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REVIEW

Sleeve Gastrectomy: Literature Results

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ABSTRACT

Sleeve gastrectomy (SG) is the most frequently performed bariatric procedure globally. However, data regarding short- and long-term results remain insufficient. This study aimed to evaluate the short- and long-term effects of SG. We performed a thorough PubMed search for references that mentioned sleeve gastrectomy was carried out. In terms of weight loss and resolution of comorbid disorders, the immediate results have been encouraging. Although long-term results are still being obtained, a large number of individuals have experienced persistent weight loss. Eight short-term studies were extracted for the present review. Each study clarified that SG was utilized as a management technique for a high-risk patient population or as a component of a stepwise therapeutic procedure. The laparoscopic SG method was examined in all studies. The percentage of patients who were followed up for 30 days or longer after LSG was reported. Significant weight loss has been observed in studies that evaluated short-term results. An excess weight loss of 67.3% and a significant decrease in body mass index (BMI) were observed in a systematic evaluation of 5,218 patients. In long-term studies, SG was administered to 2713 patients, of whom 1626 completed the five-year follow-up period. Among all patients, 71.3% were women and 28.7% men. The mean BMI before surgery was 46.9 kg/m^2. The follow-up durations ranged from 5 to 11 years. The mean five-year follow-up rate was 66% (range 57–100%). At 5, 6, 7, 8 and 11 years, the mean percentage excess weight decreases were 58.4%, 59.5%, 56.6% and 62.5%, respectively. Five years after SG, resolution of type 2 diabetes resolved in 77.8% of patients, and arterial hypertension, dyslipidemia, obstructive sleep apnea, gastroesophageal reflux disease and degenerative joint diseases improved or resolved in 68.0%, 65.9%, 75.8%, 30.6% and 55.7% of patients, respectively. Laparoscopic SG is more technically straightforward and has fewer surgical complications than other more complex surgical techniques. Laparoscopic SG is an effective treatment option for bariatric surgery. It is relatively easy to perform, well tolerated by patients and effective for long-term excessive weight loss and resolution of comorbidities.

Keywords: sleeve gastrectomy, obesity, bariatric, short and long term, outcomes, weight loss.

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LIST OF ABBREVIATIONS

BPD-DS: biliopancreatic diversion with duodenal switch
BS: bariatric surgery
BMI: body mass index
DVT/PE: deep vein thrombosis/pulmonary embolism
EWL: excess weight loss
EBMIL: excess body mass index loss
GERD: gastroesophageal reflux disease
HR-QoL: health related quality of life
LVSG: laparoscopic vertical sleeve gastrectomy
LSG: laparoscopic sleeve gastrectomy
LAGM: laparoscopic adjustable gastric banding
LRYGB: laparoscopic Roux-en-Y gastric bypass
MBSAQIP: metabolic and bariatric surgery accreditation and quality improvement program
NASH: non-alcoholic steatohepatitis
OSA: obstructive sleep apnoea
QoL: quality of life
RCT: randomized controlled trial
RYGB: Roux-en-Y gastric bypass
SM-BOSS: Swiss Multicenter Bypass or Sleeve Study
T2DM: type 2 diabetes mellitus
TODAY: treatment options of type 2 diabetes in adolescents and youth
Teen-LABS: teen-longitudinal assessment of bariatric surgery
WR: weight reduction
WR QoL: weight related QoL

INTRODUCTION

Obesity is one of the most critical risk factors for life-threatening diseases. There are more than one billion overweight adults and at least 300 million obese people, meaning that their body mass index (BMI) exceeds 30 kg/m^2 (1). Recent investigations have shown that the prevalence of obesity in adults has dramatically increased over the past ten years. Cancer death statistics show that one out of seven men and one out of five women in the United States are obese (2). Researchers have demonstrated that obese people in the identified classes (I, II or III) have a higher risk of obesity-related diseases and comorbid conditions, a lower quality of life (QoL) and an increased mortality compared to those with a BMI within the normal range (18.5–24.9 kg/m^2) (3, 4). Although having a healthy lifestyle seems to be an ideal option to lose weight, surgical treatment continues to be the most efficient and scientifically successful method for those with excessive amounts of adipose tissue (class II or III). The most commonly and popularly performed bariatric surgery (BS) procedures include gastric bypass, sleeve gastrectomy (SG), adjustable gastric band and biliopancreatic diversion with the duodenal switch (5).

