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REVIEW

Laparoscopic sleeve gastrectomy: More than a restrictive bariatric surgery procedure?

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Abstract

Sleeve gastrectomy (SG) is a restrictive bariatric surgery technique that was first used as part of restrictive horizontal gastrectomy in the original Scopinaro type biliopancreatic diversion. Its good results as a single technique have led to a rise in its use, and it is currently the second most performed technique worldwide. SG achieves clearly better results than other restrictive techniques and is comparable in some aspects to the Roux-en-Y gastric bypass, the current gold standard in bariatric surgery. These benefits have been associated with different pathophysiologic mechanisms unrelated to weight loss such as increased gastric emptying and intestinal transit, and activation of hormonal mechanisms such as increased GLP-1 hormone and decreased ghrelin. The aim of this review was to highlight the salient aspects of SG regarding its historical evolution, pathophysiologic mechanisms, main results, clinical applications and perioperative complications.

Key words: Bariatric surgery; Sleeve gastrectomy; Severe obesity; Dyslipidemia; Hypertension; Type 2 diabetes mellitus

Core tip: The most salient aspects of sleeve gastrectomy, a restrictive bariatric surgery technique yielding better results than other restrictive techniques that cannot simply be explained by weight loss, are reviewed.

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HISTORY: FROM OUTSET TO TODAY

Sleeve gastrectomy (SG) began to be used in 1988 as a variation of biliopancreatic diversion (BPD) with duodenal switch[1-3]. In contrast to the BPD described by Scopinaro *et al*[4] in which a horizontal gastrectomy was performed, the pylorus and duodenum were preserved in SG, yielding a reduction in dumping symptoms and marginal ulcers. In addition, gastrectomy was more restrictive, permitting a decline in the malabsorptive component and nutritional secondary effects[2]. Initially, this technique was performed openly, with Ren *et al*[5] being the first to perform it laparoscopically in the late 1990's. In the early 2000's, given the high frequency of complications in patients with a high body mass index (BMI)[6], Regan *et al*[7] described a two-step approach to treat patients with high surgical risk. In a first step, SG was implemented to achieve sufficient weight loss to permit the Roux-en-Y gastric bypass (RYGB) or BPD to be performed more safely in a second step[8,9]. Given the good results obtained, a second intervention was unnecessary in many cases which, together with low morbidity and mortality, rapidly installed SG as a single procedure[10-12]. Subsequently, Baltasar *et al*[13] recommended a multipurpose strategy, applying SG as a single procedure in mildly-obese patients or after failed gastric banding, and as a 2-step procedure for high-risk patients, who were either extremely obese or had serious comorbidities. In recent years, some technical modifications, such as a progressive decrease in gastric remnant size, have been made in order to prevent weight gain in the long term[14], or the use of natural transluminal orifice endoscopic surgery[15] and single incision laparoscopic surgery[16].

SG has gradually gained in popularity, becoming established as the second most used bariatric procedure worldwide, closer to RYGB, the considered gold standard. Thus, according to the International Federation for the Surgery of Obesity and Metabolic Diseases, between 2008 and 2013, SG use increased from 5.3% to 27.9% of all procedures while RYGB, albeit remaining the most widely-used technique, has fallen from 49.0% to 46.6%[17].

THE TECHNIQUE

SG is a bariatric technique consisting of subtotal vertical gastrectomy with preservation of the pylorus, including longitudinal resection of fundus, corpus

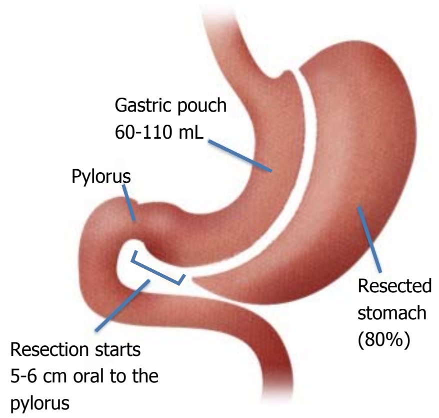

Figure 1 Sleeve gastrectomy.

