esophagitis, we do not offer sleeve gastrectomy as a bariatric surgery option.

9.4 Surgical Technique

This section will highlight the key steps for performing laparoscopic SG, as performed at our institution. We recognize that there may be variation in the technical aspects of this procedure and we recommend that variations to the steps below be adopted by surgeons as needed in an effort to maximize both patient safety and surgeon comfort.

1. Routine preoperative interventions are performed, including the administration of preoperative antibiotics and deep venous thrombosis prophylaxis as recommended by the Surgical Care Improvement Project (SCIP) guidelines.
2. Patients are placed supine on the operating room table and both arms are left comfortably abducted.
3. General anesthesia is induced after which we request that an orogastric tube be placed to decompress the stomach prior to gaining access to the abdominal cavity. We also perform selective Foley catheterization.

4. Access to the abdominal cavity is obtained using a Veress needle technique, usually in the left upper quadrant. It is important to pay attention to the opening pressure when insufflation is begun. If the opening pressure is >12 mm of Mercury (mm Hg) it is important to consider that either the patient is not fully relaxed or the Veress needle is either preperitoneal or has penetrated an intra-abdominal structure. If intraabdominal pressures remain high after trouble-shooting these potential causes, an alternative approach to intra-abdominal access, such as with the use of an optical trocar or open, Hasson technique should be employed.
5. We place five trocars: one 15-mm trocar 20 cm from the xiphoid process along the mid-abdominal line near the umbilicus, one 12-mm trocar in the left mid-clavicular line along the rectus muscle approximately 5 cm above the periumbilical/mid-abdominal trocar, one 5-mm port in the left subcostal location along the anterior axillary line, one 5-mm port in the right subcostal location along the rectus muscle just medial to the anterior axillary line, and one 5-mm port just lateral to the falciform ligament (Fig. 9.1).
6. The patient is placed in a reverse Trendelenburg position to allow the small intestine and transverse colon to fall away from the stomach. A liver retractor is positioned through the right lateral port and beneath the left lobe of the liver.
7. The lesser sac is opened and the omental attachments to the greater curvature of the stomach are taken down with the use of an energy device (Fig. 9.2). We begin this dissection at least four centimeters proximal to the pylorus in order

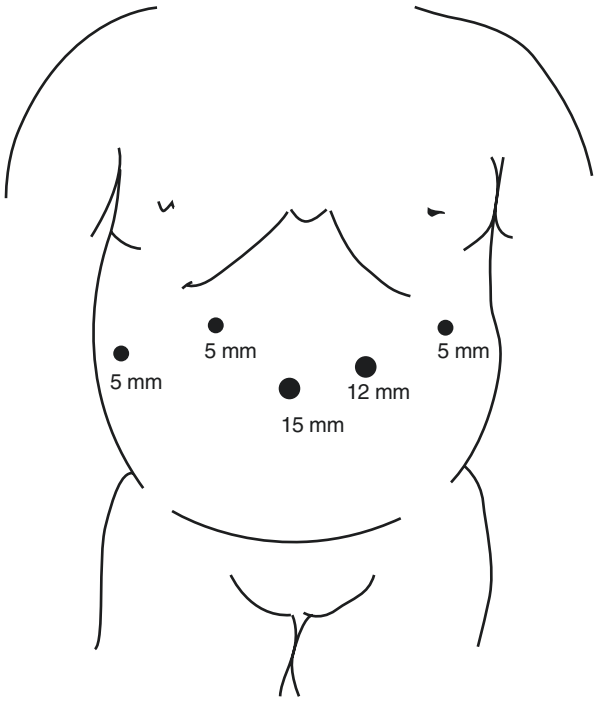


Fig. 9.1 Location and sizes of port used. The right lateral port is used for placement of an articulating liver retractor. The left lateral port is used by the first assistant. The right and left mid-clavicular ports are working ports. The periumbilical port is used for both the camera and as a working port

