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Sleeve gastrectomy: have we finally found the holy grail of bariatric surgery? A review of the literature

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Abstract. – OBJECTIVE: Laparoscopic sleeve gastrectomy has become one of the most commonly performed bariatric operations. It is essentially a restrictive bariatric operation; however, a series of hormonal changes occurring postoperatively contribute to decreased appetite and reduced food intake.

PATIENTS AND METHODS: This is a literature review of recent articles published on Pubmed, Medline and Google Scholar databases in English.

RESULTS: Although, laparoscopic sleeve gastrectomy is commonly performed worldwide, there is still a lack of standardization regarding the surgical technique. Standardizing the surgical technique is essential in order to minimize postoperative complications and offer patients the best long-term weight loss.

CONCLUSIONS: Laparoscopic sleeve gastrectomy appears to be an effective bariatric operation. It is relatively easy to perform, well tolerated by the patients and very effective regarding long-term excessive weight loss and resolution of the comorbidities, with minimum nutritional deficiencies.

Key Words
Bariatric surgery, Sleeve gastrectomy, Laparoscopyic surgery, Morbid obesity, Gastric sleeve.

Introduction

Laparoscopic sleeve gastrectomy (LSG) has become one of the most commonly performed bariatric operations over the last years[1]. With more than 94.000 procedures performed in 2011, LSG has not only gained popularity, but also became the second most commonly bariatric operation performed after gastric bypass[1]. With more than 1.9 billion overweight and over 600 million obese people worldwide in 2014, obesity is rightfully classified as a disease by WHO. Bariatric surgery can effectively treat obesity and also improve or even resolve a number of related comorbidities, offering patients a better life. Based on recent studies, LSG is not only a safe, but also an effective bariatric procedure with long-lasting results[2]. The aim of this report is to approach the role of sleeve gastrectomy as a contemporary bariatric procedure through a comprehensive and concise review regarding various aspects of this promising technique. Articles on sleeve gastrectomy, published on Pubmed, Medline and Google Scholar databases in English were thoroughly revised and included in the discussion.

Historical evolution

Sleeve gastrectomy was first performed by Hess in 1988 as part of his biliopancreatic diversion with the duodenal switch (BPD-DS) procedure, adapted from Scopinaro's biliopancreatic diversion (BPD) and DeMeester's duodenal switch (DS) procedures[3-5]. Later in 1991 and 1993 Marceau also proposed his modifications on Scopinaro's biliopancreatic diversion that effectively included early forms of sleeve gastrectomy variations[6,7]. With the evolution of laparoscopic surgery during the 1990s, Gagner performed essentially the first laparoscopic sleeve gastrectomy as part of BPD-DS in 1999[8]. As a less demanding technique, sleeve gastrectomy quickly gained popularity early in the 21st century. Initially, it was performed as a first step intervention for super-obese patients (BMI > 60 kg/m^2), before definite intervention was undertaken with either gastric bypass or biliopancreatic diversion procedures[9,10]. Nowadays laparoscopic sleeve gastrec-

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tomy (LSG) is considered a principal laparoscopic bariatric procedure, mainly due to the many advantages it possesses.

Mechanisms of action

The LSG is essentially a restrictive bariatric operation. Weight loss is achieved by drastically reducing the gastric volume, which in turn leads to reduced food intake. In addition, a series of hormonal changes occurring postoperatively in bariatric patients, contribute to decreased appetite, reduced food intake and long-term weight loss (Figure 1)[11, 12]. Ghrelin, a hormone produced primarily by the oxyntic cells of the fundus of the stomach during fasting, stimulates appetite by increasing the expression of the orexigenic hypothalamic neuropeptide Y (NPY)[11]. By removing the gastric fundus, patients undergoing sleeve gastrectomy have markedly decreased levels of ghrelin and suppressed appetite respectively[13]. Peptide YY (PYY), a hormone produced postprandially from the gut, inhibits the release of NPY and has an anorectic effect[14]. PYY is notably increased after sleeve gastrectomy, leading to prolonged satiety and reduced food intake[13]. Glucagon-like peptide-1 (GLP-1) is secreted from the enteroendocrine L-cells in the intestine as a response to food indigestion. GLP-1 stimulates insulin release, inhibits glucagon secretion and has a satiating effect. Both rapid gastric emptying and postprandial hyperglucagonemia observed after sleeve gastrectomy lead to increased GLP-1 levels[15, 16].