and antrum, to create a tubular duct along the lesser curvature. Resection comprises approximately 80% of the stomach and the remnant gastric has a capacity > 100 mL. It is considered an easier technique than other procedures such as RYGB, since multiple anastomoses are required[18] (Figure 1). Variants of SG have been described, and although no comparative studies have been conducted, none seems to offer advantages. Furthermore, SG has been performed with different degrees of intestinal bypass, including variants with 2 exits from the stomach such as SG transit with bipartition[19] and SG with loop bipartition[20]. In an attempt to achieve a surgery with more metabolic effects, SG has also been linked with ileal transposition[21]; finally, short-term studies on SG with a gastric band have been reported[22].

MECHANISMS

SG yields better results than other restrictive techniques and is similar to RYGB in terms of weight loss and carbohydrate metabolism improvement in the short and medium term[23]. This SG superiority over other restrictive techniques has been related to different mechanisms such as modification of gastrointestinal motility, hormonal mechanisms, alterations in bile acids and gut microbiote.

Unlike other restrictive techniques such as gastric banding, SG provokes a rapid gastric emptying[24] and accelerated intestinal transit[25]. It seems that the rapid transit may trigger hormonal mechanisms that will be described below; it could also cause increased satiety, as occurs with drugs that enhance gastric emptying[26].

GLP-1 is an incretin hormone secreted by L-cells of the distal intestine in response to eating. It has beneficial effects on weight and glucose metabolism since it promotes insulin secretion, inhibits gastric emptying, glucagon secretion and hepatic glucose production[27]. SG has repeatedly produced an exaggerated postprandial increase in GLP-1[28-30] comparable to that of RYGB. In the latter, the rise in GLP-1 could be explained by the hind-gut hypothesis, in which stimulation of the distal gut caused by the bypass lead to an amplified increase in GLP-1. However, after SG, the mechanism by which the surgery would increase GLP-1 secretion is unclear. One hypothesis could be that the enhanced transit resulting from SG also causes distal intestine stimulation[24]. A further possibility would arise from the lack of gastric response to the intestinal signals that normally slow emptying[24]. Others have proposed that an increase in GLP-1 levels would be an effort to restore intestinal gastric motility in response to accelerated gastric emptying[31]. Since GLP-1 response is also increased by infusing nutrients directly into the duodenum, the existence of an independent gastric emptying mechanism has also been suggested[24]. Moreover, given the rapid increase in GLP-1 following ingestion and presumably before nutrients contact L-cells, the existence of a proximal-distal circuit causing GLP-1 secretion has been proposed that does not require direct contact between chime and L-cells, which could be mediated *via* a neural[32] or hormonal pathway through cholecystokinin (CCK)[33].

Peptide YY (PYY), also known as peptide tyrosine tyrosine or pancreatic peptide YY_{3-36}, is an anorexigenic peptide released by L-cells in mucosa of the gastrointestinal tract, especially the ileum and colon, in response to feeding[34]. In addition to reduce appetite, PYY increases nutrient absorption in the ileum, inhibits gastric and pancreatic secretion, attenuates gallbladder contraction and slows gastric emptying. Reduced secretion in obese patients, which is associated with lower satiety, has been reported[35]. Like GLP 1, numerous studies have demonstrated a significant increase in PYY after SG, and again the results are comparable to those observed after RYGB[29,30], suggesting that the mechanism for increase will be shared.

Ghrelin is a neuropeptide with orexigenic action predominantly synthesized by oxyntic cells of the gastric fundus[36]. Under physiologic conditions, ghrelin levels increase during fasting with a preprandial peak and are suppressed by food. It also has diabetogenic effects such as the suppression of insulin secretion[37]. A drop in ghrelin concentrations after SG compared to baseline levels[38,39] and other restrictive techniques[40,41] or RYGB[28,29] has consistently been demonstrated. This drop off has been associated with fundus resection and there is speculation that it may be one of the main mechanisms accounting for the superiority of SG over other restrictive techniques and its similarity to RYGB. Nevertheless, some experimental studies found that the decline in ghrelin concentrations could not be decisive. Chambers *et al*[42] showed that ghrelin-deficient mice continued to lose weight, had improved glucose metabolism and inappetence for fatty foods after SG. However, the authors warned that a possible compensatory mechanism in ghrelin-deficient animals may underestimate the effects of surgery. In favor of the beneficial effects of ghrelin reduction after SG, an increase in ghrelin after weight loss by diet or by other restrictive techniques has been observed[40,41]. This suggests that weight loss triggers compensatory mechanisms to recover weight that could be deleted after SG[43].