Sleeve gastrectomy is a new, safe and efficient method for the treatment of obesity, with higher survival rates among patients (6). During the procedure, a large part of the stomach, which accounts for the regulation of appetite, is resected. Over the last few years, SG has captured remarkable surgical interest, mainly because this technique does not require gastrointestinal anastomosis or intestinal bypass. It is minimally invasive and considered less technically challenging than laparoscopic Roux-en-Y gastric bypass (LRYGB). Sleeve gastrectomy avoids implantation of an artificial device around the stomach, whereas in the laparoscopic adjustable gastric banding technique (LAGB), an inflatable silicone device is placed around the top portion of the stomach to decrease food consumption. Sleeve gastrectomy is technically less complex, with a relatively short learning curve (7). It probably has less impact on normal physiology than other widely approved standard bariatric surgeries such as LRYGB and biliopancreatic diversion with duodenal switch (BPD-DS) because it does not require an anatomic bypass, anastomosis or malabsorption (7-10). Discussing the short- and long-term effects of SG is the goal of this review. ❑

MATERIALS AND METHODS

A detailed search of PubMed was performed for citations that included SG. During the initial review, only eight papers for short-term outcomes and 16 reports for long-term outcomes appeared to meet our criteria; all those reports were examined and their entire text was scrutinized. Case reports (<five patients) and study reporting techniques were not included. Substudies of a larger series by the same group were not included in our analysis of the total number of performed procedures in order to avoid duplica-

tion of data. Simple counts and means were used to describe the patients, study and weight loss data using descriptive statistics. The percentage of excess weight loss (%EWL) was used to describe weight loss following LSG. No uniformity was observed across studies for the method of reporting data on weight loss. ❑

RESULTS AND DISCUSSION

1. Short-term outcomes

A total of eight studies (11-18) was selected for the present review. All studies clearly stated that LSG was employed as part of a staged therapeutic approach or as a management strategy for a high-risk population. A follow-up rate of ≥ 30 days after LSG has been reported. The total number of patients enrolled in these studies was 118,936. In all eight trials, the average preoperative BMI was 46 kg/m^2 (Table 1). Laparoscopic SG is a safe and well-tolerated procedure.

A 2005 study of Medicare recipients in Washington, USA, revealed a higher early mortality rate than anticipated, which prompted a national policy decision limiting the reimbursement for bariatric surgery (20). Since then, bariatric surgery has proven to be both secure and efficient with the passage of time and experience. Following the national coverage decision, a follow-up study found that Medicare beneficiary outcomes were better (12). Further information has confirmed that bariatric surgery was a safe approach, with the Longitudinal Evaluation of Bariatric Surgery Collaboration's study on a patient cohort of 4,776 patients showing a mortality rate of 0.3% and a severe adverse event rate of 4.3% within 30 days after surgery. (13). A study of 24,117 patients who had undergone LVSG or bypass surgery for morbid obesity looked at data from the NSQIP database. Those who underwent LVSG had a shorter operating time (101 *vs*. 130 minutes) than those who underwent RYGB as well as lower rates of serious morbidity (3.8% *versus* 5.8%), blood loss requiring transfusion (0.6% *versus* 1.5%), deeper wound infection (0.06% *versus* 0.2%) and 30-day reoperation rates (1.6% *versus* 2.5%) than the RYGB group (14). When compared to RYGB, patients who received LVSG had lower values of death rate (0.1% *vs*. 0.2%), morbidity rate (5.8% *vs*. 11.7%) and leak rate (0.8% *vs*. 1.6%), according to an examination of the 2015 Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) database of 134,142 patients (15). In the short term, LVSG can significantly affect weight and the resolution of obesity-related comorbidities. By volume limitation, LVSG limits the number of calories a patient can consume at once, which lowers the overall calorie intake and promotes weight loss; LVSG also eliminates ghrelin-producing cells in the stomach, which reduces appetite (16). Studies on short-term outcomes have demonstrated significant weight loss. A systematic review that included 5,218 patients demonstrated an excess weight loss of 67.3%, which resulted in a significant reduction in BMI. At one year, the surgery had a significant impact on comorbidities as well, with remission occurring in 81.9% of patients with diabetes, 66.5% of those with hypertension and 64.1% of patients with dyslipidemia (20). Participants in the SLEEVEPASS study were randomly allocated to receive either RYGB or LVSG and results were directly compared to LRYGB. A total of 240 individuals were enrolled in the study and underwent LVSG or RYGB. Patients in the SG group experienced similar rates of excess weight loss (49.2% *vs*. 52.9%), resolution or improvement in diabetes (84.3% *vs*. 93.3%), hypertension (76.8% *vs*. 81.9%) and hypercholesterolaemia (64.1% *vs*. 69.0%) at six months as those in the bypass group (17). A staple line leak is among the LVSG's short-term consequences that people are most afraid of. If the blood flow to a portion of the staple line is reduced following LVSG, this could cause ischemia, which could then lead to a leak. A systematic review of 4,889 patients found that 89% of leaks occurred in the proximal area of the stomach, making this the location where leaks occur most frequently (18). This might be the effect of the change in blood flow that an LVSG can cause here. An analysis of sleeve gastrectomies

