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# Laparoscopic Sleeve Gastrectomy for Morbid Obesity: The Future of Bariatric Surgery?


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## ABSTRACT

The incidence of obesity has significantly increased worldwide. Surgery has proven to be the most effective long-term treatment for sustained weight loss and improvement of co-morbidities in morbidly obese patients. Laparoscopic sleeve gastrectomy (LSG) is a relatively new procedure for weight loss with lower surgical risks, which is particularly suitable for those patients at highest risk for surgery, either because of their co-morbidities or their weight. LSG is being explored as a viable surgical option for treating morbid obesity, after simply being considered the first step of a staged procedure in super-obese/high-risk patients to allow some weight loss before a laparoscopic Roux-en-Y gastric bypass or biliopancreatic diversion-duodenal switch procedure. With the revelation that patients experience safe weight loss after LSG, interest in using this procedure as a bridge to more definite surgical procedures has risen. Outright reported benefits of LSG include the low rates of complications, the avoidance of foreign material, the maintenance of normal gastro-intestinal continuity, the absence of malabsorption, and the reduction of gherlin producing mass, accounting for its superiority to other restrictive bariatric surgical procedures. Although early results after LSG are promising in terms of short-term weight loss, more studies are required to evaluate the long-term durability of LSG especially effective weight loss, maintenance of weight loss, resolution of co-morbidities, and the potential of gastric tube dilatation with weight regain.



*Keywords: Morbid obesity; laparoscopic sleeve gastrectomy; bariatric restrictive surgical procedure;*



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# 1. INTRODUCTION

## 1.1 General

Obesity has assumed pandemic proportions mainly attributable to dietary habits and sedentary lifestyles. More than 1.7 billion adults are overweight and at least 300 million of them are clinically obese (Deitel, 2003). It is a major contributor to the global burden of chronic disease and disability. Often co-existing in the developing countries with under-nutrition, obesity is a complex condition, with serious medical, social, psychological, and economical implications, affecting virtually all age groups (World Health Organization, 2000). Current evidence suggests an early onset of obesity-related co-morbidities in Asians at lower Body Mass Index (BMI) levels (Chowbey et al., 2009; Misra and Vikram, 2001). The co-morbidities include type 2 diabetes, cardiovascular disease, hypertension, hyperlipidemia, hypoventilation syndrome, asthma, sleep apnea, stroke, pseudotumor cerebri, arthritis, several types of cancers, urinary incontinence, gallbladder disease, and depression (Tice et al., 2008; Fuks et al., 2001).

Obesity shortens life expectancy (Dindo et al., 2004) with increasing BMIs, resulting in proportionally shorter lifespan (Moorehead et al., 2003). With over 300,000 victims in the USA each year, morbid obesity is projected to overtake smoking as the leading cause of death in the near future (Braghetto et al., 2007). Non-operative management with diet, exercise, behavior modifications, and medications rarely achieves adequate sustainable weight loss (Almogy et al., 2004). Surgery is the only proven long-term effective treatment for morbid obesity (Mognol et al., 2005). However, surgical treatment of high-risk patients remains a challenge even in highly specialized centers. High-risk patients include super-super-obese patients with BMI >60 $kg/m^2$ and patients with severe co-morbidities. Both have higher peri-operative morbidity and mortality following bariatric operations (Fernandez Jr. et al., 2004).

## 1.2 Bariatric Surgery and Minimal Invasive Surgery

Since the advent of minimally invasive therapies, there has been a dramatic increase in gastrointestinal procedures that produce significant sustainable weight loss, with noticeably lower complication rates (Jacobs et al., 2009; Oluseum et al., 2007). Surgically induced weight loss is associated with total resolution or improvement of co-morbid diseases in 75-100% of patients (Buchwald et al., 2004), in addition to a reduced mortality, compared with medically treated patients (Busetto et al., 2007). The most commonly performed bariatric procedure in the USA is Roux-en-Y gastric bypass (RYGBP) (Gumbs et al., 2005). This is due to its effective long-term weight loss and treatment of co-morbidities, as well as due to the fact that it is being increasingly performed laparoscopically (Cottam et al., 2003; Gumbs et al., 2007). Laparoscopic adjustable gastric banding (LAGB) was approved in the USA after a lengthy FDA trial. However, there is some concern about its effectiveness due to lesser weight loss achieved, compared to RYGBP and the fact that up to one-third of bands had to be removed in some studies (Gumbs et al., 2005; Balantyre et al., 2005). In 2004, the *Centers for Medicare and Medicaid Services* (CMS) added Biliopancreatic Diversion (BPD) to the list of recommended bariatric procedures for the surgical management of morbid obesity. LSG was first described as a modification to the BPD and combined with a duodenal switch (DS) in 1998, and was first performed laparoscopically in 1999 (Marceau et al., 1998). BPD-DS consists of a sleeve gastrectomy as a component of restriction and then duodeno-ileostomy as an intestinal bypass. Benefits of sleeve gastrectomy in BPD-DS include preservation of the pyloric valve and gastric antrum as compared to distal gasterctomy in standard BPD, resulting in decreased complications associated with gastrojejunostomy such as marginal ulceration and dumping syndrome (Gagner and Boza 2006; Lee et al., 2007).

