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Sleeve Gastrectomy: Procedure, Outcomes, and Complications

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Abstract Over 300 million adults are considered clinically obese worldwide. Obesity is associated with multiple comorbidities including type 2 diabetes mellitus (T2DM), hypertension, and sleep apnea. Bariatric surgery, as part of a comprehensive weight management strategy, has been shown to produce marked weight loss and improvement of comorbidities. While laparoscopic sleeve gastrectomy (LSG) was initially introduced as the first procedure in a two-staged approach for high-risk super-obese patients, it has emerged as an important stand-alone surgical option. LSG is typically classified as a primarily restrictive procedure; however, recent evidence suggests that it performs better than other restrictive procedures, in terms of weight loss and T2DM remission. The procedure involves creation of a gastric tube with an approximate capacity of 60 to 100 mL. In this review, we explore LSG as a technical procedure, its efficacy in obese patients, and potential complications that may arise.

Keywords Obesity · Type 2 diabetes mellitus · Bariatric surgery · Sleeve gastrectomy

Introduction

The prevalence of obesity has continued to increase over the last few decades. Currently, it is estimated that there are greater than 1.7 billion overweight adults, and 300 million obese individuals worldwide [1]. In Canada, an estimated 60% of the population is considered overweight and 24% are classified as clinically obese [2]. The prevalence of obesity in children has increased in the last 15 years, from 2% to 10% in boys and 2% to 9% in girls [3]. The ongoing increase in obesity may be associated with a multitude of factors including but not limited to genetics, western diet, culture, and a general decline in exercise regimens.

Obesity is generally measured by body mass index (BMI) to estimate the degree of adiposity. Obesity is most commonly defined as a BMI$\geq$30 kg/m^2, and morbid obesity is defined as a BMI$\geq$40 kg/m^2. Some significant obesity-related comorbidities include type 2 diabetes mellitus (T2DM), hypertension, obstructive sleep apnea, hyperlipidemia, gastroesophageal reflux disease, degenerative joint disease, depression, and cancers [4•].

Laparoscopic sleeve gastrectomy (LSG) has recently emerged as viable bariatric surgical option. Classified as a primarily restrictive bariatric procedure, it has been shown to produce marked weight loss in severely obese individuals. In this review, we describe LSG as a procedure, and explore important outcomes such as weight loss and improvement of T2DM. Furthermore, we discuss LSG-related complications.

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Bariatric Surgery

Bariatric surgery is currently the most effective evidence-based approach to produce marked weight loss in severely obese patients [5•, 6]. Bariatric surgical procedures have been shown to lead to improvement or remission of obesity-related comorbidities such as T2DM [6]. The two general categories of bariatric operations are primarily restrictive bariatric procedures and primarily malabsorptive bariatric procedures. Restrictive bariatric surgical procedures mechanically limit the amount of caloric intake, by limiting the size of available stomach. Restrictive procedures include LSG, vertical banded gastroplasty, and laparoscopic adjustable gastric banding. Primarily malabsorptive bariatric procedures limit the absorption of nutrients in the intestine. Biliopancreatic diversion with or without duodenal switch (BPDDS) and Roux-en-Y gastric bypass (RYGB) are the most common malabsorptive procedures.

These bariatric surgical procedures combined with a comprehensive weight management strategy are a reasonable options for obese individuals. Surgical treatment may alleviate the harmful effects of comorbid conditions and may also improve quality of life. According to the National Institutes of Health Consensus Conference of 1991, the four main criteria for bariatric surgery are [7]:

1. BMI≥40 kg/m^2 with or without comorbid medical conditions associated with obesity;
2. BMI greater than 35 kg/m^2 with obesity-related comorbidities;
3. Previous failed attempts at non-surgical weight loss treatments;
4. Psychologically stability.

Sleeve Gastrectomy History

LSG was initially introduced in the early 1990s as the first step to a two-stage approach to BPDDS in high-risk severely obese patients [6]. It has since gained popularity as studies have shown positive short-term weight loss comparable to more invasive bariatric procedures [8, 9]. It is currently offered as a stand-alone primary bariatric procedure. Advantages of LSG compared to other bariatric surgical procedures include avoidance of foreign body implantation and gastrointestinal anastomosis. In addition, it immediately restricts caloric intake, and is less technically demanding relative to malabsorptive bariatric procedures (ie, RYGB). Other advantages include avoidance of dumping syndrome, pylorus preservation, and unaltered absorption of oral medications [10]. However, the most notable disadvantages of LSG are irreversibility and the availability of long-term outcome results [11].

Sleeve Gastrectomy Procedure

The procedure begins with the placement of several trocars into the abdomen. There is one primary operating trochar, a camera, and several retracting trocars. The operation begins by dividing the gastrocolic ligament to a point about 5 to 10 cm proximal to the pylorus. The short gastric vessels are then divided to the angle of His. The anesthetist then inserts a 32 to 60 French bougie into the stomach and along the minor curvature. A vascular stapler is then used successively alongside the length of the bougie to separate part of the stomach. The separated stomach is then removed through one of the port excisions (Fig. 1). A drain is then put in to complete the procedure [12].