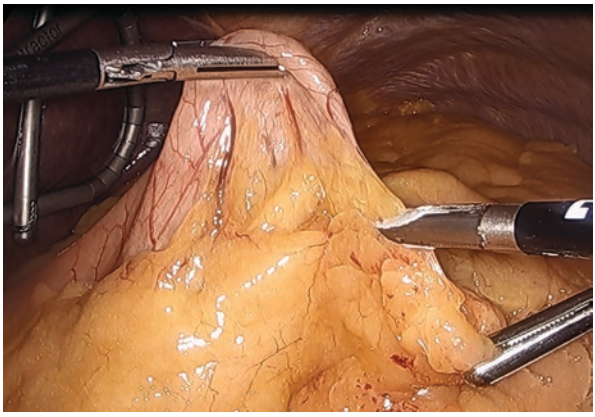


Fig. 9.2 We use the LigaSure™ Device to gain access to the lesser sac and to take down the omental adhesions to the greater curvature of the stomach. This dissection should begin at least four centimeters proximal to the pylorus of the stomach and extend to the angle of His. In this picture, the operating surgeon has placed upward and cranial retraction on the stomach while the assistant has placed downward and caudal retraction on the greater omentum to aid in access to the lesser sac

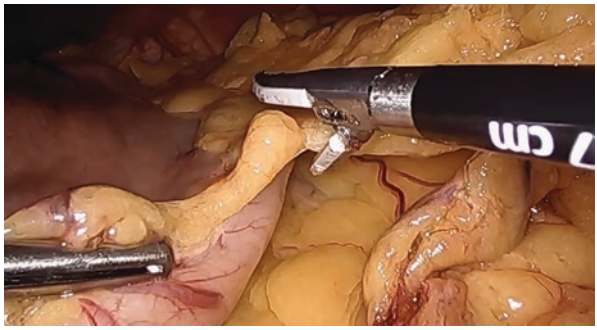


Fig. 9.3 Access to the lesser sac has been achieved. With the use of an energy device, the omentum is completely dissected off of the greater curvature of the stomach, starting near the pylorus and working cephalad towards the hiatus

to minimize the risk of dehydration postoperatively [1]. This dissection along the greater curvature of the stomach is carried proximally to the angle of His (Figs. 9.3 and 9.4). If the patient has a thick omentum that is difficult to retract with just one assistant port, and additional port can be placed in the left upper quadrant to help facilitate better retraction of omentum.

8. Once the greater curvature of the stomach is mobilized, the orogastric tube is withdrawn from the stomach. Once the orogastric tube is withdrawn from the stomach, we confirm with the Anesthesiology team that there are no other foreign objects remaining in the stomach prior to beginning creation of the gastric sleeve.
9. The beginning of the gastric sleeve is started at least four centimeters proximal to the pylorus. We use the end of our atraumatic bowel grasper (2.5 cm when open) to help measure this length (Fig. 9.5).

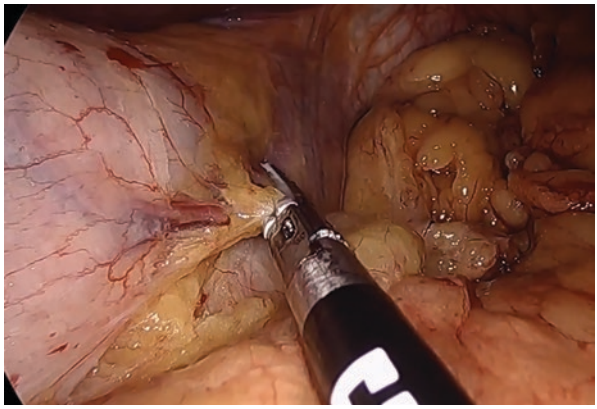


Fig. 9.4 The most cephalad extent of the dissection along the curvature, which releases the hiatal attachments to the angle of His

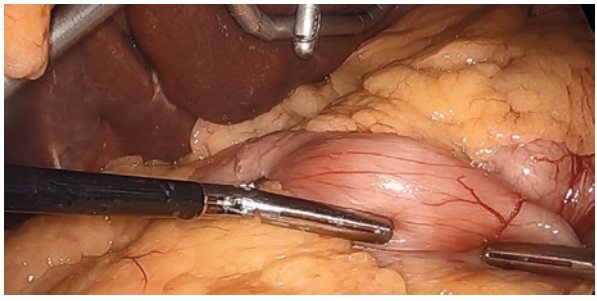


Fig. 9.5 The end of the atraumatic bowel grasper measures 2.5 cm when wide open. This instrument is used to measure the distance from the pylorus and to identify the site at which to begin the sleeve gastrectomy

