19.2
Laparoscopic Sleeve Gastrectomy

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With the current epidemic of obesity spreading worldwide, surgical weight loss has been shown to be the most effective treatment. However, severely obese patients, that is, those with a body mass index (BMI) over 60, have an increased number of comorbid conditions and thus an increased operative risk. Several studies have demonstrated an increased rate of complications with weight-loss surgery in this group of patients with approximately two to three times greater risk of morbidity and mortality than the morbidly obese patient with a BMI less than 60 (1–3).

Patients with a high BMI (>60) or associated high-risk medical conditions have the greatest to gain from procedures such as the Roux-en-Y gastric bypass (RYGBP) and biliopancreatic diversion with duodenal switch (BPD-DS), but the increased risk of postoperative complications often renders them poor surgical candidates. To this end, investigators have attempted various bridging procedures designed to impart an effective weight loss and reduce the risk of complications in the subsequent, definitive weight loss procedure. These include an array of restrictive procedures such as endoscopically placed intragastric balloons, laparoscopic adjustable gastric banding (LAGB), and laparoscopic sleeve gastrectomy (LSG). The second stage would involve completion to RYGBP or BPD-DS.

The LAGB is generally performed as a primary weight loss procedure, whereas LSG has traditionally been performed as part of a BPD-DS. Indications for performing only a LSG include super-super-morbid obesity (BMI >60), high-risk comorbid conditions, increased age, unfavorable anatomy (cirrhosis, profuse visceral fat, poor exposure, extensive intraabdominal adhesions), and any combination of these factors (Table 19.2-1). The LSG has also been used in patients with inflammatory bowel disease, in whom integrity of anastomoses is a concern, and in patients with gastric nodules, in whom performance of a RYGBP would make surveillance of the gastric remnant extremely difficult.

Technique

There are minor variations of the procedure, but in general, 75% to 80% of the greater curvature is excised, leaving a tubularized stomach. We use the same port placement for LSG as we do for laparoscopic gastric bypass (see Chapter 21.4). The lesser sac is entered by opening the gastrocolic ligament. A point on the greater curve, on the antrum, is chosen as the starting point. This has previously been described as ranging from 2 to 10 cm from the pylorus. A laparoscopic stapler, with a blue load (3.5-mm staple height), is introduced and fired on the antrum, toward the angle of His. A 32- to 60-French bougie is then passed transorally into the pylorus, placed against the lesser curvature. The stapler is fired consecutively along the length of the bougie until the angle of His is reached (Fig. 19.2-1). At this point, approximately 75% to 80% of the stomach has been separated. The short gastric vessels and the greater curvature ligaments (gastrosplenic and gastrocolic) are divided with ultrasonic dissection to complete the resection (Fig. 19.2-2). The specimen may be removed by enlarging one of the 12-mm ports. A drain is then placed alongside the staple line.

Although the procedure does not involve any anastomoses, the length of the staple line still renders the patient at risk for bleeding or a leak. Several authors have described oversewing the long staple line, while others have employed buttressed staples or fibrin glue as a sealant. The potential benefits of an absorbable polyglyconate polymer staple line buttress were demonstrated in a randomized study of patients undergoing LSG with or without BPD-DS (4). Ten patients were randomized to a control group in which the LSG was performed in the conventional fashion, and the other 10 patients underwent a LSG, in which the absorbable polymer membrane was integrated into the length of the gastric staple line. Although the number of patients was small, the investigators were able to demonstrate significantly less intraoperative blood loss in the buttressed staple line group

Table 19.2-1. Indications for laparoscopic sleeve gastrectomy

First stage toward Roux-en-Y gastric bypass (RYGBP) or biliopancreatic diversion with duodenal switch (BPD-DS) in
Super-super-obese (BMI >60)
Severe comorbidity
Advanced age
Combination of any of above
Poor intraoperative conditions
Extreme hepatomegaly or cirrhosis
Profuse visceral fat
Poor exposure
Extensive intraabdominal adhesions
Cardiopulmonary instability
Inflammatory bowel disease
Surveillance of gastric remnant required

(120 vs. 210 mL, $p < .05$). Furthermore, two staple line hemorrhages occurred in the control group postoperatively, but none in the buttressed staple line group. Of the 20 patients, no staple-line leaks occurred.