LSG-Associated Weight Loss

The effectiveness of LSG to produce weight loss has been proposed to be due to two main mechanisms. First, as a primarily restrictive operation, it mechanically limits food intake and restricts gastric distention [13]. Second, hormonal mechanisms have been suggested to be involved. Specifically, this is thought to be associated with decreased circulating ghrelin levels secondary to gastric fundus resection [13]. Furthermore, decreased concentrations of ghrelin may also induce feeling of satiety following meals [13]. Arias et al. [14] retrospectively assessed 130 morbidly obese patients (mean BMI, 43.2 kg/m^2) and observed a mean excessive weight loss (EWL) of 67.9% at 2-year follow-up. Lee et al. [15] also reported similar results (EWL=59%) at 2-year follow-up following LSG in 216 obese patients. Fuks et al.

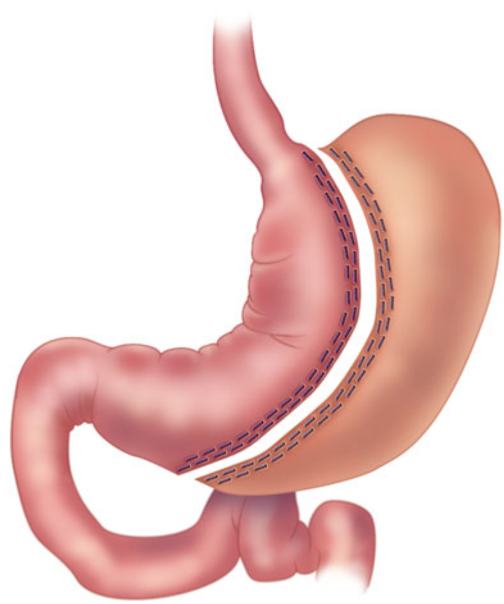

Fig. 1 Sleeve gastrectomy

[16] prospectively assessed 135 patients with a BMI≥ 35 kg/m^2 and observed a mean EWL of 49.6% after 1-year follow-up.

Interestingly, a retrospective study of 126 high-risk morbidly obese patients (BMI>60 kg/m^2) by Cottam et al. [17] found comparable results, and reported an EWL of 46% following 12 months. These prospective and retrospective studies have been analyzed in recent systematic reviews. A systematic review by Brethauer et al. [11] reported an overall mean excess weight loss following LSG of 55.4%. Comparatively, our review revealed an EWL of 47.3% based on 27 studies (673 patients) at 13.1 months follow-up [5•]. Furthermore, our review reported a reduction in BMI from 47.4 kg/m^2 to 35.9 kg/m^2 following LSG. A recent study by Bohdjalian et al. [18] assessed long-term weight loss and plasma ghrelin levels following LSG in 26 patients. They reported an EWL of 55% following LSG, along with reduced plasma ghrelin levels immediately postoperatively, which were maintained at 5-year follow-up.

Type 2 Diabetes Mellitus

Along with producing marked weight loss, LSG has been associated with improvement of glucose tolerance and T2DM [17]. Cottam et al. [17] followed 126 obese patients with T2DM following LSG. They observed remission of T2DM in 81% of patients at 12-month follow-up. Vidal et al. [19] reported a similar T2DM remission rate of 84.6% in 39 severely obese patients post LSG at 12 months. Supportively, Shah et al. [20] observed euglycemia in 96.2% with BMI greater than 33 kg/m^2 following LSG. In comparison to other restrictive bariatric surgical procedures, Abbatini et al. [21•] reported T2DM remission rate of 80.9% following LSG versus 60.8% following gastric banding in obese patients. Similarly, a recent systematic review reported T2DM remission rates following malabsorptive bariatric surgical procedures [6]. According to this review, remission of T2DM following BPDDS and RYGB was 98.9% and 83.7%, respectively. Interestingly, our systematic review revealed improvement of T2DM in 97.1% of patients following LSG at a mean follow-up of 13.1 months [5•].

Improvement of T2DM following LSG has been proposed to be related to subsequent weight loss. However, other mechanisms involving gastrointestinal hormones have been suggested. Ghrelin is a peptide hormone mainly produced by the stomach [12]. It is thought that ghrelin is responsible for appetite stimulation in humans, as there is preprandial rise and postprandial fall in ghrelin levels [12]. Resection of the gastric fundus following LSG appears to reduce the levels of circulating ghrelin levels [22]. A prospective double-blind study by Karamanakos et al. [22] looked at 16 patients undergoing LSG and found that there was a decreased fasting ghrelin levels 12 months postoperatively along with greater suppression of appetite. Another theory involves decreased suppression of adiponectin following LSG secondary to depressed levels of ghrelin [10]. Thus, increased adiponectin levels allow for increased sensitization to insulin.

