LSG: Outcomes

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Abstract

Laparoscopic sleeve gastrectomy (LSG) is gaining widespread use and has displaced gastric banding in popularity. Short, medium, and long-term data regarding the weight loss associated with LSG and its durability are encouraging. Resolution of comorbidities and improvement in health-related quality of life are comparable or better than other bariatric procedures. In the long term, weight regain is a natural course in a proportion of patients who may undergo a second procedure. It is used as a first stage in a two-stage duodenal switch procedure for weight loss in the super-obese group. Gastroesophageal reflux disease (GERD) is a concern following LSG, but concomitant hiatal hernia repair may prevent this problem.

Keywords

Laparoscopic Sleeve Gastrectomy • Obesity • BMI • Outcome • Weight loss • Comorbidity • Quality of life

28.1 Introduction

Laparoscopic sleeve gastrectomy (LSG) has gained popularity in recent years around the world. It constitutes up to one-third of all the bariatric procedures performed in the USA [1, 2]. It also ranks as a leading procedure in Asia, Middle East, and Australia where obesity is prevalent and rising. The relative ease of technique, avoidance of insertion of a foreign body, and the immediate restriction of caloric intake led to its adoption by many bariatric centers throughout the world. LSG does not alter the gastrointestinal continuity. The procedure does not involve any anastomosis, thus eliminating the possibility of anastomosis related complications as seen to be associated with gastric bypass.

LSG also has the advantage of fewer perioperative complications, especially in the high-risk group. The long-term nutritional complications are low. Patients with inflammatory bowel disease, previous abdominal surgery, recurrent peptic ulcer disease, and protein-losing enteropathy are considered suitable for this procedure.

28.2 Technical Factors Affecting Outcome

Laparoscopic sleeve gastrectomy is an evolving procedure. Variations in technique such as the distance from the pylorus where the greater curvature resection begins, sizing of the antrum, ideal bougie size, completeness of resection of fundus, and identification and repair of hiatus hernia will make standardization of the technique difficult. This lack of standardization in the surgical technique has a bearing on the complications, efficacy, and durability reported in different studies. This has been discussed in detail in Chap. 29.

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28.3 Short-Term Weight Loss

Factors affecting the degree and duration of weight loss in LSG are not fully understood. Many published retrospective studies and a systematic review has shown that the excess body weight loss (EBWL) at 1–2 years after LSG can vary from 47 to 76 % [3–6]. This variation in outcomes is seen mainly because of a lack of standardization of the surgical technique.

Weight loss achieved after LSG is variable, but most studies report that it is comparable to that achieved by gastric bypass and better than the weight loss achieved following gastric banding [7, 8]. A single surgeon experience with 500 sleeve gastrectomy with 3-year follow-up showed that the mean EBWL was 76 %, 71 %, and 73 % at 12, 24, 36 months, respectively [9]. Short-term weight loss achieved by other surgeons is shown in Table 28.1. A study comparing LSG with laparoscopic adjustable gastric banding (LAGB) and laparoscopic Roux-en-Y gastric bypass (LRYGB) found that weight loss at one year following LSG was 13 % lower than that after LRYGB, but 77 % higher than the weight loss achieved through gastric banding [17]. A comparative study between LSG and LRYGB showed that LSG is associated with fewer complications and similar weight loss after one year. Prospective and case-matched studies have claimed that LSG is safer with similar weight loss at 2 years when compared to LRYGB [18–20].

The first report from the American College of Surgeons Bariatric Surgery Center Network has placed LSG between band and bypass in terms of weight loss at one year. For LSG patients, the average reduction in body mass index (BMI) is 11.87 kg/m^2 at 1 year. In comparison, LAGB has a BMI reduction of 7.05 kg/m^2 and the LRYGB 15.34 kg/m^2 [21].

A review article including 24 studies and a total of 1749 patients showed a mean percentage EBWL of 60.7 % with the follow-up period ranging from 3 to 36 months after LSG [22].