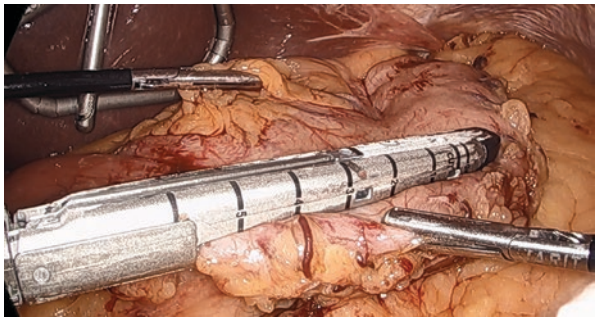
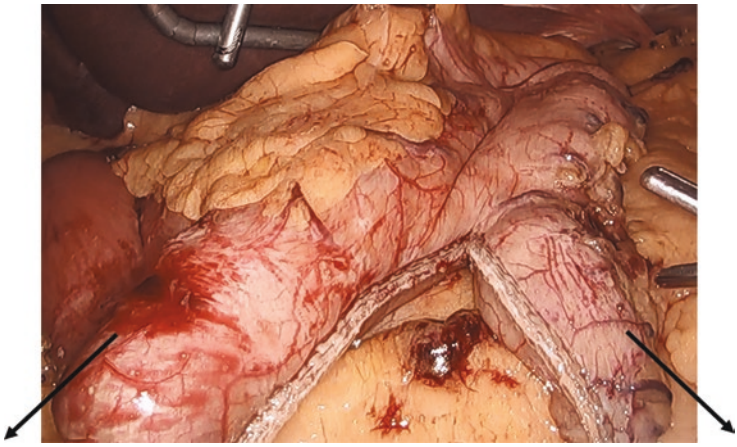


Fig. 9.6 The beginning of the sleeve gastrectomy is started with a thicker (5–6 mm) stapler load. The stapler is articulated as far to the right as possible to minimize encroachment of the incisura angularis

10. We use a thicker stapler load (5 to 6-mm height) to begin the gastric sleeve. In order to prevent postoperative narrowing of the gastric sleeve, this stapler load is articulated as far to the right as possible so that the stapler is oriented parallel to the lesser curvature to minimize the risk of encroachment of the incisura angularis (Fig. 9.6).
11. A blunt-tipped Bougie is introduced by the Anesthesiology team through the mouth, down the esophagus, and into the stomach. The Bougie is guided by the surgical team to lay along the lesser curvature of the stomach (Fig. 9.7). If difficult is encountered during Bougie placement, a lighted Bougie or endoscope,



Beginning of the sleeve gastrectomy with a 40-French blunt-tipped Bougie in place along the lesser curvature of the stomach.

Beginning of the excluded stomach.

Fig. 9.7 In coordination with the Anesthesiology team, a blunt-tipped Bougie is placed through the mouth, down the esophagus, and into the stomach. The bougie should lay along the lesser curvature of the stomach with the distal aspect near the pylorus and adjacent to the beginning of the gastric sleeve staple line

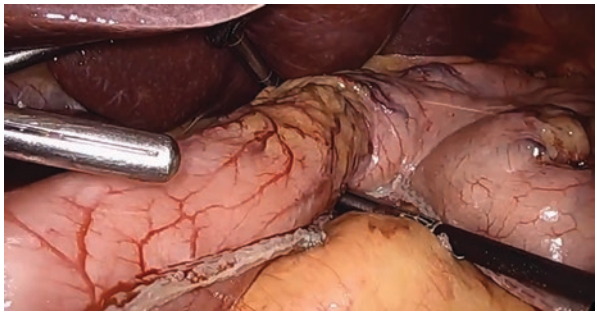


Fig. 9.8 This picture displays a partially created gastric sleeve. The right bowel grasper is pushing on the lateral aspect of the gastric sleeve to identify the Bougie to determine the location of the part of the staple line

depending on a particular institution's resources, can be used instead. We typically use a 40-French (Fr) bougie. The size of the Bougie varies somewhat across institutions but typically ranges from 32 to 50 Fr [1].