The LSG is a purely restrictive operation that reduces the size of the gastric reservoir to 60 to 100 mL, permitting intake of only small amounts of food and imparting a feeling of satiety earlier during a meal. More recently, studies have examined whether ghrelin levels may explain the mechanism of success of the LSG. Ghrelin, thought to be a hunger-regulating peptide hormone, is mainly produced in the fundus of the stomach. By resecting the fundus in an LSG, the majority of ghrelin-producing cells are removed, reducing plasma ghrelin levels and subsequently appetite.

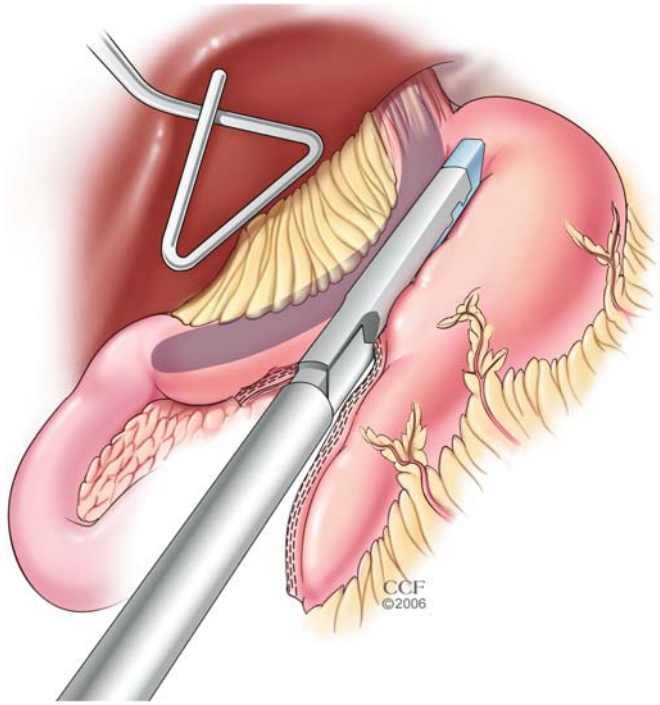

Figure 19.2-1. Laparoscopic sleeve gastrectomy. The stapler is fired successively from the antrum to the angle of His adjacent to an intragastric bougie. (Courtesy of the Cleveland Clinic Foundation.)