### 1.3 Comparing LSG to Others

Initial success in bariatric surgery is defined as a >50% loss of excess weight (Balantyre et al., 2005). Average excess weight loss is greatest with BPD (range 75-80%), followed by RYGBP (range 65-80%), and then vertical band gastroplasty (range 50-60%). Patients experience excellent weight loss after LSG alone, and recently, several studies have recommended LSG as single therapy in the treatment of morbid obesity (Alexander et al., 2009; Hamoui et al., 2006.; Tucker et al., 2008; Nguyen et al., 2005; Regan et al., 2003; MoonHan et al., 2005; Baltasar et al., 2005). Nonetheless, the use of LSG as a bridge to more definite surgery is perhaps its most striking role (Gumbs et al., 2005). In super-obese (BMI >50 $kg/m^2$) and super-super obese (BMI>60 $kg/m^2$) patients, the incidence of complications and mortality is increased due to more prevalent co-morbidities and increased difficulty in performing surgery. By using less invasive procedures such as LSG as initial management in the super-obese patients, an over-all morbidity and mortality may be reduced (Carmichael et al., 2001).

## 2. OPERATIVE TECHNIQUE OF LSG

### 2.1 The Setup

The procedure can be performed in any operating room suitable for bariatric patients and equipped with the necessary laparoscopic instruments. Patient preparation includes pre-operative heparinization, intra-arterial and central venous lines, nasogastric tube, urine catheter, and customized compression stockings. All pressure points are cushioned. The patient is placed in a steep reverse Trendelenberg position with the knees slightly flexed and hip externally rotated.

### 2.2 The Surgery

Pneumoperitoneum is created using the Veress needle technique. Ports placement is shown in Figure 1.

Using the xiphisternum as an anatomical landmark, an arc is made at 18 cm, with ports in the midline (camera port), right and left mid-clavicular lines, and left mid-axillary line. The liver is retracted using a Nathanson's self-retaining liver retractor via an epigastric (sub-xiphisternal) port. The surgery begins by the division of the gastrocolic omentum, starting 5–6 cm proximal to the pylorus (identified by the "crow's foot") using the Harmonic Scalpel™ (Ethicon Endosurgery, Cincinnati, OH, USA) and proceeding up to the angle of His. The short gastric vessels are identified and divided. The first short gastric vessel is generally divided between clips. Dissection is performed up to the left crus of the hiatus, and all attachments are released to completely mobilize the fundus. The gastric sleeve is created using sequential firings of a 60-mm linear stapling device (Echelon™ 60 Endopath® Stapler ethicon Endosurgery, Cincinnati, OH, USA). The staplers are applied alongside a 36-Fr calibrating bougie positioned in the stomach against the lesser curve so as to avoid stenosis and to obtain a narrow gastric tube. Bioabsorbable glycolide co-polymer Gore Seamguard (W.L. Gore & Associates, Inc, Flagstaff, AZ) is used to reinforce the staple line in an attempt to reduce the risk of hemorrhage and staple-line leakage. The bougie is withdrawn, and a leak test is performed using per-operative intragastric methylene blue dye. The resected specimen is placed in an endobag and retrieved via the 15-mm port. Following sleeve gastrectomy, a simultaneous cholecystectomy is performed in patients with a pre-operative diagnosis of gallstones. A suction drain is placed in the lesser sac, hemostasis is ensured, and port sites are closed.