Leptin, synthesized in white adipose tissue proportionally to the amount of body fat[44], reduces intake and body weight through actions in the central nervous system. In obesity, a decreased sensitivity to leptin has been suggested, resulting in an inability to detect satiety despite high energy stores[45]. It is unclear whether the improvement in leptin resistance plays a direct role in weight loss after SG. While related genes seem to increase its expression[46], recent studies suggest that the reversal of leptin resistance could be regulated by protein availability[47].

Increasing endocrine functions for bile acids have been recognized and associated with an increased GLP-1 response, carbohydrate metabolism improvement and reducing liver steatosis[48]. The increased serum bile acid concentrations after SG[49] are probably related to rapid transit that will increase their availability in the area of maximum absorption, the terminal ileum. It also appears that these effects could be mediated by the farsenoid X receptor (FXR), since Ryan *et al*[50] showed that this pathway is needed to improve glucose metabolism, prevent compensatory hyperphagia and maintain long-term weight loss after SG.

Another mechanism which potentially influences the metabolic benefits of SG is the change in the gut microbiome, which improves the flora composition as in lean subjects[50,51] in a similar way to but less striking than RYGB. Although the mechanisms are yet to be discovered, the way is open to a complex and promising system of host-bacteria interactions[52].

With a view of greater perspective, control energy homeostasis involves a sophisticated communication system among the gut, adipose tissue and central nervous system[42,46]. *Via* hormonal and neural signals, the central nervous system integrates the information on what happens in the gut, *e.g.*, type and amount of ingested nutrients and on energy reserves and acts by regulating appetite, satiety and feeding behavior. For instance, against a negative energy balance, this system could compensate by hyperphagia or increasing preference for high-calorie food to restore normal weight[46]. In this respect, the key for the effectiveness of SG as metabolic surgery appears to lie in preventing these compensatory responses, modifying both hormonal and neural signaling pathways or even leading to changes at central level[47].

RESULTS

Weight loss

Although several studies have analyzed the efficacy of SG compared with other techniques, few randomized

Table 1 Randomized trials of bariatric surgery studies including laparoscopic sleeve gastrectomy

Ref.	Country	Follow-up (mo)	Intervention groups	Preoperative BMI (kg/m^2)	Weight loss	T2DM	T2DM remission	T2DM remision criteria
Langer *et al*[53]	Austria	6	SG (10)	48.3	61.4%EWL	10%	NR	
			LAGB (10)	46.7	28.7%EWL	30%		
Himpens *et al*[54]	Belgium	36	SG (40)	39.0	66%EWL	NR		
			LAGB (40)	37.0	48%EWL			
Lee *et al*[55]	Taiwan	12	SG (30)	30.3	76.3%EWL	100%	93%	FG < 126 mg/dL and A1c < 6.5%
			RYGB (30)		94.4%EWL		47%	without hypoglycemic therapy
Karamanakos *et al*[56]	Greece	12	SG (16)	45.1	69.7%EWL			
			RYG (16)	46.6	60.5%EWL			
Kehagias *et al*[57]	Greece	36	SG (30)	44.9	68.5%EWL	16.7%	80%	FG < 126 mg/dL without
			RYGB (30)	45.8	62.1%EWL	16.7%	80%	hypoglycemic therapy
Peterli *et al*[58]	Switzerland	12	SG (11)	44.7	65.6%EWL	0%		
			RYGB (12)	46.7	77.0%EWL	0%		
Schauer *et al*[59]	USA	36	SG (50)	36.2	81%EWL	100%	26.5%	A1c < 6.0% without
			RYGB (50)	37.0	88%EWL		42%	hypoglycemic therapy
			Medical therapy (50)	36.8	13%EWL			
Schauer *et al*[60]	USA	12	SG (50)	36.2	21.1%TWL	100%	29%	A1c < 6.0% without
			RYGB (50)	37.0	24.5%TWL		46%	hypoglycemic therapy
			Medical therapy (50)	36.8	4.2%TWL		0%	
Paluszkiewicz *et al*[61]	Poland	12	SG (36)	46.1	67.6%EWL	27.8%	40%	FG < 100 mg/dL and A1c < 6.0%
			RYGB (36)	48.6	64.2%EWL	38.9%	64.3%	without hypoglycemic therapy
Ramón *et al*[28]	Spain	12	SG (8)	43.5	NR	25.0%	100%	NR
			RYGB (7)	44.2		28.6%	100%	
Vix *et al*[62]	USA	12	SG (45)	45.5	82.9%EWL	8.9%	NR	
			RYGB (45)	47.0	80.3%EWL	8.9%		