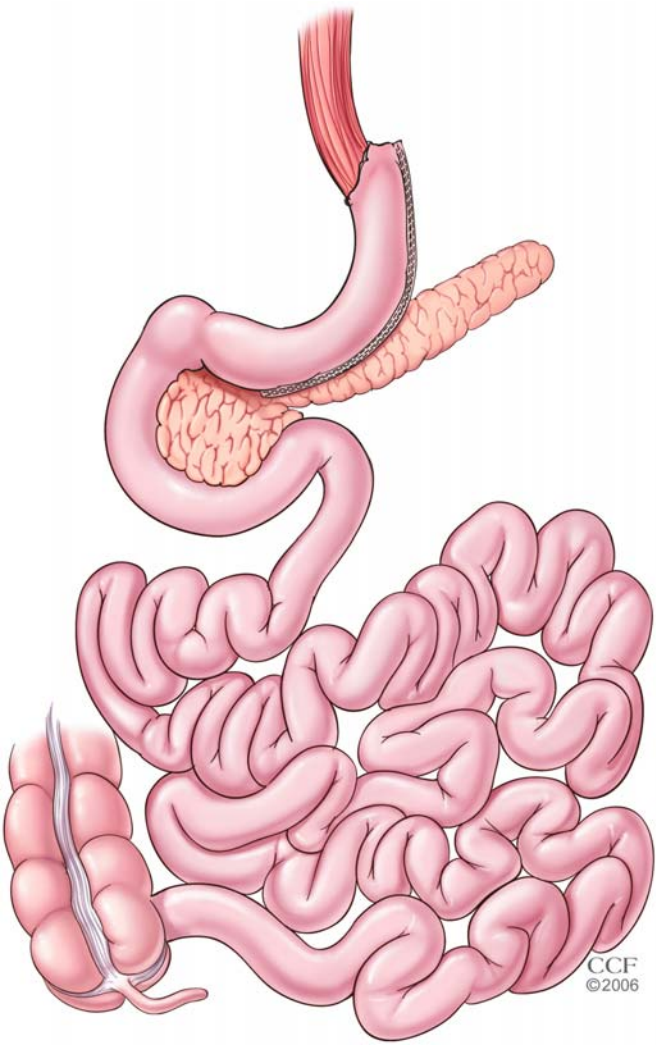

Figure 19.2-2. Completed sleeve gastrectomy demonstrating a tubularized stomach. (Courtesy of the Cleveland Clinic Foundation.)

Outcomes

In a prospective study of 20 patients, the effects of LSG on immediate and 6 months postoperative ghrelin levels were compared to that of LAGB (5). Ten patients each were randomized to undergo either LSG or LAGB. Groups were comparable at baseline, with an overall mean BMI of 45 ± 4.7. Patients who underwent LSG achieved a higher excess weight loss at 1 and 6 months postoperatively compared with the LAGB group. The LSG patients also showed a significant decrease of plasma ghrelin levels at day 1 compared to preoperatively, which remained low

through 6 months. In contrast, in patients who underwent LAGB, plasma ghrelin levels did not change perioperatively and were found to significantly increase at 1 month. Although both procedures are purely restrictive in nature, the superior short-term weight loss experienced by LSG patients may be attributed to the lower ghrelin levels, which may prevent an increase in appetite as a compensatory mechanism.

These results were confirmed in a subsequent study of super-super-obese patients (6). Four female patients, with BMI ranging from 61 to 67, underwent a LSG. Weight loss and ghrelin levels were compared to a group of 15 patients (BMI 39–50) who underwent LAGB. Again, the patients who underwent LSG experienced a greater degree of weight loss compared to their LAGB counterparts (mean decrease of BMI 16.3 vs. 7.6). As well, the study confirmed that ghrelin levels were reduced after LSG, a value of 23.3% less than preoperatively (mean follow-up 6 months). Conversely, in the LAGB group, ghrelin levels had increased by 14% at a mean follow-up of 18 months. Despite the protracted decrease in ghrelin levels in the LSG patients, weight regain was noted in one patient after 1 year. Although ghrelin may be integral to the mechanism of weight loss in LSG, further studies will require larger patient groups and collection of ghrelin levels over a prolonged postoperative time course.

The safety and efficacy of LSG has been examined in a prospective study by Mognol et al. (7). The study included 10 patients, all with BMI >60 (mean 64, range 61–80), and average age of 42.7 years. Patients had an average number of 3.4 comorbidities, but 50% had hypertension and 90% had sleep apnea. Mean operative time was 120 minutes (range 90–150 minutes), and average length of stay was 7.2 days. In this small study group, there were no mortalities and no complications. At 6 months postoperatively, there was 41% excess weight loss, and average BMI had been reduced to 48. At 1 year post-LSG, excess weight loss increased to 51% and BMI further decreased to 41, although there was only 30% follow-up. Improvement of comorbidities was not reported.