Weight loss after LSG

A major advantage of LSG is that despite being an easy, quick and safe bariatric procedure, it is also an effective surgical technique, offering patients considerable excess weight loss (%EWL)[17-19]. Boza et al[20] reported, after 1000 consecutive cases, that the %EWL at 1, 2 and 3 years had been 86.6%, 84.1% and 84.5% respectively. Similarly, Rawlins et al[21] found a %EWL of 86% at 5 years. In contrast to these very promising results, most publications agree that patients undergoing LSG achieve a 60%EWL at 5 years[22-27]. After an initial high %EWL, most series report some weight regain after the second year[19]. Respectively, Himpens et al[25] and D'Hondt et al[28] observed that patients regain weight after 5 years, with the % EWL dropping below 60%. However, Sarela et al[29] reported a %EWL of 69% at 9 years, the longest follow-up to date.

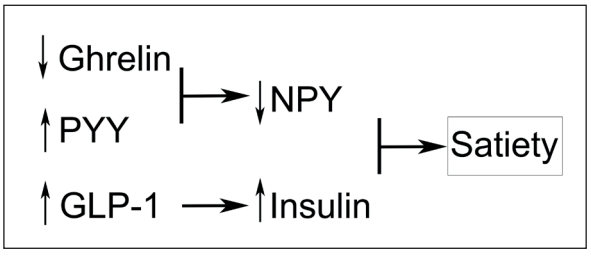

Figure 1. Hormonal changes occurring postoperatively after LSG.

Nutrient deficiencies

It is well documented that obese patients are generally malnourished, mainly due to a non-varied diet high in fats and carbohydrates and low in quality protein products, dairy and vegetables. Most nutrient and micronutrient deficiencies persist postoperatively in patients undergoing bariatric surgery and as a result multivitamin supplementation is necessary for these patients[30,31]. However, nutritional deficiencies vary greatly between different bariatric operations, with LSG having only a minimal impact on the nutrient status[22,32,33]. Similarly to other types of bariatric procedures, most commonly observed nutrient deficiencies like iron, folate and thiamine persist postoperatively, but can be easily resolved with a daily multivitamin supplementation[22,32-35]. Iron deficiency and anemia in particular, commonly seen in bariatric patients, are also present after LSG. However, the risk for anemia after LSG is lower compared to the other type of procedures, when the iron supplement is administered postoperatively[33,36]. Vitamin D deficiency is common among obese patients due to malnutrition and limited sun exposure. Postoperative hypovitaminosis D, however, is not common after LSG due to loss of adipose tissue and adequate supplementation[22,32]. Respectively vitamin B12 deficiency is also not common after LSG as compared to gastric bypass and BPD[22,32,34,36,37]. Vitamin B12 is absorbed in the terminal ileum when banded to intrinsic factor, which is produced from the parietal cells in the antrum and duodenum. As compared to other malabsorptive bariatric operations, where the duodenum is bypassed, the uptake of vitamin B12 is not disturbed in LSG[32,36].

Improvement in metabolic changes (diabetes)

Besides excess weight loss (%EWL), LSG has a positive effect on diabetes. Several studies report that type 2 diabetes mellitus (T2DM) resolves in a significant percentage of patients undergoing LSG[19,38,39]. Improvement and resolution rates as high as 86% of patients are reported, which are similar to those seen after RYGB and superior to LAGB[22,40-44]. Control of T2DM after LSG is achieved, as in other bariatric operations, with the rapid excess weight loss. However, glycemic control without diabetic medication, normalization of hemoglobin A1c and improvement or even resolution of T2DM are seen early after LSG[45]. A reason for the early improvement of T2DM after LSG is the notable low levels of ghrelin. Ghrelin not only suppresses appetite, but also has a diabetogenic effect[46]. Also, Shah et al[47] documented that the faster gastric emptying and small bowel transit time observed after LSG have an additive effect on the control of T2DM.

Improvement in systematic diseases (comorbidities)

Apart from diabetes mellitus, LSG offers improvement and even resolution for a series of comorbidities[48]. Various studies report improvement or remission of hypertension, dyslipidemia, obstructive sleep apnea and degenerative joint disease after LSG[18,49]. Weiner et al[50] reported that hypertension either improved or resolved in 97% of the patients, whereas dyslipidemia improved in 77% of the cases. Long-term results presented, show a resolution in hypertension in half of the patients undergoing LSG[22, 23]. Obstructive sleep apnea, commonly seen in morbidly obese patients, can also be improved in 80% of patients after surgical intervention[51].