12. Using the Bougie (or endoscope) as a guide, creation of the gastric sleeve is continued proximal towards the angle of His using 4–5 mm stapler loads. The stapler firings after Bougie (or endoscope) placement are typically slightly angled to the left. The stapler should be close enough to the Bougie (or endoscope) to create a small sleeve but should not be too close as to risk stapler misfiring or tension on the staple line.
13. We complete the sleeve gastrectomy approximately 2 cm lateral to the esophagogastric junction, using the gastroesophageal fat pad as a landmark (Figs. 9.8 and 9.9). If bleeding is encountered at any point during staple firing, first we

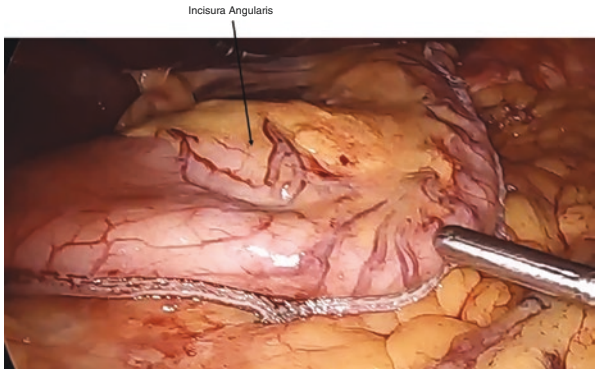


Fig. 9.9 A completed gastric sleeve, with adequate distance between the incisura angularis and the gastric sleeve staple line

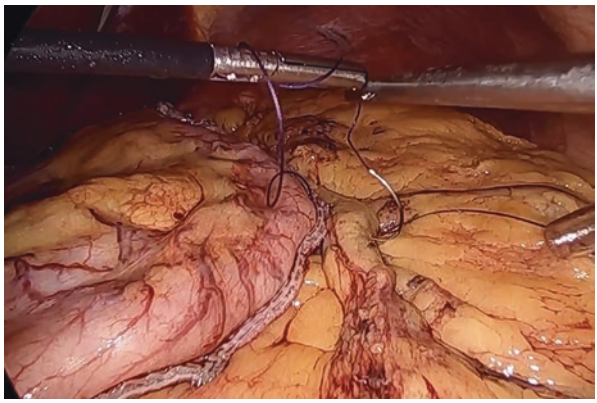


Fig. 9.10 Anchoring of the greater omentum to the gastric sleeve. This helps to prevent twisting or kinking of the gastric sleeve and improves postoperative staple line hemostasis

ensure that the stapler did in fact staple. Next, we ask our Anesthesiology colleagues to lower the patient's blood pressure if it is safe to do so while we hold pressure with an atraumatic grasper at the site of bleeding. If there is brisk bleeding or bleeding persists despite these interventions, we have a low threshold for oversewing the site of the bleeding.

14. The excluded stomach is removed through the 15 mm trocar site. We typically do not use a specimen retrieval bag to remove the excluded stomach.
15. Under laparoscopic visualization, the Bougie is removed from the gastric sleeve by the Anesthesiology team.
16. In order to assist with staple line hemostasis, we anchor the greater omentum to the gastric sleeve using Vicryl suture (Figs. 9.10 and 9.11) [17]. It has been our experience that this intervention also helps to minimize angulation or twisting of the sleeve in the early postoperative period.