BMI: Body mass index; T2DM: Type 2 diabetes mellitus; EWL: Excess weight loss; LABG: Laparoscopic adjustable gastric banding; FG: Fassting glucose; SG: Sleeve gastrectomy; RYGB: Roux-en-Y gastric bypass; %EWL: Percentage excess weight loss; %TWL: Percentage total weight loss; NR: Not reported; LAGB: Laparoscopic adjustable gastric banding.

clinical trials showing SG superiority in terms of weight loss compared with other restrictive techniques such as laparoscopic adjustable gastric banding (LAGB) and similar to RYGB have been conducted (Table 1)[28,53-62]. One of the main limitations of those clinical studies was the small sample size that may have accounted for the lack of differences with RYGB. In this regard, Li *et al*[63] conducted a meta-analysis including 21 prospective and 12 retrospective studies with a total of 1375 patients, and no differences were found in excess percentage weight loss (%EWL) at 12 mo between SG (67.1%) and RYGB (68.9%). The few long-term observational studies indicate that although patients regain weight after SG, they achieve a "durable" long-term weight loss. A review of 16 long-term studies revealed %EWL to be 62.3%, 53.8%, 43% and 54.8% at 5, 6, 7 and 8 or more years of follow-up, respectively[64]. Similarly, Himpens *et al*[65] reported that patients regained weight over 3 to 6 years, but most subjects had maintained an %EWL > 50% at 6 years. It is unclear whether this weight regain after SG can justify that RYGB and SG cease to be equally effective in the long term in terms of weight loss. On the one hand, Lim *et al*[66] found no difference up to five years, although it is notable that a high number of patients were lost to follow-up. Moreover, a study by our group found that, unlike what occurs during the first 4 years, RYGB was independently associated with greater weight loss than SG[67]. This weight regain after SG may have several potential reasons. One could be gastric tube dilation. In this respect, Weiner *et al*[68] published a weight regain after SG associated with widening or enlargement of the sleeve after surgery with increased capacity of the gastric tube. A further possible explanation may be incomplete resection of the gastric fundus where ghrelin is produced.

Type 2 diabetes mellitus

Assessment of the effects of SG on diabetes mellitus shows SG to be more than a restrictive bariatric surgery procedure. Clinical studies with a 1-2-years follow-up showed that SG produced higher type 2 diabetes mellitus remission rates than those obtained after other restrictive techniques such as LAGB[69]. Furthermore, as with RYGB, this improvement occurred soon after surgery when significant weight loss had not yet been achieved[70]. These findings could be attributed to changes in the gut hormonal mechanisms previously cited, such as increased GLP-1 secretion or decreased ghrelin. Nevertheless, recent studies seem to show that hormonal mechanisms would be crucial in the short term but would outweigh other factors related to weight loss such as hepatic and peripheral insulin sensitivity in the medium to long term[31].

However, it is noteworthy that in most studies

Table 2 Complication and mortality rates of the different bariatric surgery techniques according to the American College of Surgeons - Bariatric Surgery Center Network

	LSG	LAGB	LRYGB
30-d mortality	0.11	0.05	0.14
1-yr mortality	0.21	0.08	0.34
30-d morbidity	5.61	1.44[1]	5.91
30-d readmission	5.40	1.71[1]	6.47
30-d reoperation	2.97	0.92[1]	5.02[1]

[1]Statistically-significant differences compared with LSG. LSG: Laparoscopic sleeve gastrectomy; LAGB: Laparoscopic adjustable gastric banding; LRYGB: Laparoscopic Roux-Y-gastric bypass.