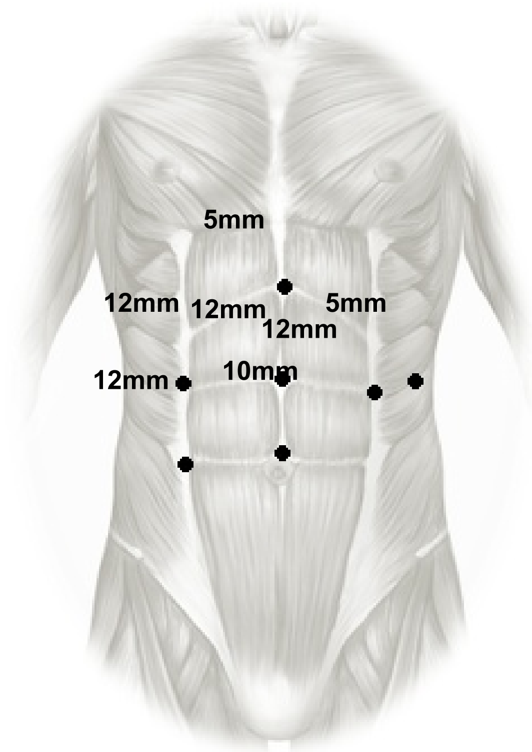


**Fig. 1. Trocar placement for laparoscopic sleeve gastrectomy**

## 3. COMPLICATIONS OF LSG

Apart from the commonly reported complications of LSG (Table 2), the most frequently encountered are the following;

### 3.1 Gastric Pouch Dilatation

There has been growing concern about the gastric pouch dilatation following LSG. In an effort to avoid gastric dilatation in the long-term, surgeons began performing LSG with the smallest possible bougies to create an acceptable micropouch. Durable weight loss can be achieved after LSG if a bougie no larger than a 42 Fr. is used for primary treatment of morbid obesity (Rao et al., 2006). Alexander et al used a band of processed human dermis (AlloDerm) around the upper portion of a sleeve gastrectomy to prevent late dilatation and weight gain. The results were comparable to RYGBP, matched for sex, age, and initial BMI.

### 3.2 Staple Line Leak and Hemorrhage

Another potential complication site after LSG has been the long staple-line created along the stomach. Concerns regarding staple-line hemorrhage and leak have resulted in attempts to avoid these complications by the use of buttressing material. Initially non-absorbable material was used acting as a buttress along staple-lines. However, after one case of bovine pericardium migration and expulsion in a patient's vomitus, this practice was abandoned (Silecchia et al., 2006). Gumbs et al. (2005) reported the use of an absorbable polymer buttress material along LSG staple-lines and noted decreased incidence of staple-line hemorrhage and leak. Use of this material resulted in decreased overall complications and hospital stay. Importantly, many groups use a continuous running suture of the staple-lines and note that this adequately controls staple-line hemorrhage and may decrease adhesion formation with a lower overall operative cost (Catheline et al., 2006).

The major disadvantage of LSG is its irreversibility which can be a potential argument against this procedure.

## 4. MAJOR APPLICATIONS OF THE LSG

### 4.1 LSG as A Stand-Alone Procedure

LSG, as the first operation in a two-stage management of morbid obesity, was first reported in super-obese patients who underwent LSG, which was followed by a second-stage laparoscopic RYGBP (Regan et al., 2003). Since that initial study, a number of studies have been published looking at outcomes reported as % excess weight loss (%EWL) after LSG with at least 6 months follow up. Although % excess BMI loss would be more accurate (Deitel, 2003), most researchers did not report it, as shown in Table 1 (Langer et al., 2006; Milone et al., 2005; Sapala et al., 2001; Consten et al., 2004; Frezza et al., 2009).

The mean %EWL is reported as 49% and 56% at 6 and 12 months, respectively. The average follow-up time is 12 months for these studies. Complications occurred in ~9% of patients as demonstrated in Table 2; the data quoted from the same studies mentioned in Table 1.