9.5 Postoperative Management and Long-Term Follow-Up

Postoperatively, most patients can be safely transitioned to a surgical floor without continuous monitoring. It is important that patients are either transferred to a bariatric specific surgical floor or that they are taken care of by a nurse who has received

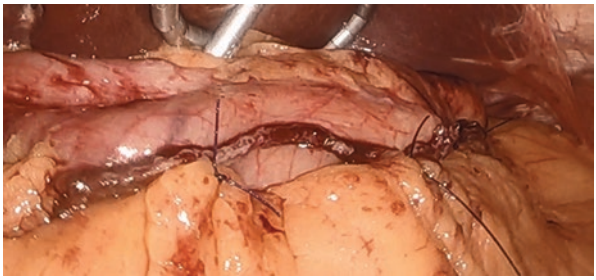


Fig. 9.11 Gastric sleeve staple line reinforcement. This is achieved by placing several interrupted stitches using absorbable sutures from the greater omentum to the lateral aspect of the gastric sleeve

specialty training in caring for postoperative bariatric patients. Our standard postoperative management of bariatric patients is consistent with published recommendations by Telem et al. [18] and includes:

1. Postoperative Diet. Patients are initially made nil per os (NPO). If patients appear well in the afternoon of their surgery day, they are advanced to phase one of our bariatric diet, which includes one ounce per hour of clear, non-carbonated liquids. Prior to discharge from the hospital, patients must be tolerating phase three of our bariatric diet, which includes three ounces per hour of full, non-carbonated liquids and protein shakes. We recommend that all patients drink 60–80 ounces of fluid in addition to a protein intake of at least 60 g in a 24-h period. Once discharged from the hospital, a patient's diet is slowly advanced over the course of the next several weeks, first to a pureed diet then to a soft diet and finally a regular consistency diet of small, frequent meals and snacks by 4–6 weeks postoperatively.
2. Management of Home Medications. All diuretic medication and long-acting insulins are held while patients are in the hospital. There have been few occurrences where a patient has had persistently elevated blood pressure or blood sugar postoperatively. In these instances, we have a low threshold to consult our Internal Medicine or Endocrinology colleagues for further assistance. We instruct patients that they should check their blood pressure and/or blood sugar at least daily after discharge and that they should schedule an appointment with their primary care physician within 2 weeks of their bariatric operation for further management of their home medication regimen.
3. Use of Non-Invasive Ventilation. Patients with obstructive sleep apnea who undergo bariatric surgery should continue to use their continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BiPAP) machines postoperatively. We encourage patients to have their machine re-fitted prior to surgery and for them to bring their own machine for use postoperatively [19].
4. Postoperative Pain Management. We encourage a multi-modal pain regimen with the minimization of narcotic pain medication, as possible.
5. Postoperative Venous Thromboembolism (VTE) Prophylaxis. While in the hospital, all patients are either administered subcutaneous Heparin 7500 units three times daily or subcutaneous enoxaparin 40 mg daily. We use the risk calculator developed by Aminian et al. to identify those patients who would benefit from

extended VTE prophylaxis [20]. For patients who are identified as having a high-risk for developing postoperative VTE, they are instructed to self-administer enoxaparin 40 mg daily for 4 weeks postoperatively. Of note, there is currently no consensus as to the type or duration of extended VTE prophylaxis, and these practices may be different by institution [21, 22]. Patients are provided with home enoxaparin teaching prior to discharge from the hospital.

6. Postoperative Protein, Vitamin, and Mineral Supplements. Patients are instructed to begin bariatric protein supplements immediately postoperatively with the addition of a bariatric vitamin/mineral supplement by the first postoperative visit.
7. Postoperative Follow-Up. All patients are evaluated by their bariatric surgeon within the first 7–10 days postoperatively. Thereafter, patients are seen in the bariatric surgery clinic by a certified bariatric surgery nurse practitioner and dietician. Patients are seen in the bariatric surgery clinic at 1, 3, 6 months, and 1 year postoperatively and then annually thereafter. Bariatric vitamin and mineral panels are checked at each of these visits and vitamin and mineral supplementation is tailored, as appropriate.
8. Reporting of Postoperative Outcomes. Weight loss outcomes and improvement and resolution of cardiometabolic comorbidities are documented based on the standard definitions proposed by Brethauer et al. [23]

9.6 Conclusions

The long-term success of any bariatric procedure depends on appropriate patient selection, a thorough informed consent process, and sound surgical technique. It is our intention that this chapter serves as a guide to the perioperative management of patients undergoing laparoscopic SG. While we recognize that there will be some variation in surgical technique, the key steps described in this article are essential to producing long-term and durable outcomes following laparoscopic SG.

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