Decreased ghrelin levels after the procedure may work by this mechanism, as well as increasing insulin secretion by islet cells in the pancreas. Furthermore, it is thought that LSG speeds up the movement of stomach contents in the gastrointestinal tract [23]. The hindgut theory postulates that the increased delivery of undigested nutrients through the bowel upregulates the secretion of glucagon-like peptide-1 (GLP-1) [24]. The increased levels of GLP-1 may cause an anti-apoptotic effect on β cells in the pancreas as well as stimulating increased insulin secretion. This effect may partially explain the improved glucose tolerance following LSG.

LSG-Associated Complications

Gastric Leak

The most concerning complication related to LSG remains the loss of integrity of the gastric staple line [25]. Gastric leak from the staple line may occur secondary to alteration in the normal healing process. Local risk factors include compromised blood supply leading to poor healing of the suture line and ischemia caused by the use of electrocautery. The incidences of gastric leaks have been reported to range from 0.7% to 5%, with a mean of 2.3% [26]. A study done on 118 morbidly obese patients with a BMI greater than 30 kg/m^2 reported an overall gastric leak rate of 3.4% [27]. Comparatively, Frezza et al. [28] performed LSG on 53 patients and reported a gastric leak rate of 3.7%. A study by Lalor et al. [29] showed an impressively low rate of gastric leak in 164 patients of 0.7%. Similarly, Moy et al. [30] reported a leak rate of 1.4% following LSG in 135 superobese patients (mean BMI, 60.1 kg/m^2). The most common location of gastric leaks occurs in the proximal third of the stomach, occurring about 85% of the time in this location [26].

Patients with early-onset gastric leaks, occurring on postoperative day 1 to 3, typically present with increasing abdominal pain and tachycardia. However, these patients may present with fever, septic shock, and multiorgan failure. If the gastric staple compromise is suspected intraoperatively, methylene blue dye may be used to identify compromised gastric staple line [31]. Postoperatively, a radiographic upper gastrointestinal contrast study is most commonly used to identify gastric leaks. Another modality that may be considered is an abdominal computed tomography (CT) scan with oral contrast. CT findings that may suggest a leak include extravasation of swallowed contrast material, free intra-abdominal air, and collection of contrast adjacent to the sleeve.

The key to appropriate management of gastric leaks is early identification and prompt management. Patients identified with a gastric leak early (<4 days) may be appropriate candidates for immediate surgical repair of the defect [32]. For delayed presentation of the gastric leak (5–10 days), conservative management may be preferred. In this case, management involves use of broad-spectrum antibiotics, parenteral nutrition, high-dose proton pump inhibitors, and percutaneous drainage of fluid collections [32]. Another viable option to consider would be use of an endoluminal stent, which may be deployed to prevent leakage at the defective site to allow time for healing [27]. However, this treatment option may be limited by distal stent migration.

Bleeding from the Gastric Staple Line

Other complications of LSG include hemorrhage. Hemorrhage following LSG can be a result of trauma to the spleen or liver, or trochar site bleeding. Bleeding along the gastric staple line can occur as well, since the gastric staple line is close to the blood supply of the lesser curvature [33]. The incidence of bleeding following LSG is quite low, with Nath et al. [34] observing a postoperative gastric bleeding rate of 2% in 100 patients following LSG. A systematic review by Brethauer et al. [11] gathered similar results, and reported a hemorrhage rate of 1.0% in patients undergoing primary LSG. Some surgeons have proposed reinforcing the gastric staple line with absorbable sutures to reduce the incidence of gastric hemorrhage. A study by Dapri et al. [35] compared using no staple line reinforcement, buttressing the staple line with absorbable material, or oversewing the staple line in 75 patients undergoing LSG. They reported that there was a statistically reduced staple line–associated blood loss with staple line buttressing [35]. However, there are conflicting data from Albanopoulos et al. [36•] who conducted a study on 90 LSG patients (48 received buttressed suture, 42 received a continuous suture). They suggested that there was no significant difference between the groups in terms of staple line bleeding (4.2% vs 2% in buttressed and continuous suture groups, respectively) [36•]. Additional studies are needed to determine the efficacy of staple line reinforcement.

Limitations

Despite the increasing experience and evidence supporting LSG, a few limitations in the literature exist. First, long-term sustained weight loss following LSG remains to be determined. This is in part to the novelty of LSG as a stand-alone bariatric surgical procedure. Second, the underlying mechanisms leading to weight loss and improvement in T2DM need further exploration. Restriction of caloric intake partially explains the steady weight loss following LSG. However, it does not completely clarify the improvement in T2DM seen in patients following LSG, but not in other restrictive bariatric surgical procedures. Lastly, despite LSG being a primarily restrictive bariatric procedure, malabsorption may occur. Further research is needed to elucidate potential nutritional complications specific to LSG.

Conclusions

The prevalence of obesity continues to increase worldwide. LSG has emerged as a reasonable bariatric surgical option in obese individuals. Current evidence suggests LSG may produce marked weight loss in these obese individuals, with low morbidity. Furthermore, LSG has been shown to improve T2DM in obese patients. Despite being less technically demanding than malabsorptive bariatric surgical procedures, complications such as gastric leakage and bleeding may arise. Nevertheless, LSG has been shown to be a viable stand-alone bariatric surgical procedure.

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