

## Prospective Study

**Five-year outcomes of laparoscopic sleeve gastrectomy as a primary procedure for morbid obesity: A prospective study**

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**Abstract****AIM**

To prospectively evaluate the postoperative morbidity and weight loss evolution of patients who underwent a laparoscopic sleeve gastrectomy (LSG) as a primary bariatric procedure during 5 years of follow-up.

**METHODS**

Since 2006, data from patients undergoing a highly restrictive primary LSG have been prospectively registered in a database and analysed. Preoperative co-morbid conditions, operating time, hospital stay, early and late complications rate and evolution of weight loss after 5 years of follow-up were analysed.

**RESULTS**

A total of 156 patients were included, 74.3% of whom were women. The mean age was  $43.2 \pm 13.1$  years and the mean body mass index (BMI) was  $41.5 \pm 7.9$  kg/m<sup>2</sup>. Seventy patients (44.8%) presented a BMI under 40 kg/m<sup>2</sup>. The mortality rate was 0%. The leakage rate was 1.2%, and the total 30-d morbidity rate was 5.1% (8/156). With a mean follow-up of  $32.7 \pm 28.5$  (range 6-112) mo, the mean percent of excess of weight loss (%EWL) was  $82.0 \pm 18.8$  at 1 year,  $76.7 \pm 21.3$  at 3 years and  $60.3 \pm 28.9$  at 5 years. The mean percent of excess of BMI loss (%EBMIL) was  $94.9 \pm 22.4$  at 1 year,  $89.4 \pm 27.4$  at 3 years and  $74.8 \pm 29.4$  at 5 years. Patients with preoperative BMI less than 40 kg/m<sup>2</sup> achieved greater

weight loss than did the overall study population. Diabetes remitted in 75% of the patients and HTA improved in 71.7%. CPAP masks were withdrawn in all patients with obstructive sleep apnoea.

### CONCLUSION

LSG built with a narrow 34 F bougie and starting 3 cm from the pylorus proved to be safe and highly effective in terms of weight loss as a stand-alone procedure, particularly in patients with a preoperative BMI lower than 40 kg/m<sup>2</sup>.

**Key words:** Sleeve gastrectomy; Morbid obesity; Bariatric surgery; Obesity surgery; Laparoscopy; Long-term results; 5-year results

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**Core tip:** The number of laparoscopic sleeve gastrectomies (LSGs) performed worldwide as a primary bariatric procedure has grown exponentially in recent years, given the simplicity of the technique, the low complication rate and the good short- and mid-term results regarding weight loss and the resolution of co-morbidities. However, there are a limited data from long-term studies. In this study, a standardized LSG proved to be safe (no mortality and a leakage rate of 1.2%) and highly effective in terms of weight loss after 5-year of follow-up, particularly in patients with a low preoperative body mass index. This manuscript provides additional evidence supporting the role of laparoscopic sleeve gastrectomy as a stand-alone procedure for selected morbidly obese patients.

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## INTRODUCTION

The laparoscopic bariatric procedure commonly referred to as "sleeve gastrectomy" (LSG) is a left partial gastrectomy of the fundus and body to create a long tubular gastric conduit constructed along the lesser curve of the stomach<sup>[1]</sup>.

LSG was initially proposed as a first-stage procedure to reduce the mortality and postoperative morbidity of more complex bariatric procedures in higher-risk patients<sup>[2]</sup>, such as the duodenal switch, to complete the biliopancreatic diversion or the Roux-en-Y gastric bypass (RYGB) in a second stage. Soon, it was noted that many patients frequently lost sufficient weight such that a second-stage operation became unnecessary<sup>[3]</sup>. LSG is not merely a restrictive procedure. LSG provokes a rapid gastric emptying of solid food, accelerates intestinal transit

and induces a favourable change in the gut hormones, thereby facilitating weight loss through restriction and appetite suppression, given the reduction in the ghrelin levels after resection of the gastric fundus<sup>[3-7]</sup>. Since then, LSG has been performed as a primary and definitive bariatric procedure in patients whose weight and medical condition are not sufficiently severe to require a complex bariatric operation, moving to a second stage only in those selected patients in which weight loss was inadequate<sup>[8]</sup>. Eventually, LSG was performed in some patients with special conditions in which the usual bariatric operations might be too aggressive<sup>[9]</sup>.