RYGB showed a trend toward greater improvement in type 2 diabetes mellitus, which may suggest there was a lack of power in those studies. This fact appeared to be confirmed in the meta-analysis of Li *et al*[63] that included 32 studies and 6,526 patients and in which the diabetes remission rate was slightly higher with RYGB (HR = 1.49, 95%CI: 1.04-2.12). This suggests that SG would be placed slightly below RYGB and clearly above other restrictive techniques in terms of type 2 diabetes remission.

Results on the efficacy of SG in long-term diabetes remission are also scant. Abbatini *et al*[23] reported a type 2 diabetes remission rate up to three years of 80.9% with SG, similar to that obtained with RYGB (81.2%) and higher than with LAGB (60.8%). Jiménez *et al*[71] meanwhile detected no differences between SG and RYGB in their cohort of 155 diabetic patients followed for 35.4 ± 13.5 mo.

Hypertension

SG effectiveness in hypertension is greater than other restrictive techniques and below RYGB. In a systematic review, Braghetto *et al*[72] reported a hypertension remission rate of 69% (55%-82%) for SG, 45% (27%-56%) for LAGB and 81% (68%-88%) for RYGB. Similarly, the meta-analysis of Li *et al*[63] detected HR of 1.47 (1.115-1.86) for hypertension remission with RYGB. The superiority of SG over LAGB can be justified by the fact that weight loss is a crucial factor in achieving hypertension remission[73]. Moreover, the superiority of RYGB over SG can be explained by the effects of incretin hormones on blood pressure.

Dyslipidemia

Regarding lipid profile, like other restrictive techniques, SG has a neutral effect on LDL cholesterol concentration[74,75]. Consistent with these results, the hypercholesterolemia remission rate of in the meta-analysis of Li *et al*[63] was higher for RYGB and more clearly so than in other comorbidities (HR = 2.41, 95%CI: 1.87-3.11). Several data support the hypothesis that the main factor involved in lowering LDL cholesterol is the malabsorptive effect of the surgical technique. First, Pihlajamäki *et al*[76] found, as expected based on observed weight loss, decreased serum levels of cholesterol synthesis markers after RYGB or gastric banding. However, a reduction in cholesterol absorption markers was only observed after RYGB, an effect not reported following gastric banding. Second, a relationship exists between the extent of intestinal bypass, which in turn relates to a reduced intestinal absorption area, and the effects on LDL cholesterol. This fact could explain the greater reduction (50%) in LDL cholesterol concentrations seen after purely malabsorptive techniques such as BPD[77] compared to the 17%-20% reported for RYGB[78], a technique with a lower degree of malabsorption.

For HDL cholesterol, SG, like RYBG, produces an increase in its concentration in the short term. We must emphasize that, in a study by our group, the increase in HDL cholesterol was higher for SG[75]. This finding needs to be corroborated by other studies.

Finally, with respect to triglycerides, weight loss is the major factor involved in the reduction in their concentration after different bariatric surgery techniques. As in weight loss, no differences between RYGB and SG in terms of triglyceridemia improvement have been detected[75].

Gastroesophageal reflux

SG may worsen gastroesophageal reflux (GER) owing to increased intragastric pressure, reduced gastric emptying and decreased lower esophageal sphincter pressure. On the other hand, acceleration of gastric emptying and weight loss may improve GER. The results of clinical studies are controversial[65,79]. This controversy could be attributed to methodologic differences in the evaluation of GER and the different follow-up. Some authors proposed that randomized clinical trials should be conducted and that standardized criteria to define GER, validated questionnaires and objective measurements such as pH monitoring should be used to assess the effects of SG[80].