Improvement in quality of life (QoL)

Laparoscopic SG results in considerable improvement in the quality of life (QoL) and psychosocial functioning[52-55]. First and foremost, LSG is a pill and food friendly bariatric operation. Pills are generally well tolerated, as well as drugs like aspirin and NSAIDS. In addition, food tolerance is very good, especially in the long-term[55,56]. The majority of patients report high rates of satisfaction postoperatively and a significant number of them change their eating habits to a healthier diet over time[56]. Furthermore, due to the quick rehabilitation and the adequate weight loss, physical activity, sexual life and self-esteem are also improved postoperatively[52]. Additionally, in contrast to laparoscopic adjustable gastric banding (LAGB) procedure, which is also considered to be safe and one of the least invasive bariatric operations, no foreign bodies are used during LSG[57]. As a result, long-term complications like gastric erosion and infections are not seen after LSG[57]. However, the extended gastric resection performed during LSG has a significant impact on gastric acid secretion and motility. Many patients experience a series of gastrointestinal (GI) symptoms postprandial, like heartburn, epigastric pain, distress and dysphagia. Nevertheless, the impact of all these GI symptoms on QoL is limited[58].

How to Sleeve

Sleeve gastrectomy (SG) is essentially a bariatric procedure consisting of a left partial gastrectomy of the fundus and the body in order to create a long, tubular formation along the lesser curvature of the stomach[59]. Although open SG has been used for high-risk patients in the past, nowadays LSG is considered a primary bariatric procedure[60,61]. Sleeve gastrectomy can be safely performed even with other minimally invasive surgical techniques like single access surgery or robotic surgery, with comparable results[62-65]. The preoperative management of the patients undergoing LSG does not differ from other laparoscopic bariatric procedures. Therefore, preoperative risk assessment and evaluation to exclude other causes of obesity should be performed in every patient.

To date there is a lack of standardization regarding the surgical technique of LSG, which may affect the long-term outcome of the patients. However, in 2012 the first international expert panel consensus statement regarding the "best practice guidelines" was published, based on the experience of more than 12,000 cases of LSG[61].

The first step of LSG is the identification of the Crow's foot, the pylorus and the antrum. Following this, a window in the greater omentum is made, laterally of the antrum[66]. Most experts agree that it is important to mobilize the fundus before transection and to resect the short gastric

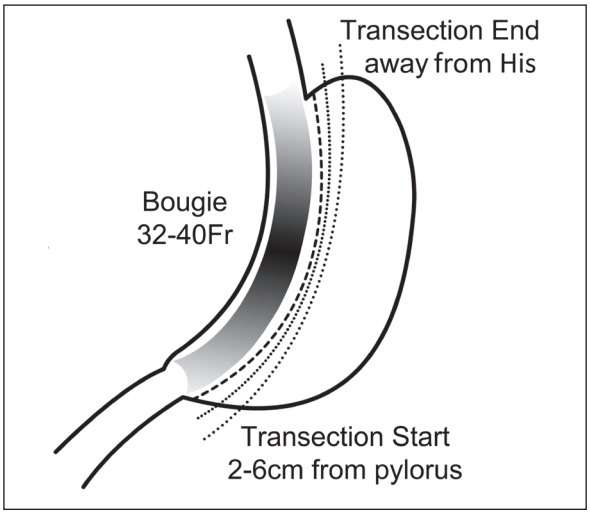

Figure 2. Surgical technique of LSG, showing how the size of the final gastric pouch changes in regard to the usage of different bougie sizes and different starting and ending transection points.

vessels before stomach division. This will assist the creation of a small gastric pouch and allow the identification of any hiatal hernia[61]. If a hiatal hernia is present, it should be repaired at the same time by posterior crural approximation[19].