The number of LSGs performed worldwide has grown exponentially over the last decade, because it appears to be an easier and safer technique<sup>[10-13]</sup>. Many surgeons now perform LSG as their standard bariatric operation<sup>[3]</sup>. The advantages of the LSG include its technical simplicity, shorter operative time, maintenance of bowel integrity and preservation of the pylorus<sup>[3,10]</sup>. The long-term problems associated with other complex bariatric procedures, including internal hernias and small bowel obstruction are avoided with LSG. In addition, patients who underwent LSG had fewer nutritional deficiencies than that did patients who underwent RYGB or biliopancreatic diversion<sup>[14]</sup>. The LSG can later be modified by a laparoscopic approach if required, to a more complex procedure (such as RYGB or duodenal switch) in patients who develop severe gastroesophageal reflux symptoms or those who regain weight.

LSG has proven highly effective at achieving durable weight loss and co-morbidity reduction over the short and intermediate terms and is comparable in some aspects to RYGB, the current gold standard in bariatric surgery<sup>[7,15-18]</sup>. However, some questions must be answered regarding the long-term results of LSG because there are a limited data from long-term studies and because of the variability in both the reported follow-up among series and the rate of patients lost to follow-up.

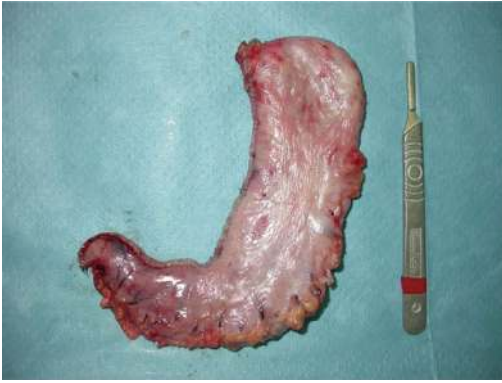
The aim of this study was to assess the safety and outcomes of patients who underwent a LSG as a primary bariatric procedure in analysing mortality, postoperative morbidity rate, late complications and evolution of weight loss after 5 years of follow-up.

## MATERIALS AND METHODS

### Patients selection and study design

From 2006 to January 2016, data from patients who underwent a LSG as a single procedure treating morbid obesity were collected in an electronic database (Microsoft Access 2003 Microsoft Corporation, Redmond, QA, United States) for analysis. All study participants, or their legal guardian, provided informed written consent prior to study enrolment. The study was officially registered under the identification number researchregistry 1580 on researchregistry.com.

The indications for LSG included patients with body mass index (BMI) less than 45 kg/m<sup>2</sup>, primary



**Figure 1 Specimen after sleeve gastrectomy.** The whole fundus had to be removed. Stapler firings must be properly aligned to avoid excessive narrowing of the sleeve and functional obstruction due to rotation.

procedure in super-obese patients as the initial stage of a two-staged approach for weight loss (RYGB or BPD in 2 stages), adolescents (under 18 years old of age) with morbid obesity and obese patients with impaired medical conditions or other important co-morbidities such as liver cirrhosis.

The first endpoint of this study was to assess the safety of the procedure by analysing the 30-d mortality and early postoperative complications: Suture leak rate, haemorrhages, wound infection rate, deep venous thrombosis, pulmonary embolism and cardiac and pulmonary complications.

The second endpoint was to evaluate the outcome of LSG in terms of weight loss 5 years after the procedure. Weight loss was measured using BMI evolution and the percentage of excess weight loss (%EWL). Given the variability of %EWL depending on the definition of ideal body weight, we also used the percentage of excess body mass index loss (%EBMIL)<sup>[19]</sup>. Excessive BMI itself was defined as initial BMI minus 25. Values are reported as the mean  $\pm$  standard deviation.

The following variables were also evaluated: Resolution of preoperative co-morbid conditions [diabetes, hypertension, obstructive sleep apnoea syndrome (OSA)], length of hospital stay and late complications (stricture, functional obstruction, gastroesophageal reflux, trocar-site hernia rate).

### **Surgical technique**

Under general anaesthesia the patients were placed in the reverse Trendelenburg position with the surgeon standing between the legs. All patients received intravenous antibiotic prophylaxis with 2 g of cefazoline. Compression stockings were used during the operation to prevent deep vein thrombosis and thromboembolism.