**Table 1. Functional outcome results of reported data of laparoscopic sleeve gastrectomy**

| Author | Pt. No. | Pre-op BMI | EWL 6/12 mons | Compl. (%) | Mort. (%) | Weight regain (%) |
|---|---|---|---|---|---|---|
| Hammoui (2006) | 118 | 55 | 38/49 | 15 | <1 | NR |
| Roa (2006) | 30 | 41 | 53/NR | 13 | 0 | NR |
| Silecchia (2006) | 41 | 57 | NR | NR | NR | NR |
| Cottam (2006) | 126 | 65 | NR/45 | 14 | <1 | NR |
| Catheline (2006) | 4 | 65 | 40/NR | 25 | 0 | 0 |
| Langer (2006) | 23 | 48.5 | 46/56 | 4 | 0 | 13 |
| Baltasar (2005) | 31 | 35-74 | 56-71 | 3 | 3 | NR |
| Milone (2005) | 20 | 69 | 35/NR | 5 | 0 | NR |

*Compl: complications; Mort; mortality; NR; Not reported; EWL; Excess weight loss*.

**Table 2. Complications after laparoscopic sleeve gastrectomy**

| Complications | No. |
|---|---|
| Leak | 6 |
| Prolonged Ventilator Requirements | 5 |
| Strictures | 5 |
| Renal Insufficiency | 4 |
| Postoperative hemorrhage | 2 |
| Atelectasis | 2 |
| Pulmonary Embolus | 2 |
| Delayed Gastric Emptying | 2 |
| Gastric Dilation | 1 |
| Prolonged vomiting | 1 |
| Subphrenic abscess | 1 |
| Trocar-site infection | 1 |
| Splenic Injury | 1 |
| Trocar site hernia | 1 |
| Death | 4 |

#### 4.1.1 Complications of the LSG as a stand-alone procedure

Postoperative complications included trocar-site problems such as infection, hernia and hemorrhage. Other postoperative complications included urinary tract infection and atelectasis. There was one documented leak at the transection site with delayed gastric emptying, presenting as gastric dilation and prolonged emesis. There were 4 reported mortalities (<1%): one was due to a traumatic trocar insertion (Cottam et al., 2003), the second was in the peri-operative period (Tucker et al., 2008), the third due to primary peritonitis 3 weeks after surgery; even though no leak or bowel ischemia were identified at autopsy (MoonHan et al., 2005), and the fourth patient died secondary to a pulmonary embolus 3 months after surgery (Baltasar et al., 2005).

### 4.2 LSG as A Revisional Approach for Failed Laparoscopic Adjustable Gastric Banding

LAGB is a commonly performed bariatric operation worldwide. Initially introduced in the early 1990s, it has grown in popularity due to acceptable weight loss, resolution of co-morbidities, and low operative mortality (Chapman et al., 2004; Weiner et al., 2003). Five year follow-up results report % excess weight loss averaging 54-58% (Biertho et al., 2005; Suter et al., 2006). However, the failure rate and complications increase with time (Baltasar et al., 2005), and when major complications are encountered or when weight loss has failed, a revisional procedure may become necessary. Traditionally, the options for revisional surgery are re-do banding in cases of a band-related complication, conversion to RYGBP, or BPD. Recently, Acholonu et al (2009) investigated the role of LSG as a revisional approach for failed LAGB in the treatment of morbid obesity. One-step revisional LSG was performed in 13 patients (86.7%), while a two-step procedure was done in 2 (13.3%). Mean pre-operative weight and BMI were 233.02 (181.4-300) and 38.66 (29.7-49.3) kg/m$^2$, respectively. Mean weight loss at 2, 6, 12, 18, and 24 months post-operatively was 20.7, 48.3, 57.2, 60.1, and 13.5 lb, respectively. Similarly, mean % excess BMI loss was 28.9%, 64.2%, 65.3%, 65.7%, and 22.5%, respectively at 2, 6, 12, 18, and 24 months. There are several other reports which documented the effective use of LSG for failed LAGB with indications including weight gain, intolerable symptoms, band slippage, esophageal erosion and pouch dilatation (Deitel, 2003; Krawczykowski et al., 2005). Barnatte et al (2006) published a series of 8 patients operated on following a failed initial procedure, with a mean BMI of 50.5, before the revision procedure. The mean operative time for the revision LSG was 90 minutes with a mean length of hospital stay of 4 days. This study reported no complications or mortality in the series. The % EWL at 2, 6, and 12 months were 22%, 47%, and 57%, respectively. Such data is quite promising for any revision bariatric surgical procedure (Frezza et al., 2009).