One of the most controversial points in LSG is the distance from the pylorus at which the gastric division should begin. The aim of the surgeon is to perform a restrictive bariatric operation, with improved gastric emptying and decreased intraluminal pressure, in order to avoid a leak. The 2012 expert panel agreed that the transection should begin 2-6 cm from the pylorus[61]. Although most authors start the resection at these distances, there are some that prefer the limits. Baltasar et al[67] and Mognol et al[68] begin their resection at 2 cm from the pylorus in order to create a very small gastric pouch, since LSG is mainly a restrictive bariatric procedure. Others, like Givon-Madhala et al[69] and Silecchia et al[70] begin their division at 6-8 cm from the pylorus, thus, preserving the gastric antrum and its contractile function. However, the bariatric surgeon should always consider the fact that a smaller gastric pouch with intact gastric antrum, leads to increased intraluminal pressures and gastric emptying difficulties, that could place patients at higher risk for leaks and proximal fistula formation at the gastroesophageal junction[71].

Furthermore, another controversy in LSG is where to end the gastric division. It seems that most experts agree on the importance to stay away from the gastroesophageal junction during the last staple firing[61]. Soricelli et al[73] tried to explain the vascular anatomy of this area, because one of the best supported theories of proximal fistula formation is the vascular-ischemic theory[72]. A "critical area" of vascularization is created at the angle of His and the resection on that area could lead to an ischemic gastric remnant, with an increased likelihood for a leak. Therefore, it is important to avoid resection too close to the esophagus and avoid creating a stenosis at the level of the angular incisure[71].

In order to maintain a standardized gastric volume and allow the reproducibility of the technique between different bariatric surgical teams a bougie is used during the gastric division to facilitate the resection. However, the size of the bougie is not standard and various sizes have been used from different bariatric surgeons. The bougie size is measured in French (Fr) where 1 Fr equals 0.33 mm. This means that a 36 Fr bougie equals 1.2 cm and a 40 Fr equals to 1.3 cm. Most surgeons use a bougie between 32-40 Fr and, considering the above, we can safely assume that they practically use the same bougie size[61,74]. Small size bougies have been associated with a higher incidence of staple line leaks, longer hospital stay, tendency toward increased nausea, more emergency department visits, and readmissions[74-77]. Using bigger than 40 Fr bougies, reduces the relative risk for a leak up to 66%[74,75]. As a matter of fact, bigger bougies result in larger gastric pouches and this may affect the long-term weight loss. However, several studies have shown that using bougies larger or equal to 40 Fr does not impact %EWL, at least for the first three years postoperatively[75,77,78]. In addition, different surgeons resect the stomach at a different distance in respect to the bougie. Some prefer to be very close to the bougie, while others keep a small distance, in order to perform a subsequent reinforcement of the staple line with invaginating sutures[72].

The experts seem to agree that staple line reinforcement may reduce bleeding along the staple line, although many authors do not routinely perform this reinforcement[61, 79]. Another reason for reinforcing the staple line is the control of postoperative leaks. Fistulas on the staple line may be of mechanical-tissular cause, when the intraluminal pressure exceeds the staple line strength, or of ischemic cause, as proposed in the vascular-ischemic theory. Ischemic leaks typically occur on the fifth or sixth postoperative day, during the inflammatory-proliferation phase of wound healing. Respectively, if the cause is mechanical-tis-

sular, leaks present early on the first two postoperative days[80]. Based on this fact, some surgeons have adapted their technique, in order to reduce the risk of a mechanical failure of the stapling line. A number of different reinforcing materials have been introduced and many studies have tried to provide evidence for their use[81-84]. Yet, staple line invagination with a simple running sero-serous suture, with or without the addition of an omental patch, could efficiently control bleeding and attempt to reduce postoperative leaks without increasing the cost[67,72,85]. Choi et al[86] and Glaysher et al[87] have published important meta-analyses and review studies in order to answer the critical question of staple line reinforcement. However, while current evidence suggests that staple-line reinforcement may reduce the incidence of postoperative leaks and other associated complications, it does not significantly reduce bleeding complications and cannot be recommended as a standard technique[61,86].

In order to identify potential leaks or defect sites of the staple line, many surgeons test the integrity of the newly-formed gastric pouch by introducing air or methylene blue at the end of the operation. Nevertheless, a negative test does not exclude a postoperative leak and many authors do not perform these tests at all[88,89]. A simpler test to discover a potential staple line defect is to inflate the resected stomach with air using a regular syringe[89].