The procedure was performed using 4 or 5 ports (two or three 12-mm trocars and two 5-mm trocars). The greater curvature of the stomach was completely freed starting from the antrum (3 cm proximal to pylorus) until the left pillar of the diaphragm and the gastroesophageal junction were completely exposed. If a hiatal hernia is identified, dissection should be carried posteriorly to achieve appropriate closure of the crus. If a hernia

is found, it should be repaired<sup>[10]</sup>. A harmonic scalpel (Ultracision®, Ethicon Endo-Surgery Inc., Johnson and Johnson, Cincinnati, OH, United States) was used to divide the gastroepiploic and the short gastric vessels. Then, the adhesions of the posterior side of the stomach were dissected to achieve an appropriate sleeved stomach. The LSG was performed by sequentially firing an articulating linear stapler (Echelon Flex™ Endopath, Ethicon Endo-Surgery Inc., Johnson and Johnson, Cincinnati, OH, United States). The gastric division started at 3 cm proximal to the pylorus. Two 60-mm green staple cartridges (open height = 4.1 mm) were usually used to transect the antrum, and gold (3.8 mm) and blue loads (3.6 mm) were later applied at the gastric corpus and fundus. The whole fundus had to be removed. Special attention was required at that point to avoid rotation and functional obstruction of the sleeve by ensuring equal (and not excessive) traction on both walls of the stomach. It is of utmost importance to align the stapler firings properly to avoid excessive narrowing, especially at the level of the *incisura angularis* (Figure 1).

The calibration of the LSG was obtained using a 34 F oral gastric tube (1.13 cm). The gastric stapled line was always oversewn with a 2/0 absorbable running suture (Monoplus®, B. Braun, Melsungen, Germany) in the 125 initial cases. A bovine pericardial strip (BPS-Peristrip) was used in 5 patients. Since 2014, bioabsorbable membranes (Gore Seamguard® from WL Gore and Associates, Newark, DE, United States) were used instead of the reinforcement suture to achieve better hemostasis and reduce the suture leakage rate<sup>[15]</sup>. Intraoperative leak testing using methylene blue dye was routinely performed. A suction Blake or Jackson-Pratt drain was placed along the suture line. Finally, the gastric specimen was withdrawn through the right 12-mm port. All 12-mm wounds were closed with Monoplus® or Monomax® 2/0 sutures (B. Braun, Melsungen, Germany) using an Endoclose™ trocar-site closure device (Covidien Products, Medtronic, Minneapolis, MN, United States).

Patients started to walk 8 to 12 h after the procedure. A liquid diet was initiated on the first postoperative day and was implemented for two weeks. The patients were usually discharged on the second or third postoperative day. The treatment included oral analgesia, proton-pump inhibitors (PPI) and low molecular weight heparin against deep vein thrombosis for 30 d.

### **Postoperative follow-up**

The first follow-up control was scheduled at the medical office eight days after the procedure. Follow-up data were obtained at the medical office after 15 d, 1, 3, 6 mo, 1 year and semi-annually thereafter by the surgeon who performed the procedure and by a nutritionist. All data were prospectively collected.

## **RESULTS**

Data from 156 patients who underwent LSG until January 2016 were analysed. Of the patients, 116 (74.4%) were

**Table 1** Patients' characteristics and general data of the series

Number of patients	156
Age <sup>1</sup> (yr)	43.2 ± 13.2 (16-71)
Gender (Female/male)	116 / 40
BMI <sup>1</sup> (kg/m <sup>2</sup> )	41.5 ± 7.9
BMI < 40 kg/m <sup>2</sup>	70 (44.9)
BMI 40-50 kg/m <sup>2</sup>	71 (45.5)
BMI > 50 kg/m <sup>2</sup>	15 (9.6)
Comorbidity	
HTA	39 (25)
Diabetes	12 (7.6)
Obstructive sleep apnea (with CPAP)	21 (13.4)
Other	67 (42.9)
Operating time <sup>1</sup> (min)	95 ± 14.1 (65-155)
Hospital stay <sup>1</sup> (d)	3.5 ± 0.7 (1-18)
Follow-up <sup>1</sup> (mo)	32.7 ± 28.5 (6-112)

<sup>1</sup>Data are frequency counts (percentage of total) or the mean ± SD plus range in parentheses. BMI: Body mass index; HTA: Arterial hypertension; CPAP: Continuous positive airway pressure.