Similar results were demonstrated in a retrospective study by Baltasar et al. (8) that analyzed the experience of 31 patients who underwent LSG for varying reasons. Seven patients were super-super-obese (mean BMI 65, range 61–74) and they underwent the LSG as a first stage toward completion BPD-DS. Another 23 patients had significant comorbidities or intraoperative findings that did not make the full BPD-DS advisable. One patient was converted from LAGB to LSG due to severe symptoms from the initial procedure. There were no instances of deep vein thrombosis (DVT)/pulmonary embolism (PE), leak, or pneumonia. However, there were two instances of trocar-related intraabdominal bleeding, one leading to death. Mean excess weight loss ranged from 56.1% (at 4 to 27 months) in the super-obese patients to 62.3% (3–27 month follow-up) in the lower BMI patients with significant comorbidities.

In another study, Almogy et al. (9) retrospectively examined 21 patients who underwent LSG. Indications for the procedure included high-risk patients, that is, those with severe pulmonary dysfunction, history of myocardial infarct, renal transplant, hypercoagulable state, and nephrotic syndrome. The remaining patients were initially planned for a BPD-DS, but due to intraoperative considerations (unfavorable anatomy or hemodynamic instability), only a sleeve gastrectomy was performed. Initial average BMI was 57.5 (range 53–71.5) and mean age was 44. Overall, patients had a mean number of comorbidities of 3.6, with a majority having hypertension, diabetes mellitus, venous stasis, and significant joint disease. There were no perioperative deaths, but there were two late deaths (at 3 and 6 months). Five of the 21 patients had complications (23.8%), which included postoperative hypotension, aspiration pneumonia, wound infection and sepsis, hepatic insufficiency, and a perioperative myocardial infarct. One year following LSG, patients experienced approximately 45% excess weight loss. Furthermore, hypertension, diabetes, and congestive heart failure had resolved or improved in 38%. Following sleeve gastrectomy, patients were thus able to achieve significant weight loss with an acceptable complication rate. Three patients lost enough weight to undergo subsequent spine or pelvic procedures, and two patients were able to continue on to BPD-DS, demonstrating the possibility of using LSG as an interim procedure in high-risk patients.

Debate exists as to what is the most effective initial procedure in high-risk patients. Besides LSG, options include LAGB and placement of an endoscopic intragastric balloon. Gagner's group (10) therefore compared LSG to the BioEnterics intragastric balloon (BIB) as a first-stage procedure for effective initial weight loss prior to definitive weight loss surgery. Numerous intragastric balloons have been tested and abandoned due to various complications such as erosion, ulcers, and intestinal obstruction. However, the BIB has become accepted as a viable option for weight loss outside the United States (11). The balloon is placed endoscopically and reduces the volume of the stomach, thereby acting as a restrictive procedure.

Gagner's group (10) retrospectively examined their experience in 20 LSG patients with BMI >50 to that of 57 BIB historical controls (BMI >50) described over two studies in the literature. At 6 months, the LSG group experienced a greater excess weight loss than the two BIB groups (34.9% vs. 26.1% and 21%). Baseline BMI and weight were equal between the LSG and BIB patients, but LSG patients experienced a 15.9 decrease in mean BMI versus 9.4 and 6.4 in the BIB patients.

Each patient in the LSG and BIB group demonstrated improvement in comorbidities such as hypertension, osteoarthritis, and sleep apnea. Among the 20 LSG patients, the only complication was a trocar site infection. However, 7% (four patients) in the BIB group required removal of the balloon, and one patient spontaneously eliminated the balloon in stool. Other noted complications included severe vomiting and dehydration in two patients. Both procedures, therefore, demonstrated positive results as a possible bridging procedure in the super-super-obese, although a more significant weight loss was effected with LSG, with less complications in this limited study.