Some authors have proposed that the measurement of the resected gastric volume at the end of the procedure can safely predict the overall %EWL. A resected gastric volume of more than 500-1100 ml has been associated with %EWL of ≥ 50%[50,90]. However, the resected gastric volume is greater in patients with high preoperative BMI[91]. Finally, it is important to send for routine histological examination all gastric specimens. In about 8% of the cases unanticipated findings warranting further clinical follow-up may be revealed, like *H. pylori* gastritis, autoimmune gastritis with a microcarcinoid formation, intestinal metaplasia or even neoplasia[92].

Indications and contraindications

Laparoscopic SG should be considered a primary bariatric procedure or the first stage of a 2-step approach for the management of morbidly obese patients[18,59,61,93]. In the later, LSG has been used to treat initially super obese or high-risk patients, before a prospective second-stage bariatric procedure (mainly RYGB) is performed, within two years[18].

It is important that all patients undergo comprehensive interdisciplinary assessment by a team of specialists experienced in obesity management and bariatric surgery. Sleeve gastrectomy candidates should undergo routine preoperative assessment, like any other major abdominal surgery. Laparoscopic SG adheres to the indications and guidelines of all other bariatric procedures[94]. Therefore, it should be offered to morbidly obese patients with metabolic syndrome and to patients with a BMI of 35 kg/m2 and associated co-morbidities[61,94].

Super obese patients, with BMI > 50 kg/m2, can be offered LSG as this procedure seems to be also effective for this group of patients[95-97]. However, super obese patients tend to regain weight after the first 12 months of follow-up, while maintaining the improvement in co-morbidities[98,99]. Considering the above some authors believe that LSG should be the first step of a 2-step procedure for the management of super obese patients[9,61].

Laparoscopic SG seems to be a feasible and safe procedure for high-risk surgical patients. It can be used as a safe first surgical procedure in order to achieve rapid weight loss in high-risk patients who need to undergo a second non-bariatric procedure such as knee replacement, nephrectomy or spine surgery[100]. Chaudhry et al[101] and Tariq et al[102] have also published promising data regarding morbidly obese patients with end-stage organ failure who successfully underwent LSG. Laparoscopic SG has proved to be technically feasible and effective in obese patients awaiting kidney transplantation, for adequate pre-transplantation weight loss, thus improving their access to transplantation[103]. Sleeve gastrectomy can be also used as a post-transplantation bariatric procedure in kidney recipients, because by retaining the intestinal continuity the uptake of immunosuppressants is not disturbed[104]. Obese compensated cirrhotic patients can also tolerate LSG well. Laparoscopic SG can be safely performed in cirrhotic patients, with low risk for postoperative complications, improving their metabolic syndrome and reducing hepatic steatosis[105,106].

Inflammatory bowel disease (IBD) is considered a contraindication for bariatric surgery. However, in a study from Steed et al[107] more than 18% of IBD population found to be obese. Furthermore, overexpessed obesity-related cytokines play a significant role in the development

of IBD[108]. Laparoscopic SG found to be safe and effective for the management of obese patients with IBD[78,109,110].

Regarding the age of the patients LSG there are many studies that have published positive results for pediatric, adolescent and geriatric patients who underwent LSG. Alqahtani et al[111] reported their experience with LSG in children and adolescents (5-21 years of age) with a follow-up of 24 months with very promising results. They reported no serious postoperative complications, resolution of co-morbidities and acceptable %EWL. However, it is impossible at this time to estimate the overall long-term consequences. Therefore, these patients should be managed in bariatric centers of excellence that offer all available surgical options and a strict long-term follow-up[112].

Morbid obesity in elderly patients is a substantial health problem. Perioperative management of medical complications is crucial. Qin et al[113] in their recent multi-institutional study showed that LSG may be a preferable option for elderly patients. Furthermore, LSG can be safely performed in elderly patients, with low long-term reoperation and readmission risk. The perioperative risk of LSG in this patient population is predominantly associated with the anticipated morbidity of advanced age[113]. Other studies have also confirmed the safety and effectiveness of LSG in the geriatric population[114-116].

Other indications may include cases that the small bowel is inaccessible due to adhesions from prior operations and patients in whom repeated endoscopy of the duodenum is necessary[110].