women, and 40 (25.6%) were men; overall, the mean age was 43.2 ± 13.1 (range 16-71) years, and the mean BMI was 41.5 ± 7.9 (range 34-76) kg/m<sup>2</sup>. Seventy patients (44.9%) presented BMI under 40 kg/m<sup>2</sup>, and only 15 patients (9.6%) were super-obese (BMI greater than 50 kg/m<sup>2</sup>). All the procedures were performed laparoscopically by the same surgeon. The mean hospital stay was 3.5 ± 0.7 d (range: 1-18). All patients completed the 6-mo outpatient follow-up at the medical office. The mean follow-up was 32.7 ± 28.5 mo (Table 1).

The mean operating time was 95 ± 14.1 min. Conversion to laparotomy was necessary in 2 patients (1.2%) due to intraoperative haemorrhage. One patient was a woman suffering from a cavernous transformation of the portal vein and the other required a lateral segmentectomy to remove a bleeding 8-cm liver haemangioma.

### Morbidity and mortality

No mortality was observed in this series. The total 30-d postoperative complication rate was 5.1% (8/156 patients). The type and severity of complications are listed in Table 2. A leakage in the staple-line was detected in 2 women (1.2%). The first woman (after oversewing the staple line) healed successfully with medical management 14 d after. The second (Peristrips<sup>®</sup> reinforcement) required a laparoscopic reoperation to drain a subphrenic abscess secondary to a leak at the angle of His. No endoprosthesis or self-expanded wall-stent was needed. There was no relationship between leakage and patients' BMI, age or technical difficulties during the sleeve gastrectomy procedure. Intraoperative leak testing was not predictive of the later development of staple line leaks. No patients presented with deep vein thrombosis or pulmonary embolism.

Regarding late complications, one patient (without symptoms of previous staple-line leak) developed a gastric stricture 10 mo after the LSG and submitted to a laparoscopic gastric bypass (0.6%). Twenty-four patients (15.3%) referred to new-onset symptoms suggesting

**Table 2** Mortality, early and late complications after laparoscopic sleeve gastrectomy *n* (%)

Mortality	0
Total 30-d complications	8 (5.1)
Staple line leakage	2 (1.2)
Staple line haemorrhage	1 (0.6)
Wound infection	2 (1.2)
Pneumonia	1 (0.6)
Cutaneous rash	1 (0.6)
Urethral bleeding	1 (0.6)
Late complications	
Symptomatic gastroesophageal reflux	24 (15.3)
Hiatal hernia needing laparoscopic repair	1 (0.6)
Gastric stricture - conversion to gastric by-pass	1 (0.6)
Symptomatic cholelithiasis	7 (4.4)

Data are frequency counts (percentage of total).

gastroesophageal reflux requiring daily low-dose of PPI. One of these patients developed a hiatal hernia and underwent laparoscopic hiatoplasty and a Hill gastropexy with good outcomes. To date, three patients (1.9%) have developed a trocar-site hernia. Cholecystectomy due to symptomatic gallstones was performed during the follow-up in 7 patients (4.4%); 2 of them presented with acute pancreatitis. There were no data on the cholelithiasis rate in asymptomatic patients.

### Weight loss

The mean follow-up was 32.7 ± 28.5 mo (range 6-112). There were 140 patients with at least 1 year of follow-up. Fifty-one patients reached more than 5 years of follow-up.

The mean initial BMI was 41.5 ± 7.9 kg/m<sup>2</sup> (range 34.2-76.0), and the mean initial percentage of excess of weight (%EW) was 83.1% ± 18.1%. The preoperative BMI of 72 patients (44.9%) was less than 40 kg/m<sup>2</sup>. Marked weight loss was observed during the first year in all patients, achieving a mean BMI of 26.4 kg/m<sup>2</sup>, with a mean %EWL of 82.0 ± 18.8 and a mean %EBMIL of 94.9 ± 22.4 after the 1-year follow-up. However, weight loss dropped progressively during the follow-up with remarkable differences among the patients (Figure 2). The mean %EBMIL was 89.4 ± 27.4 at 3 years and 74.8 ± 29.4 (range: 27.2-119.0) at 5 years. The evolution of mean BMI, %EWL and %EBMIL at different follow-up points is shown in Figure 2 and Table 3.