Single anastomosis gastric bypass and laparoscopic greater curve plication are procedures that are increasingly being offered to patients. According to a report from India which compared single anastomosis gastric bypass (mini gastric bypass, Omega loop bypass) with LSG, the percentage EBWL was 63 % vs. 69 % at one year and 68 % vs. 51.2 % at five years [23]. Postoperative GERD was a less common finding with single anastomosis gastric bypass (2.8 %) than with LSG (21 %).

28.4 Long-Term Weight Loss

Studies with follow-up of 5 years or more after surgery are considered to be long-term at this point. This definition is likely to change as we follow patients up for a longer duration in the future. The technique used in all these studies show variation with regards to the size of bougie, distance from pylorus to the first staple, and use of staple-line reinforcement.

One study, in which the surgeon created a narrow sleeve with a gastroscope as bougie and started transection at 3 cm from the pylorus, had a follow-up rate of 90 % at 5-years [24]. The study showed an EBWL of 86 %. A recently published randomized trial quoted a greater weight loss in antral resecting-LSG than in the antral preserving-LSG group in one year though there was no significant statistical difference. There is an urgent need for more studies comparing antral preserving-LSG and antral resecting-LSG focusing on long term outcomes [25].

Another retrospective study revealed more than 50 % EBWL in 40 % of patients at five years and 10 % of patients had a second procedure [26]. Another study showed a 57 % EBWL in 77 % of patients at five years [13]. A comparative study between LSG and LRYGB with five years follow-up showed similar percentage of EBWL [27], but a randomized controlled trial from China showed a 76 % EBWL with LRYGB and 63 % EBWL for LSG at five years [28]. There was no difference in resolution of comorbidities. In a published series of 53 patients who had LSG, the follow-up rate was 78 %. At 3 and 6 years, the EBWL was 73 % and

Table 28.1 Percentage of excess body weight loss up to 4 years after LSG

Article	1 year (n)	2 years (n)	3 years (n)	4 years (n)
Himpens et al. 2006 [10]	58 % (40)		66 % (40)	
Jacobs et al. 2010 [3]	78 % (131)	75 % (33)		
Himpens et al. 2010 [11]			73 % (41)	
Lee et al. 2011 [12]	76 % (30)			
Gluck et al. 2011 [5]	70 % (77)	62 % (34)	62 % (9)	
Gibson et al. 2013 [9]	76 % (258)	71 % (102)	73 % (12)	
Kehagias et al. 2013 [13]			71 % (90)	
Sieber et al. 2013 [14]	61.5 % (68)	61.1 % (66)		
Catheline et al. 2013 [15]		57.1 % (45)		
Hoogerboord et al. 2014 [4]	54 % (NA)	64 % (NA)		
van Rutte et al. 2014 [16]	68.4 % (866)	67.4 % (342)	69.3 % (163)	70.5 % (62)

n number of patients, *y* year(s), *NA* not available

Table 28.2 Percentage of excess body weight loss at 5 years and beyond following LSG

Study (year of publication)	% EBWL in 5 years (n)	% EBWL in 6 years (n)	% EBWL in 7 years (n)	% EBWL in 8 years (n)
Santoro et al. 2007 [29]	55 %			
Weiner et al. 2007 [30]	40 % (8) EBMIL			
Bohdjalian et al. 2010 [31]	55 % (21)			
Himpens et al. 2010 [11]		53 % (30)		
D'Hondt et al. 2011 [32]	71 % (27)	56 % (23)		
Strain et al. 2011 [33]	48 % (23) EBMIL			
Sarela et al. 2012 [34]				69 % (13)
Eid et al. 2012 [35]		52 % (19)	43 % (13)	46 % (21)
Abbatini et al. 2012 [36]	56 % (13)			
Braghetto et al. 2012 [37]	57 % (60)			
Saif et al. 2012 [38]	48 % (30) EBMIL			
Kehagias et al. 2013 [13]	58 % (21)			
Zachariah et al. 2013 [39]	64 % (6)			
Catheline et al. 2013 [15]	51 % (45)			
Brethauer et al. 2013 [40]	50 % (23)			
Sieber et al. 20123 [14]	57 % (54) EBMIL			
Rawlins et al. 2013 [24]	86 % (49)			
Lim et al. 2014 [27]	57 % (14)			
van Rutte et al. 2014 [16]	58.3 % (19)			