The only absolute contraindication for performing LSG is Barrett's esophagus. The progression from erosive reflux disease to Barrett's esophagus and gastric and esophageal cancer is well established[19, 61]. Yet, the preoperative presence of gastroesophageal reflux disease (GERD) is only a relative contraindication, mainly due to the fact that reflux symptoms may worsen after LSG[22, 28, 61]. The long-term effect of LSG in GERD is controversial. Chiu et al[117] in their systematic review concluded that there is not enough evidence to consolidate to a consensus regarding the effects of LSG on GERD. From the studies they reviewed, some showed an increase in the incidence of GERD, while other reported a decrease. Himpens et al[28] reported a biphasic pattern of GERD after LSG. Reflux symptoms initially present in the first postoperative year, they gradually improve and reappear after the sixth year postoperatively.

Complications and their management

Laparoscopic sleeve gastrectomy has been considered to be a technically simple bariatric procedure with acceptable weight loss, resolution of comorbidities and low postoperative complications. Compared to laparoscopic gastric bypass and biliopancreatic diversion, LSG is easier to perform and thus involves less risk. However, its complications can be more severe than those of other bariatric surgical techniques[72]. The complication rates after LSG vary among studies from 0% to 18%, with a 30-day postoperative mortality ranging from 0%-0.4%[118-120]. The postoperative complications can be distinguished in early and late.

Early complications generally involve bleeding, gastric leak, obstruction, abscess formation, wound infection as well as all the other possible postoperative complications of major laparoscopic surgical procedures[27]. Late complications specific to LSG are the development of a fistula, GERD, stenosis, neofundus, spiral sleeve and intathoracic sleeve migration, weight loss failure and nutritional deficits[37,72].

The most common and major early complication is certainly the postoperative bleeding which can occur in up to 16% of patients with a reported average of 3.6%[120-122]. Usually, it occurs during the first or second postoperative day and generally originates from the stapling line or the divided gastroepiploic vessels. Other sources of bleeding include trocar site, splenic injury or liver laceration[119]. Intraluminal bleeding has been reported to occur in 2% of cases[19]. Reinforcing the staple line seems to be associated with a decreased risk of staple line hemorrhage[86,123]. In addition, in a recent randomized trial, Sroka et al[124] proposed routine elevation of the systolic blood pressure to 140mmHg before termination of the procedure in order to identify possible bleeding sites. The treatment can be conservative, with blood transfusion and patient resuscitation, but there are cases for which reoperation is necessary for the definite control of the bleeding[119].

The gastric leak is a serious complication of LSG with an incidence ranging from 0% to 3.7%[61,72,77]. Proximal staple line leaks are more common than distal ones[59]. The basic concept is that a leak happens when the intraluminal pressure exceeds the staple line or tissular strength[125]. This situation usually occurs when local factors like poor blood supply, stapling

issues or infection acutely impair the gastric wall healing[72]. In order to avoid leaks, tissues should be handled carefully and devices like staples, electrocautery or other surgical equipment should be used rationally[72,126]. A number of studies investigated the use of staple line reinforcing materials[81-84]. Recent studies suggest that staple-line reinforcement may reduce the incidence of postoperative leaks[86,87]. Nevertheless, a running sero-serous suture that invaginates the staple line from the angle of Hiss to the midpoint of the transection, and a second continuous suture from this point to the end, with or without an omental patch may be adequate in order to reduce leak rate[67,72,85]. During stappling, it is also very important to compress the gastric tissue carefully for a prolonged time (e.g. 30 sec) before firing in order to reduce tissue edema[127]. Additionally, a nasogastric tube can be left in the newly-formed gastric pouch for 24 hours to reduce intraluminal gastric pressure[128].

Many authors routinely perform upper gastrointestinal swallow studies postoperatively in order to evaluate the presence of an early leak, between the first and third postoperative day. However, the sensitivity of these studies is low and a negative test does not exclude the presence of a leak[126,128-130]. Although gastric leaks can be accurately diagnosed with computed tomography, CT scans should only be performed when the clinical suspicion is high and not for screening[129,130]. If a leak occurs, the management is crucial for the outcome. The clinical presentation can vary greatly between patients and while most patients are completely asymptomatic, complications like peritonitis, septic shock, multi organ failure and death have been reported. Burgos et al[126] observed that tachycardia can be the initial sign of a leak. Patients with hemodynamic instability or those who cannot be controlled using conservative measures require intervention. Postoperative leaks can be categorized into acute (within 7 days), early (within 1-6 weeks), late (after 6 weeks) and chronic (after 12 weeks) in regard to the time of presentation[61]. An acute fistula can be repaired surgically if the defect can be identified[126]. However, primary repair of a fistula is associated with high rates of recurrence. In late fistulas simple primary repair of the defect is not possible due to chronic inflammation and concomitant presence of an abscess[128]. Stable patients can benefit from conservative treatment, like nothing by mouth, intravenous antibiotics and total parental nutrition with or without CT-guided percutaneous drainage of the abscess[131]. Endoscopic stenting after percutaneous drainage of an abscess is a valid treatment option for a proximal leak[61,128,131]. The endoscopic use of fibrin glues, plugs or clips has also been reported, although their efficacy is not proven[72,131]. The surgeon should wait for at least 12 weeks with conservative therapy before considering a reoperation to address a leak. Revision of the procedure and conversion to another operation are possible options[61]. In the case of a re-intervention, conversion to gastric bypass, Roux-en-Y, or total gastrectomy can be performed[61,132,133].