The overall success rate, defined when %EWL is > 50%, was 96.1% of the patients after 1 year, 95.1% after 2 years, 89.5% after 3 years, 82.1% after 4 years and 73.0% after 5 years. It must be highlighted that the patients with a lower initial BMI, especially those with initial BMI under 40 kg/m<sup>2</sup>, achieve excellent results in terms of %EWL and %EBMIL (Figure 3).

### Revisonal surgery

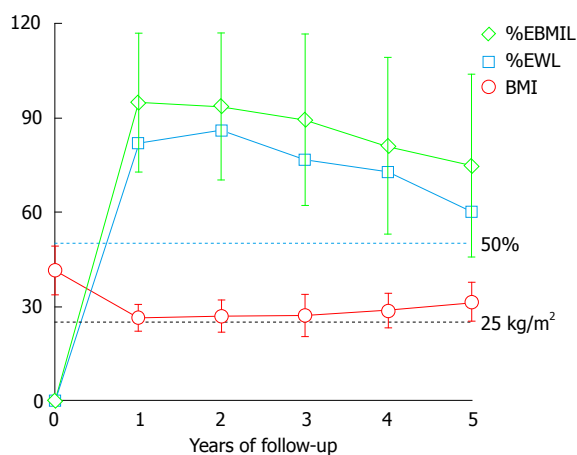
During postoperative follow-up, re-operation because of weight regain from %EWL > 50% to %EWL < 30% was necessary in 4 patients (2.5%), all of them beyond



**Table 3** Weight loss results of laparoscopic sleeve gastrectomy over time

Follow-up	Preoperative	1 yr	2 yr	3 yr	4 yr	5 yr
n	156	140	99	66	56	51
BMI <sup>1</sup>	41.5 ± 7.9	26.6 ± 4.4	26.3 ± 3.7	27.2 ± 5.8	28.7 ± 5.5	30.1 ± 6.1
%EWL <sup>1</sup>		82.0 ± 18.8	86.1 ± 28.9	76.7 ± 21.3	72.8 ± 22.6	60.3 ± 28.9
%EBMIL <sup>1</sup>		94.9 ± 22.4	93.7 ± 23.5	89.4 ± 27.4	81.1 ± 28.3	74.8 ± 29.4

<sup>1</sup>Data are frequency counts (total) or the mean ± SD. BMI: Body mass index; %EWL: Percentage of excess weight loss; %EBMIL: Percentage of excess body mass index loss.



**Figure 2** Evolution of body mass index, excess weight loss and excess body mass index loss during the follow-up. BMI: Body mass index; %EWL: Percent of excess weight loss; %EBMIL: Percent of excess body mass index loss.

the fourth year of follow-up. A 70-year-old woman received a laparoscopic re-sleeve, one patient underwent a SADI's and two received a laparoscopic RYGB.

### Resolution of co-morbidities

After the first postoperative year, the rate of remission or improvement of hypertension was 71.7% (total remission in 25 patients and improvement in 3). CPAP was withdrawn in all patients with obstructive sleep apnoea (OSA). Complete remission of type 2 diabetes (T2DM) was observed in 75% (9/12) of preoperative diabetic patients (remission was considered when anti-diabetic medication was discontinued and blood glucose level was under 120 mg/mL). One patient receiving preoperative insulin improved and now receives per-oral anti-diabetic medication.