EBWL excess body weight loss, *n* number of patients, *EBMIL* excess BMI loss

57 %, respectively [11]. Many studies now have consistently reported more than 50 % weight loss at five years and beyond as listed in the Table 28.2. A recent review of results of 16 studies analyzing a total of 492 patients post LSG, % EBWL was 62.3 %, 53.8 %, 43 %, and 54.8 % at 5, 6, 7, and 8 or more years [41]. These long-term results support LSG as a bariatric procedure achieving weight loss that can be defined as success based on Reinhold criteria [42] and are durable.

28.5 Diabetes Resolution/Remission after LSG

The greater the weight loss, the better is the resolution of type 2 diabetes mellitus (T2DM) [43]. While it was initially thought that the effects of weight loss and glucose regulation were only caused by restriction and malabsorption, a multitude of evidence show that there are many physiological changes that mediate the above effects. Along with alterations in gut hormones such as glucagon-like peptide-1 (GLP-1), leptin, ghrelin, peptide YY (PYY), glucose-dependent insulinotropic peptide (formerly, gastric inhibitory peptide) (GIP), etc., both LSG and LRYGB seem to cause alterations in bile acid levels, its composition, and bile acid signaling pathway as well as alteration in gut microbiome [44]. These seem to play a collective and coordinated role in initiating favorable metabolic changes that help with weight loss and diabetes resolution. It has been difficult to conclude on the exact diabetes resolution rates after LSG mainly because of the different criteria used and changes in the definition of diabetes over time (Table 28.3).

According to many studies, diabetes resolution after LSG is achieved in about 60–80 % of patients and the average number of diabetic medications reduced from two to less than one [52, 53].

A study involving 23 patients with a mean follow-up for six years after LSG showed that 74 % of patients had a HbA1c of <7, and another study involving 35 patients with a median follow-up of 73 months showed improvement and remission of diabetes in 77 % of patients [35, 40].

A randomized controlled trial that compared LSG, LRYGB, and intensive medical therapy for diabetes mellitus found no statistically significant difference in patients between the LSG and LRYGB groups. The medically treated group did worse than the surgically treated groups. There was higher glycemic relapse in the LSG group when compared to LRYGB group, though it was not statistically significant, and also a higher proportion of patients in the LSG group needed glucose lowering medications [50].

According to studies, which used higher cut-off levels of hemoglobin A1c (HbA1c) due to older definitions of diabetes, a HbA1c level of 6.6 or less was achieved in 56 % of patients in as early as three months. At three years 80 % of patients achieved HbA1c of 6.6 % or less [50].

In a systematic review with a mean follow-up of 13.1 months (range 3–36 months), diabetes mellitus had resolved in 66.2 % of the patients, improved in 26.9 %, and remained stable in 13.1 % of patients [6].

Another systematic review and meta-analysis of outcomes after LRYGB and LSG for type 2 diabetes involving 33 studies (1375 patients), showed that the remission rates following LSG and LRYGB were 56 % and 67 % at three months, 68 % and 76 % at one year and 80 % and 81 % at

Table 28.3 Diabetes remission rates following LSG, using different HbA1c levels

Author, Year	Patients n/total	Follow-up (months)	HbA1c (%)	T2DM remission (%)	Comments
Nocca et al. 2011 [45]	25/33	12	7.0	76	
Vidal et al. 2008 [46]	33/39	12	6.5	85	
Lee et al. 2011 [12]	10/20	12	6.5	50	Patients BMI:25–35 kg/m^2
Nosso et al. 2011 [47]	24/25	12	6.5	96	
Pournaras et al. 2012 [48]	5/19	12	6.0	26	
Schauer et al. 2012 [49]	18/49	12	6.0	37	
Schauer et al. 2014 [50]	12/49	36	6.0	24	
Abbatini et al. 2012 [51]	22/26	36	6.0	85	
Abbatini et al. 2013 [36]	10/13	60	6.0	77	
Eid et al. 2012 [35]	27/35	73	NA	77	Remission & improvement
Brethauer et al. 2014 [40]	17/23	72	7.0	74	

LSG, Laparoscopic sleeve gastrectomy; *HbA1c*, hemoglobin A1c; *T2DM*, type 2 diabetes mellitus; *BMI*, Body mass index

three years, respectively [54]. As more studies are reported the initial enthusiasm of LRYGB having a better outcome for remission of type 2 diabetes is being challenged.