COMPLICATIONS

The introduction of different technical advances has caused a dramatic reduction in bariatric surgery-related mortality. Thus, mortality in RYGB is 10 times higher when performed in open surgery compared with laparoscopy[81]. Mortality after bariatric surgery is currently low and no significant differences exist among the different bariaric surgery techniques according to data from the American College of Surgeons - Bariatric Surgery Center Network including 28616 patients in 25 hospitals in the USA (Table 2)[82]. By contrast, both early complications (< 30 d) and time of surgery for SG yield better results than RYGB and slightly worse than LAGB.

Technical differences among surgeries may cause certain complications that are characteristic of each technique. It should be noted that up to 20% of subjects who undergo LAGB may require reoperation due to complications related to the gastric band[83]. These reinterventions often occur in the medium to long term and detract from the low rate of early complications after LAGB. Moreover, after SG patients are free of the severe complications of RYGB such as severe hypoglycemia[84], and others such as micronutrient deficiencies or internal hernias are less frequent[85]. Nevertheless, nutritional deficiencies are not uncommon after SG, with multivitamin therapy and postoperative follow-up being recommended[85].

One of the most common and characteristic complications of SG is staple line leak. Although its prevalence is variable, a meta-analysis of 36 studies and 2570 patients showed a frequency of 2.7%[86], but can be < 1% in expert hands[87]. Leaks occur in approximately 90% of cases in the angle of His, leading to detection and therapy being more complex than in RYGB. Different approaches to their management have been proposed, ranging from conservative treatment with fasting until reoperation to a stent or endoscopic treatment by placing clips, fibrin and pyloric dilation to reduce intragastric pressure[88]. Moreover, different staple line reinforcement options have been tested and have proven ineffective to prevent leaks[89].

SPECIAL POPULATIONS

In 1991, the National Institutes of Health (NIH) limited bariatric surgery indication to subjects aged an age between 18 and 60 years and who were very large (BMI > 40 kg/m^2) or large (BMI > 35 kg/m^2) with obesity-related complications[90]. Since then, numerous studies on adolescents, the elderly and subjects with BMI < 35 kg/m^2 have been reported.

As in the general population, the prevalence of obesity in children and adolescents has gradually increased in recent years. In Spain, a rise from 13.9% in 2005 to 19.1% in 2011 was estimated for this specific population[91,92]. There is currently a paucity of data on the long-term efficacy of bariatric surgery in this age range. Data available to date show that SG is safe and effective in the short term and is associated with minimal morbidity and 70% comorbidity resolution[93]. Moreover, SG may have several advantages that render it the technique of choice in obese adolescent candidates for bariatric surgery. On the one hand, SG has a lower risk of late complications such as dumping syndrome or nutritional deficits that patients would suffer for the rest of their lives. Moreover, in cases of significant weight gain, patients could be reoperated on in a second step with a malabsorptive technique.

In patients < 60 years of age RYGB is considered the technique of choice ahead of LAGB given its better risk-benefit ratio[94]. In contrast, in subjects > 60 years, the risk of surgical complications post-RYGB increases significantly and has led some authors to propose LAGB as the technique of choice[95]. No data on the efficacy and safety of SG in patients > 60 years of age are available; however, if the results of patients < 60 years are reproduced, then SG could become the technique of choice in this age range.

In Spain, 17.5% of the population have obesity grade 1 and are therefore without indication for bariatric surgery according to the NIH[96]. Conventional treatment for obesity has proved ineffective in this obese category, which has led to increased research on the effects of bariatric surgery in this weight range. Data currently available are scant and refer only to the short term. Two clinical trials in subjects with BMI < 35 kg/m^2, including SG in one group, have been reported. In the randomized controlled trial by Schauer *et al*[59], 34% of subjects had a BMI < 35 kg/m^2; weight loss and diabetes remission with SG were greater than with conventional treatment and comparable to RYGB (Table 1). Moreover, Lee *et al*[55] randomized 60 subjects to SG or minigastric bypass. In that study, no differences in weight loss between SG and minigastric bypass (94% *vs* 76% EWL, respectively) were detected; however, the diabetes remission rate was higher with minigastic bypass (93% *vs* 47%). We must emphasize that SG was a safe technique in both studies.