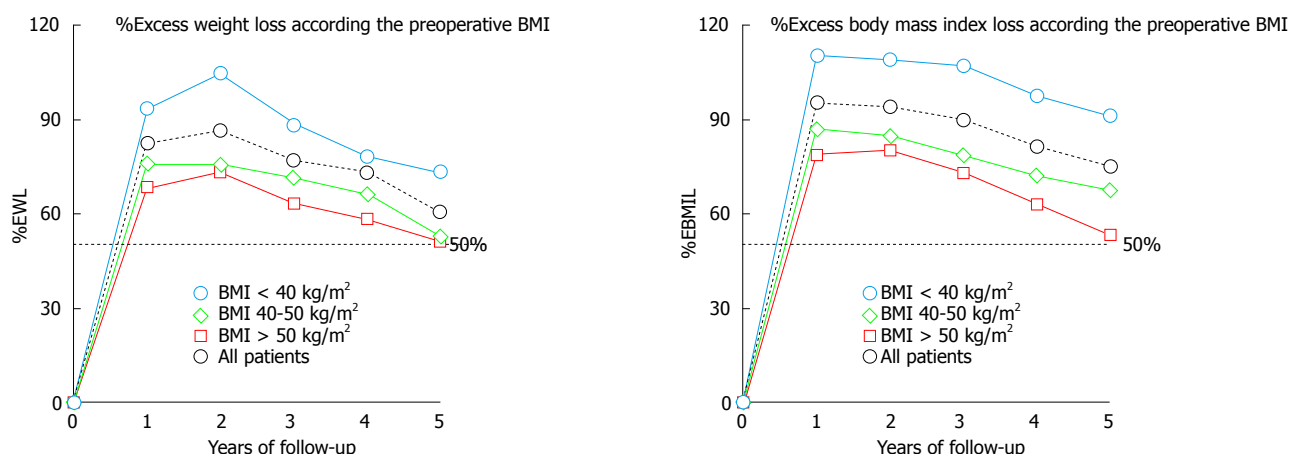
## DISCUSSION

The first endpoint of this study was to assess the safety of LSG as a primary bariatric procedure. LSG has gained popularity in recent years given its theoretical technical simplicity and low rate of complications<sup>[10,11,15]</sup>. However, LSG can be a very difficult procedure even for laparoscopic surgeons with advanced skills. The surgeon's experience and some technical aspects, such as the bougie size (less than 40 F) and the distance to the pylorus being less than

4 cm from the first stapling, have been previously reported as risk factors for the development of complications after a LSG<sup>[13]</sup>.

The mortality rate in this series was nil and the rate of 30-d severe complications related to the procedure was 1.9% (Table 1). The rate of staple-line leak and fistula, which is the most feared postoperative complication after LSG, was low in this series (1.2%), even when using a thin bougie to calibrate the stomach and sectioning the stomach at a short distance from the pylorus. According to the International Sleeve Gastrectomy Expert Panel<sup>[10]</sup>, the average leak rate is 1.06% ± 1.13%. There is currently no consensus on the most effective measures to prevent the leakage and fistula, but we share the concept that reinforcing the staple line (with sutures or buttressing material) during LSG can significantly reduce the leakage rate<sup>[7,15,20]</sup>. The method for doing so is still a matter of debate<sup>[21]</sup>. Some reports showed no differences between oversewing of the staple line and the use of buttresses<sup>[22-24]</sup>. However, a systematic review of 88 included studies representing 8920 patients<sup>[15]</sup> found that the leak rate in LSG was significantly lower using absorbable membrane (Seamguard®) staple-line reinforcement (1.1%) than was oversewing (2.0%), bovine pericardial strip (BPS-Peristrips®) reinforcement (3.3%), or no reinforcement (2.6%). We observed one leak after oversewing of the staple line and another after the use of Peristrips®. No leaks were observed in the Seamguard® subgroup but the small number of patients in this series does not allow further analysis. It must be noted that the significantly highest incidence of leaks was reported when using both sutures and buttressing material (3.6%); consequently, this approach should always be avoided<sup>[24]</sup>.

The second endpoint was to evaluate the evolution of weight loss after LSG as a primary bariatric procedure. The overall results of this study reinforce the evidence that LSG was effective at achieving a significant weight loss over short- and mid-term follow-up. Comparable outcomes in terms of weight loss over a 5-year period were reported at the 3<sup>rd</sup> International Summit of Sleeve Gastrectomy<sup>[3]</sup>, with a mean percentage of excess weight loss of 62.7%, 64.7%, 64.0%, 57.3%, and 60.0% after 1, 2, 3, 4, and 5 years, respectively. These data are all consistent with other studies published to date<sup>[16,25-38]</sup> (Table 4). LSG outcomes are comparable to the gold standard procedure in bariatric surgery, the RYGB<sup>[6]</sup>, thus



**Figure 3** Excess weight loss evolution and excess body mass index loss evolution according to preoperative body mass index. Patients with a preoperative BMI under 40 kg/m<sup>2</sup> achieve better results after 5-year of follow-up. BMI: Body mass index; %EWL: Percent of excess weight loss; %EBMIL: Percent of excess body mass index loss.