Factors that predict failure of remission of diabetes include a longer duration of T2DM, a higher pre-surgical glycated hemoglobin level, insulin treatment at baseline, and a lower EBWL. A strong predictor of remission or resolution is the percentage of EBWL. Insulin use before surgery, an older age, and weight regain predict recurrence of diabetes [55]. Natural progression of diabetes in patients may lead to recurrence of diabetes after remission and also development of diabetes de novo after surgery.

Early decrease of circulating levels of metabolites such as fetuin-A, retinol binding protein 4, and several other metabolites were demonstrated after GBP compared to LSG, preceding significant weight loss [56]. This may contribute to higher T2DM remission observed following foregut bypass procedures.

28.6 Comorbidity Resolution

LSG leads to a dramatic improvement of several other comorbidities. These include obstructive sleep apnea (88 %), hypertension (75 %), hyperlipidemia (83 %), stress incontinence (90 %), and musculoskeletal disorders. There is no significant difference in the comorbidity resolution between LSG and LRYGB in the short term [50, 53, 57].

Patients with metabolic syndrome consisting of central adiposity, dyslipidemia, insulin resistance, and hypertension are at higher risk of postoperative complications. Bariatric Outcomes Longitudinal Database (BOLD) study comparing different bariatric surgery outcomes in patients with metabolic syndrome showed higher perioperative complications with LRYGB [58]. LSG is a low-risk option in this group of patients with comparable resolution of comorbidities.

A 5-year study showed excellent resolution of the following comorbidies in the super-obese patients after LSG: hypertension (95 %), T2DM (100 %), hyperlipidemia (100 %), and obstructive sleep apnea (100 %) [24].

The effect of weight loss on chronic kidney disease progression is not well established. Obesity and diabetes lead to renal impairment and end-stage renal disease. Obese patients with end-stage renal disease are referred for weight loss surgery. Successful weight loss will optimize these patients for subsequent transplant. In patients who have undergone bariatric surgery, an improvement in creatinine clearance and microalbuminuria has been reported [50, 59]. This improvement is likely to be weight loss dependent.

A meta-analysis of studies comparing LSG and LRYGB in patients with BMI more than 30 did not show statistically significant difference in improvement of levels of triglycerides and low-density lipoproteins, but LRYGB showed a better reduction of total cholesterol and increase in high density lipoproteins [60]. Another meta-analysis of randomized controlled trials comparing LSG and LRYGB for morbid obesity and or T2DM reported that T2DM remission was higher in LRYGB. So was the weight-loss and reduction in levels of LDL, triglycerides, homeostasis model assessment index and insulin levels [61]. However, patients treated with LRYGB had a higher incidence of complications and reoperations than those treated with LSG. Though this paper concluded that LRYGB is more effective than LSG for the surgical treatment of T2DM, LSG produces comparable results and is safer due to reduced complications.

28.7 Quality of Life After LSG

Health-related quality of life (HRQOL) is assessed using the Bariatric Analysis and Reporting Outcome System (BAROS), the Medical Outcomes Study Short Form questionnaire (SF-36) and the Impact of Weight on Quality

of Life-Lite questionnaire (IWQOL-Lite). The BAROS assesses percentage of EBWL, improvement and/or resolution of comorbid conditions, five aspects of quality of life (self-esteem, physical activity, social activity, work, and sexual activity), complications, and reoperations [62] and shows good outcomes after LSG.