## 5. LSG VERSUS OTHER BARIATRIC SURGICAL PROCEDURES

Because of the rising incidence of super-obese patients, interest in less invasive techniques for the treatment of these patients as a bridge to more definitive surgery has increased. The first study to demonstrate superiority of LSG to another weight loss surgical modality was published in 2004. Comparing 20 patients who underwent LSG to historical controls of patients treated with an intragastric balloon, superior %EWL at 6 months was observed for the LSG group (Milone et al., 2005). Although the endoscopically placed intragastric balloon resulted in a % EWL of 24 over this period, LSG obtained superior % EWL (30%) and was better tolerated (Milone et al., 2005). In another study comparing laparoscopic LSG to LAGB, again superior % EWL was found after 6 months in the LSG group, 61% vs 29%. It was theorized that the resection of the fundus performed during the LSG reduced a large area of ghrelin producing stomach. The authors found decreased levels of ghrelin in the LSG patients after 1 and 6 months and no change in the levels in the LAGB patients (Langer et al., 2006). The removal of large hormonally active areas of the stomach may account for the superior results seen after LSG, but studies with longer follow-up are needed.

## 6. GHERLIN AND LSG

One of the mechanisms involved in weight loss observed after the LSG is the significant reduction in stomach size. The use of small caliber nasogastric tubes (as small as 30 Fr. for LSG) provides faster and greater weight loss. This goes in line with the role of mechanical restriction as an important determinant in terms of weight loss that can be obtained with LSG (Baltasar et al., 2005). In addition, the hormonal modifications induced by LSG differ from those found after a purely restrictive procedure such as LAGB. Ghrelin is a potent orexigenic (appetite-stimulating) peptide hormone secreted by the endocrine cells, which reside in the oxyntic glands of the gastric fundus and has been a recent focus of interest (Ariyasu et al., 2001; Neary et al., 2004). 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 (Langer et al., 2005). The LSG patients showed a significant decrease in plasma ghrelin levels at day 1 (compared to preoperative levels), which remained low through 6 months. In contrast, in patients who underwent LAGB, plasma ghrelin levels 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 resulting from the additional gastric resection, which may prevent an increase in appetite as a compensatory mechanism (Langer et al., 2005; Himpens et al., 2006).

On the contrary, Christou et al (2005) reported that the failure to lose weight after RYGBP did not correlate with the preprandial gherlin levels. The gherlin levels were inversely proportional to the BMI and did not correlate with satiety. These data support the idea that increased gherlin levels do not contribute to increased weight loss after RYGBP. Similar results were reported by Langer et al, who found that resection of the gastric fundus, predominant area of human gherlin production, reduces gherlin secretion after LSG, resulting in lower gherlin levels than after gastric bypass. The same researchers concluded that as a consequence of resection of gastric fundus in LSG, gherlin is significantly reduced, but not so much after LAGB. This reduction remains stable 6 months post operatively, which may contribute to superior weight loss achieved by LSG over LAGB.

## 7. SUMMARY OF ADVANTAGES OF LSG

The overwhelming advantages of LSG are summarized below:

1. % EWL at 6 and 12 months averages 49% and 56%, respectively (Himpens et al., 2006).
2. Improvement in co-morbidities of obesity, such as hypertension and diabetes mellitus, has been reported to occur in the majority of patients with resolution in 60-100% (Givon-Madhala et al., 2007).
3. LSG has a low incidence of mortality, and is particularly useful in the super-obese who may benefit from a two-staged procedure (Cottam et al., 2003; Regan et al., 2003).
4. No gastrointestinal anastomosis.
5. No iatrogenic mesenteric defects eliminating the risk of internal hernia (Iannelli et al. 2006).
6. No alteration in the absorption of nutrients, vitamins, minerals, and drugs.
7. Low risk of peptic ulceration.
8. Low incidence of dumping syndrome due to preserved pylorus.
9. Accessibility of entire digestive tract for endoscopy.
10. Feasible and relatively safe option for super and super-super obesity (Almogy et al., 2003).
11. In populations with an increased incidence of gastric cancer, LSG is useful for the reduction in gastric tissue and the maintenance of gastro-intestinal continuity for endoscopic surveillance (Gumbs et al., 2007).

## 8. CONCLUSION

To conclude, LSG has been shown to result in significant weight loss with a low complication rate, in addition to a beneficial impact on co-morbidities. SG can be safely integrated into a bariatric surgery program with acceptable results in terms of weight loss and quality of life. Its effectiveness in the short term as related to weight loss seems realistic; more studies are required to evaluate its feasibility in the long term.

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