**Table 4** Long-term weight loss outcome of laparoscopic sleeve gastrectomy for morbid obesity

Author	Year	Patients with 5-yr follow-up	Mean initial BMI (kg/m <sup>2</sup> )	%EWL 1 yr	%EWL 5 yr	%EBMIL 1 yr	%EBMIL 5 yr
Bohdjalian <sup>[26]</sup>	2010	26	48.2 ± 1.3	57.5 ± 4.5	55.0 ± 6.8		
Himpens <sup>[27]</sup>	2010	30	39		53.3		
D'Hondt <sup>[28]</sup>	2011	83	39.3	78.5	54.4		
Braghetto <sup>[29]</sup>	2012	60	38.4 ± 5.1	57.3	57.3		
Sarela <sup>[30]</sup>	2012	13	45.9	76	69 (8 yr)		
Rawlins <sup>[31]</sup>	2013	49	65	56	85.8		91
Sieber <sup>[32]</sup>	2014	62	43.0 ± 8.0			61.5 ± 23.4	57.4 ± 24.7
Boza <sup>[33]</sup>	2014	112	34.9	88	62.9		
Liu <sup>[34]</sup>	2015	44	41.0 ± 7.0	70.5	57.2		
Lemanu <sup>[35]</sup>	2015	55	50.7	56	40		
Pok <sup>[36]</sup>	2015	61	37.3 ± 8.1	76.5	72.6		
Alexandrou <sup>[37]</sup>	2015	30	55.5 ± 1.7	65.2 ± 6.1	56.4 ± 5.8		
Perrone <sup>[38]</sup>	2016	162	47.4 ± 4.2			75.1 ± 18.9	78.8 ± 23.5
Hoyuela	2016	51	41.5 ± 7.9	82.0 ± 18.8	60.3 ± 28.9	94.9 ± 22.4	74.8 ± 29.4

BMI: Body mass index; %EWL: Percentage of excess weight loss; %EBMIL: Percentage of excess body mass index loss.

supporting the role of LSG as a stand-alone bariatric operation for morbid obesity.

However, a significant amount of patients may regain weight over time after LSG. Long-term results of LSG still are an ongoing concern, and 10-year follow-up data are actually scarce. Furthermore, a high rate of patients lost to long-term follow-up is not uncommon in previously reported series. Although weight regain was evident with time, data from our series and some long-term observational studies indicate that a significant number of patients maintained good weight loss beyond 5 years of follow-up (Table 4). A recent systematic review of 16 long-term studies including 492 patients revealed the %EWL to be 62.3%, 53.8%, 43% and 54.8% at 5, 6, 7 and 8 or more years of follow-up, respectively<sup>[25]</sup>. Arman *et al*<sup>[39]</sup> reported a mean %EBMIL of 62.5% in patients who kept the simple sleeve construction (74.6% overall-study series) after a mean follow-up of 11.7 years.

It is still unclear why LSG ceases to be effective over time in terms of weight loss in some patients, but several reasons could be involved, including dilation of the gastric

tube, insufficient gastric fundus resection (where ghrelin is produced) or hyperactivity of previously silent ghrelin-producing cells and other hormonal changes<sup>[6,26,39,40]</sup>. Inadequate adherence to aftercare changes in eating behaviour and lack of physical activity could play a role of paramount importance in patients with poorer maintenance of weight loss. A recent systematic review by Karmali *et al*<sup>[41]</sup> concluded that the underlying causes leading to weight regain are multi-factorial and related to patient- and procedure-specific factors.

Our data showed better results regarding weight loss when the initial BMI was lower. Patients with an initial BMI less than 40 kg/m<sup>2</sup> registered excellent results (73% of EWL and 90.8% of EBMI at 5 years) compared with the overall study population (Figure 3). Age > 60 years, pre-existing co-morbidities and BMI superior to 50 kg/m<sup>2</sup> were identified as prognostic factors of poorer outcome after LSG. Super-obese patients also had poorer weight loss results in this series. These results allow us to suggest that LSG could be routinely used as a sole bariatric technique for patients whose BMI was less than

40 kg/m<sup>2</sup>.

However, we observed high variability among patients regarding weight loss maintenance over time, even in patients with similar characteristics. No other significant differences were found between subgroups of patients probably due to the small sample of patients with 5 years of follow-up. Identifying preoperative predictive factors of success might be useful for developing strategies to improve bariatric surgery outcomes and patient selection. Further long-term follow-up randomized studies that include a larger number of patients are needed to identify which patients would benefit the most from LSG.