The feasibility of LSG in the context of a staged procedure has also been examined. In a retrospective analysis of seven patients who underwent LSG followed by RYGBP, Pomp's group (12) demonstrated the efficacy and safety of a two-stage approach to surgical weight loss in high-risk super-super-obese patients. These patients had an average age of 43 and preoperative mean BMI of 63 (range 58–71). Mean operative time for stage I was 124 minutes and 158 minutes for stage II, with a length of stay (LOS) of 2.7 days, averaged over all 14 procedures. Following stage I, there were three complications in two patients (42.9%), which included postoperative bleeding, a urinary tract infection, and port-site hernia (discovered at stage II). Following stage II, there were two complications (28.6%), which included a gastrojejunal stricture and temporary arm nerve praxia. There were no mortalities. The second stage was performed within a mean of 11 months (range 4–22 months) and the BMI had fallen to 50 with average excess weight loss of 33%. Although follow-up for the completion RYGBP was short (average 2.5 months), patients continued to lose weight, with an average excess weight loss of 46%. Improvement or resolution of comorbidities was not reported.

The largest study of LSG to date involved 126 patients who underwent LSG as a first stage, en route to completion RYGBP (13). In the majority of the procedures (>90%), LSG had been planned preoperatively due to high BMI or severe comorbid conditions. The rest of the patients were chosen after intraoperative abdominal evaluation demonstrated unfavorable anatomy. The group of patients had a preoperative BMI of 65.4 ± 9 (range 45–91) and numerous comorbid conditions, the average number being around 9. Around 42% were American Society of Anesthesiology (ASA) I class II and 52% were ASA class IV.

Of the 126 patients, 36 patients proceeded to stage II completion RYGBP approximately 1 year post-LSG (range 4–22 months). At the time of the second stage, the mean number of comorbid conditions had decreased to 6.4 ± 3 and the percentage of patients with ASA III or IV was 44%, compared to 94% prior to stage I. The BMI had also reduced significantly to 49.5 ± 8. At stage II completion RYGBP, mean operative time for the 36 patients was 229 ± 65 minutes and mean LOS was 3 days. There were no mortalities after LSG and no mortalities after completion RYGBP. The complication rate after stage I was 14%, including five strictures, two leaks, two pulmonary embolisms, four cases of transient renal insufficiency, and five patients requiring more than 24 hours of ventilatory support.

Although the rate of complications appears elevated, the majority of complications were self-limited. Nevertheless, the marked improvement in the medical comorbidities reduced the operative risk in those patients undergoing stage II. Every patient with diabetes and almost all patients with sleep apnea showed improvement of their comorbidity prior to undergoing completion RYGBP. As well, all cases of peripheral edema resolved, and patients with degenerative joint disease showed significant improvement in activity levels prior to stage II, facilitating early ambulation postoperatively. Of the 36 patients, 6 experienced complications (17%), which included three postoperative bleeds, one leak, one acute cholecystitis, and one marginal ulcer. Although 6-month follow-up for completion RYGBP was limited to 20 patients at the time of publication, patients continued to lose weight [excess weight loss (EWL) 55%] and a clear majority had either resolution or improvement in major medical comorbidities.

The feasibility of LSG as a sole surgical weight loss option has also been examined in the Korean population (14). Due to various cultural factors, weight loss surgery is not as prevalent and this is reflected in the demographics of the low-risk population (mean BMI 37.2, range 30–56, and mean age 30, range 16–62). Although 130 patients underwent LSG, 1-year follow-up data were obtained on only 60 patients. Excess weight loss was 83.3% and BMI had decreased to 28. Preoperatively, there were an average of 2.1 comorbidities in the 60 patients and a majority of these had resolved or improved by 6 months. There was 100% resolution of fatty liver, sleep apnea, diabetes, and asthma at 6 months and 100% resolution of joint pain, reflux esophagitis, and amenorrhea at 1 year. Hypertension was resolved in 93% at 1 year, and improved in the remaining 7%. Dyslipidemia was the only comorbidity that was not fully improved at 1 year (65% resolution and 10% improvement). Of the 130 initial patients, there was one leak, one case of delayed bleeding, one case of prolonged vomiting, and two cases of atelectasis. There were no mortalities. Despite the excellent results, weight loss plateaued in the majority of patients at 1 year. Also, five of the 60 patients have been identified as requiring a secondary weight loss procedure for failure to lose adequate weight.