A prospective study with two quality of life (QOL) questionnaires: SF36 and IWQOL-Lite showed significant improvement in the scores for all domains of SF-36, but there was no significant correlation to the amount of weight loss. But patients who had more than 50 % EBWL showed better scores for self-esteem. Postoperative complications had a negative impact on the scores [63]. A randomized controlled trial comparing LRYGB and LSG showed similar improvement in Moorehead-Ardelt (M-A) II QOL at five years follow-up [28]. Long-term follow-up studies are lacking but with more than 50 % EBWL at 5 years being the norm after LSG, one would expect sustained improvement in QOL.

28.8 Super Obesity and LSG

Super-obese patients are defined as those with a BMI of more than 50 kg/m^2. They are an important group with a higher incidence of comorbidities [19]. The weight loss achieved in the short term from an LSG is lower than that achieved following an LRYGB [64] although there is a retrospective study showing excellent results [24]. Super-obese patients have a higher risk of failure to lose weight with all types of bariatric surgery and more chance of weight regain. In a single institution retrospective study of super-obese patients, the EBWL at one year was 39 % (interquartile range: 34–51), and 41 of the 61 patients proceeded to have the planned second-stage procedure [65].

A prospective database review of 74 super-obese patients with 93 % follow-up, six to eight years after LSG, who did not have a second-stage procedure showed a 48 % EBWL and 77 % resolution or remission of diabetes [35].

LSG offers the opportunity to add a second procedure later and the choices available are duodenal switch, re-sleeve, or LRYGB. This second procedure depends on the indication and the preference of the patient and surgeon. It is discussed in great detail in the Chap. 41.

28.9 LSG in the Elderly

It is known that weight loss in the elderly is less when compared to young adults. This is due to the slower metabolism, less calorie requirement and limitation of physical activity. Age is an independent factor in the mortality and morbidity after bariatric surgery. LSG results show better weight loss when compared to gastric banding and is believed to have fewer postoperative complications when compared to LRYGB [66] and is safe in the >65 years age group [67]. In a large study from National Surgical Quality Improvement Program (NSQIP) database, in patients aged >65 years, LSG was not associated with significantly different 30-day outcomes compared to LRYGB [68]. Comparison between patients aged >60 years and those aged 18–50 years showed that EBWL was higher in the younger group (75 % vs. 62 %). Older patients had a significantly higher rate of a concurrent hiatal hernia repair (23 % vs. 1.9 %) and postoperative minor complication rate was higher in the older group (25 % vs. 4.8 %) [69].

28.10 Late Re-operation Following LSG

Unlike LRYGB, where re-operations were mostly due to complications of the procedure, late re-operations or second operations for standalone LSG are mainly for insufficient weight loss, weight regain, refractory GERD, and stricture. The International Sleeve Gastrectomy Expert Panel Consensus Statement revealed that there is consensus among 90 % of the experts that even if 30 % of patients need a second operation, LSG is an excellent procedure [70]. In a systematic review, the re-operation rate range was 0.7–25 % in patients who were offered LSG as a standalone procedure. In patients who have LSG as a planned first-stage procedure, 9.6–28.5 % had a second operation [71]. This rate is dependent on the duration and completeness of follow-up.

Conclusion

LSG has established itself as a standalone procedure due to the relative simplicity of the technique, short learning curve, less morbidity and durable medium to long-term results. It is a serious alternative to LRYGB, which is a demanding, and complex procedure compared to LSG. At present, there is no consensus on the procedure of choice and surgeons should choose the procedure after carefully assessing the requirements of the patients and discussing the benefits and risks of each procedure. Longer-term data from quality studies will further define the role of LSG in managing the complex obesity disorder.

Key Learning Points

- There is a variation in outcomes among different studies because of a lack of standardization of the surgical technique for LSG.
- Short- and medium-term data in terms of weight loss and diabetes resolution associated with LSG are comparable to that of LRYGB.
- Long-term results of 5 years and beyond show more than 50 % EBWL though the published data is very limited.

- Patients who have failed to lose weight or had weight regain have the option of a revision operation.
- Health-related quality of life (HRQOL) in patients following LSG shows significant improvement.

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