The last endpoint was to analyse the resolution of preoperative co-morbidities in the patients who underwent a LSG. LSG allowed CPAP to be withdrawn in all patients in the series with preoperative OSA and achieved the resolution of hypertension and T2DM in more than 70%. The improvement of T2DM occurred soon after surgery, even without significant weight loss yet being achieved, and this fact could be attributed to hormonal changes, such as increased GLP-1 secretion or decreased ghrelin<sup>[6]</sup>. The long-term effects of LSG on T2DM evolution are under continuous evaluation, and Aminian *et al*<sup>[42]</sup> recently reported a 44% of long-term relapse of T2DM after initial remission and continuous complete remission for  $\geq 5$  years ("cure") was achieved in only 3% of the patients. LSG and RYGB showed comparable remission rates of T2DM in a long-term observational study<sup>[18]</sup>, but a meta-analysis including 6526 patients confirmed that RYGB achieved a higher diabetes remission rate (HR = 1.49, 95%CI: 1.04-2.12)<sup>[16]</sup>. Current data suggesting the long-term superiority of RYGB over LSG in the metabolic control of T2DM could be accounted for by the greater weight loss and by a larger contribution of weight-loss-independent mechanisms<sup>[43-45]</sup>.

In our opinion, the main limitations of this study are the sample size of the series and the heterogeneity of the patients included in the series, precluding to discover significant differences between subgroups of patients (for example, only 15 super-obese patients are included in this series). In addition, only 32% (51/156) of patients reached 5-years of follow-up. The lack of adherence to follow-up was reported previously, and it can be related to several issues, including the distance to the medical office and a lack of trust or rapport with the surgeon or the medical team<sup>[46]</sup>. However, the most relevant strength of this study is that all patients underwent a standardized LSG operative technique, first, because surgeon expertise is a key issue to lower the complications rate<sup>[13,24]</sup> and second, because there were no technical differences that may influence the weight loss results. We always tried to perform a more restrictive LSG by using a thinner bougie and beginning the dissection 3 cm from the pylorus to achieve greater weight loss, as suggested by Baltasar *et al*<sup>[8,31]</sup>. In addition, the long-term follow-up of the patients was always carried out by the same surgeon who performed the procedure.

In conclusion, a LSG built with a narrow 34 F bougie and starting 3 cm from the pylorus, proved to be safe

and highly effective in terms of weight loss as a stand-alone procedure, especially in patients with preoperative BMI lower than 40 kg/m<sup>2</sup>. In our opinion, LSG could be accepted as the first stand-alone procedure for morbidly obese patients with low BMI. Prospective randomized trials analysing long-term results (beyond ten years of follow-up) will help elucidate whether LSG is comparable to more aggressive techniques.

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## COMMENTS

### Background

The number of laparoscopic sleeve gastrectomies (LSGs) performed worldwide as a primary bariatric procedure has grown exponentially in recent years, given the simplicity of the technique, the low complication rate and the good short- and mid-term results regarding weight loss and the resolution of co-morbidities. However, the long-term results of LSG still are an ongoing concern because a significant amount of patients may regain weight over time after LSG.

### Research frontiers

Bariatric surgery is safe and efficient and allows not only to lose weight but treat conditions such diabetes, hypertension and sleep apnoea in morbidly obese people. Probably, the indications of bariatric and metabolic surgery will increase in the future treating such comorbidities, given its good results and low morbidity.

### Innovations and breakthroughs

The current prospective study suggests that LSG could be the procedure of choice for those morbid patients with a low preoperative body mass index (BMI) and without severe comorbidities. However, strict nutritional and behavioural monitoring and follow-up by the surgical team seem to be of paramount importance.

### Applications

This study provides additional evidence supporting the role of LSG as a stand-alone procedure for morbidly obese patients, particularly in patients with a low preoperative BMI.

### Terminology

**Sleeve gastrectomy:** Is a left partial gastrectomy of the fundus and body to create a long tubular gastric conduit constructed along the lesser curve of the stomach. The body mass index (BMI) is the main parameter to assess morbid obesity and is defined as the body mass (weight in kilograms) divided by the square of the body height and is universally expressed in units of kg/m<sup>2</sup>. The changes in weight and BMI expressed by means of percentage of excess weight loss and percentage of excess of BMI loss help to evaluate the success of bariatric surgery.

### Peer-review

The article addresses an important entity and many newly qualified surgeons may find this article interesting.

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