The development of GERD or the worsening of reflux symptoms has been reported by some authors as a late complication of LSG. Kehagias et al[22] and Himpens et al[28] reported a peak of GERD symptoms in the first year which declined during the first triennium. Himpens et al[28] observed a second peak after the sixth year[28]. The intact pylorus, the removal of the antrum, the severely restricted gastric capacity and the disrupted motility could create stasis and induce or exacerbate reflux symptoms[119]. When the resection is not close enough to the esophagus, a neofundus could form, which could also aggravate the reflux symptoms due to increased gastric acid production[119]. Additionally, the presence of a neofundus could also deteriorate GERD when it is migrated intrathoracically, especially in the presence of an untreated hiatal hernia. However, several studies have shown that the relationship between GERD and LSG is multifactorial. Such factors are an alteration of the lower esophageal sphincter pressure, reduction of gastric compliance and emptying, increased sleeve pressure, accelerated gastric emptying and the effect of weight loss[117,134]. Although GERD is considered a relative contraindication for LSG, some modifications have been proposed to address this problem. Identification of a hiatal hernia intraoperatively should be persistent and if found, it should be repaired[61]. This can effectively control the reflux symptoms[135]. An antireflux sleeve gastroplasty consisting of a combination of vertical gastroplasty and Nissen fundoplication has been proposed by Fedenko and Evdoshenko with encouraging results[136]. However, if reflux symptoms occur, proton pump inhibitors should be the first line of treatment[61].

Gastric stenosis and strictures following LSG, although uncommon, can occur especially after some time[137,138]. Stenoses occur either distally,

when the transection is started close to the pylorus, or proximally at the level of the esophagus following a leak and the subsequent chronic inflammation and fibrosis. Endoscopic dilations are the treatment of choice, offering a complete resolution of the problem[139]. Dapri et al[138] also reported promising results with laparoscopic seromyotomy for long stenosis, for patients that were not eligible to undergo endoscopic dilation. Additionally, conversion to Roux-en-Y gastric bypass has also been reported for persistent cases[139].

While promising data are reported on %EWL, weight loss failure and weight regain is a reality for some patients. Reasons include wrong patient selection, inappropriate technique and the continuation of unhealthy eating habits. Aslaner et al[140] have also shown that older patients tend to have a lower weight loss. Resleeve is always an option when %EWL failure is attributed to gastric pouch dilation[141]. More commonly conversion to Roux-en-Y gastric bypass and biliopancreatic diversion with duodenal switch is performed with promising results[142]. Besides weight regain, revision of sleeve gastrectomy can be performed for the recurrence of the initially remitted comorbidities and severe reflux symptoms.

Have we finally found the holy grail of bariatric surgery?

Although a thorough review on sleeve gastrectomy has been made, it seems difficult to respond to the question. A safe response is "No". If LSG was the "holy grail" of bariatric surgery, then it should be the only bariatric operation performed, but it is not. However, it offers many advantages with excellent weight loss results. It is a simple laparoscopic bariatric operation without the need for an anastomosis and with preservation of the gastrointestinal tract continuity. Complication rates, including major ones, are acceptable and the mortality is extremely low. Laparoscopic SG is effective regarding long-term excessive weight loss and resolution of the comorbidities, with minimum nutritional deficiencies and good patient tolerance. In conclusion, laparoscopic sleeve gastrectomy deserves a respectable place among the bariatric procedures performed.

Conflict of Interests

The authors declare they have no competing financial interest.

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