Recently, the International Federation for the Surgery of Obesity[97] recommended that bariatric surgery should be considered when sufficient weight loss is not achieved after a reasonable period of time with conventional treatment. The indication of bariatric surgery must be based on more on comorbidities than BMI levels, and these comorbidities should be evaluated in the expected response to the bariatric surgery compared with medical treatment. This statement does not specify what the procedure of choice would be at this BMI level. Given that one of the main reasons to indicate bariatric surgery at this BMI range may be the presence of type 2 diabetes mellitus, SG can play a major role if the same results are reproduced in terms of weight loss and diabetes remission in subjects with BMI > 35 kg/m^2.

Patients with extreme obesity have a higher risk of perioperative complications and mortality than those with a BMI < 50 kg/m^2[98]. As mentioned previously, SG was initially designed as a first step before a BPD in obese subjects at high risk[1,2]. SG as a single technique does not seem appropriate for extremely obese patients since a high percentage maintain a BMI > 40 kg/m^2 in the medium term[99]. Weight loss and improvement in comorbidities after SG are associated with improved Anesthesiologist American Society (ASA) risk and consequently a reduced risk of surgical complications[100]. This approach of two steps being safer that one step has proved effective in terms of weight loss and improvement in comorbidities in extremely-obese patients[86].

Table 3 Sleeve gastrectomy may be preferable to other procedures in the following situations

Extreme obesity (BMI > 50 kg/m^2): first-step procedure
ASA IV morbidly-obese patient
Absence of hypercholesterolemia
To avoid drug malabsorption
Extreme ages
BMI of 35-40 kg/m^2 with comorbidity
Class I obesity
Crohn's disease
Prevent potential consequences of hypoglycemia in specific occupations

BMI: Body mass index.

FUTURE PERSPECTIVES AND CONCLUSION

It can be concluded that SG can indeed be considered more than a restrictive bariatric surgery procedure. Its benefits are far more than those associated with a reduction in gastric volume and its results in terms of weight loss and improvement of comorbidities are superior to those obtained with other restrictive procedures. Additionally, SG offers further advantages such as high efficiency, low technical complexity and low rate of surgical complications. All these characteristics render SG preferable to other procedures in certain situations (Table 3) and may, in a near future, place it as the next gold standard in bariatric surgery at the expense of RYGB (Table 4). However, long-term studies aimed at establishing SG as non-inferior relative to the current gold standard, RYGB, are required.

Table 4 Clinical outcomes of sleeve gastrectomy and Roux-en-Y gastric bypass

	SG	RYGB
Weight loss	No differences with RYGB 67.1 %EWL at 12 mo[63]	No differences with SG 68.9% EWL at 12 mo[63]
Type 2 diabetes mellitus remission	Early improvement before significant weight loss More effective than other restrictive techniques	Slightly more effective than SG. HR 1.49, 95%CI: 1.04-2.12 for type 2 diabetes mellitus remission in favor of RYGB[63]
Hypertension remission	Greater efficacy than other restrictive techniques 69% (55-82) Hypertension remission for SG and 45% (27-56) for LAGB[72]	More effective than SG HR of 1.47, 95%CI: 1.115-1.86 for Hypertension remission in favor of RYGB[63]
Dyslipidemia remission	Same as other malabsorptive techniques, no hypercholesterolemia improvement	Clearly more effective than SG. HR = 2.41, 95%CI: 1.87-3.11 for Dyslipidemia remission in favor of RYGB[63]
Mortality	No differences (detailed in table 2)	No differences
Surgical complications	Less surgical time, lowest 30-d morbidity, 30-d readmission and 30-d reoperation. (detailed in table 2) Characteristic complications: staple line leaks (2.7%[86]; < 1% in expert hands[87])	Increased risk of nutritional deficiencies Characteristic complications: severe hypoglycemia
Long-term results	Limited evidence	Effective and safe in the long term
Other advantages	Possibility of conversion to a malabsorptive surgery	

SG: Sleeve gastrectomy; RYGB: Roux-en-Y gastric bypass; %EWL: Percentage excess weight loss; HR: Hazard ratio; LABG: Laparoscopic adjustable gastric banding.

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