The LSG as a sole weight loss procedure was also examined by Langer et al. (15). The aim of the study was to evaluate the effectiveness of LSG in a mostly lower

Table 19.2-2. Reported case series of laparoscopic sleeve gastrectomy

	n	Age	BMI (mean)	Comorbidities per patient	OR time (min)	LOS (days)	EWL (%)	Follow-up (months)	Mortality	Complications
Cottam et al.	126	49.5	65.4	9.4	143	3	45	12	0%	14% (18/126)
Han et al.	60	30	37.2	2.1	70	—	83.3	12	0.8% (1/130)	3.1% (4/130)
Baltasar et al.	7	—	65	—	—	—	56.1	4–27	14.3% (1/7)	0%
	7	—	>40	—	—	—	33.6–90	4–16	0%	0%
	16	—	35–43	—	—	—	62.3	3–27	0%	6.3% (1/16)
Langer et al.	23	41.2	48.5	—	—	—	46	6	0%	—
							56	12		
Almogy et al.	21	44	57.5	3.6	—	7	45	6–20	9.5% (2/21)*	23.8% (5/21)
Milone et al.	20	43	68.8	3.7	—	—	34.9	6	0	5% (1/20)
Mognol et al.	10	42.7	64	3.4	120	7.2	41	6	0%	0%
							51	12		
Langer et al.	10	39.3	48.3	1.6	—	—	61.4	6	0%	0%
Regan et al.	7	43	63	3.1	124	2.7	33	11	0%	42.9% (3/7)

BMI, body mass index; EWL excess weight loss; LOS, length of stay; OR, operatingroom.
—, not reported; * outside the perioperative period.

BMI group of patients. Of the 23 patients prospectively studied, eight patients had a preoperative BMI >50 (mean BMI of the entire group was 48.5). At 6 months, mean excess weight loss among all 23 patients was 46%, and at 1 year it was 56%. No significant differences in percent EWL were demonstrated between patients with initial BMI <50 and those with BMI ≥50. Two patients required conversion to RYGBP—one patient for failure to lose weight and the other for severe gastroesophageal reflux. Partial weight regain was observed in an additional three patients in a median follow-up of 20 months. All patients underwent a contrast study on postoperative day 1, and 14 patients underwent a follow-up contrast study at 1 year. Only one patient was noted to have dilatation of the stomach (width of gastric tube >4 cm), but this patient had experienced an adequate excess weight loss of 59% and continued to experience early satiety. Weight loss from LSG was demonstrated to be very effective, even comparable to that of RYGBP; however, follow-up was limited to approximately 1 year, when long-term durability of the sleeve gastrectomy becomes an issue. Moreover, no data are provided regarding comorbidities and postoperative complications. A summary of the currently published case series utilizing LSG is shown in Table 19.2-2.

Conclusion

As the prevalence of surgical weight loss procedures continues to increase, surgeons will be faced with an increasing number of super-obese and high-risk patients. Recognizing the potential for devastating postoperative complications in this group of patients with low physiologic reserve, staging techniques such as laparoscopic sleeve gastrectomy may reduce the overall complications. This requires a second major laparoscopic operation, which entails not only a second general anesthetic but also additional costs. However, the definitive weight loss operation can be performed when patients' anatomic factors are more reasonable and comorbid conditions have improved, thereby lessening the risk of postoperative complications.

The LSG has been shown to effect significant weight loss with a low complication rate, in addition to a beneficial impact on comorbidities. As a stand-alone procedure, excellent success has been reported in the short term. However, concerns about the longevity of the operation remain. At the present time, more long-term results are necessary to determine the durability and incidence of late complications after LSG.

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