TABLE 1. Results of the literature review

Author	Patients (n)	Mean preoperative BMI (kg/m^2)	Months of follow-up
Flum DR *et al* (37)	16.155	-	3.4 to 5
Nguyen NT *et al* (38)	3.196	-	-
Dr. F *et al* (39)	1.198	44.1	30 days
Young MT *et al* (40)	4.945	46.0	-
Kumar SB *et al* (41)	93.062	44.0	30 days
Langer *et al* (42)	10	48.3	6
Helmio M *et al* (43)	121	≥ 40	6
Aurora AR *et al* (44)	249	34 to 65.4	12
Total patients/mean	118.936	46	-

BMI=body mass index; RYGB=Roux-en-Y gastric bypass performed on cadaveric trunks showed that the left gastric artery branches that may form the gastric tube could be injured by LVSG, leaving this region more susceptible to ischemia (21). Based on an examination of the 2015 MBSAQIP database, oxygen-dependent patients as well as those who have obstructive sleep apnea, hypoalbuminemia, hypertension or diabetes, are most susceptible to this consequence (22).

2. Long-term outcomes

Twenty studies (one randomized controlled trial and 19 retrospective studies) involving 2,713 SG patients were included in the final analysis (Table 2). Patients (71.3% females and 28.7% males) had a mean age of 38 years at the time of surgery. The mean BMI before surgery was 46.9 kg/m^2. The follow-up period ranged from five to 11 years. The average five-year follow-up rate was 68.4% (ranging from 57-100%). Seventeen studies reported five-year follow-up results, five studies reported six-year follow-up results, two studies reported seven- and eight-year follow-up results and one study reported 11-year follow-up results. All studies evaluated body mass changes (Table 3) and expressed them as %EWL, except the studies by Arman *et al* (23), Sieber *et al* (24), Saif *et al* (25) and Strain *et al* (26), who reported %EBMIL. Seventeen studies involving 1,501 patients reported five-year survival data. The mean %EWL in this group was 58.4%. The six-year results in those five studies were presented with a mean %EWL of 59.4%. Two studies that reported weight loss results after seven and eight years found a mean %EWL of 56.6% and 54.8%, respectively. One study reported an EWL of 62.5% after 11 years. Regarding the study type, there was one randomized controlled trial (27) and the remaining studies were retrospective. The incidence of SG conversion to another bariatric procedure due to severe GERD ranged from 3.8% to 14.2%. Four studies (24, 28, 30) reported the incidence of incisional hernias (range 2.4%–5.7%). Only one study evaluated nutrient status after SG (25). Five studies evaluated the standard of living (26, 28, 29, 31, 32). Two studies reported preoperative and postoperative assessments of the quality of life (26). The studies conducted by D'Hondt *et al* (8), Himpens *et al* (28) and Lemanu *et al* (32) employed the Bariatric Analysis and Reporting Outcome System and the surgical results were evaluated (33). The typical scores for

TABLE 2. Summary of the literature review

Author, year (reference)	Patients (n)	Mean preoperative BMI (kg/m^2)	Months of follow-up	Patients who reached ≥five-year follow-up point	Mean five-year follow-up rate (%)	Patients lost to follow-up at five years
Arman *et al*. 2016 (23)	110	38.5	4.132	63 (57.2%)	-	-
Alexandrou *et al*. 2015 (34)	30	55.5	60	25(83.3%)	83.3 failures)	Five converted to RYGB (weight loss)
Liu *et al*. 2015 (35)	140	41	60	44 (31.4%)	84.6	Eight converted to RYGB (one intractable reflux. two sleeve strictures and five weight loss failures)
Musella *et al*. 2014 (7)	175	47.9	60	102 (58.1%)	58.1	73 (not specified)
Lemanu *et al*. 2015 (32)	96	50.7	60	55 (57.2%)	57.2	41 (28 unable to be contacted. 10 declined to participate. and three died)
Zhang *et al*. 2014 (31)	32	38.5	60	27 (84.3%)	84.3	Six (not specified)
Abd Ellatif *et al*. 2014 (36)	1.395	46	96	859	(62%)	62 (not specified)
Prevot *et al*. 2013 (37)	84	47.7	60	52 (61.9%)	81	16 (not specified)
Sieber *et al*. 2013 (24)	41	43	60	37 (91%)	92	3 (two emigrated and one died)
Catheline *et al*. 2013 (30)	65	49.1	60	53 (82%)	82	Eight-second bariatric procedures (weight loss failures)
Brethauer *et al*. 2013 (38)	23	50.7	60	23 (79%)	100	-
Eid *et al*. 2012 (39)	74	66	96	69 (93%)	93	Five (not specified)
Saif *et al*. 2012 (25)	82	52.2	60	30 (36.5%)	100	-
Rawlins *et al*. 2012 (40)	55	65	60	49 (89%)	89	Six (four converted to a duodenal switch. two died)
Abbatini *et al*. 2012 (9)	33	52.1	60	13 (39.3%)	100	-
Strain *et al*. 2011 (26)	77 reported	56.1	60	23 (29.8%)	-	Not reported
Sarela *et al*. 2011 (41)	20	45.9	496	13 (65%)	-	Not reported
D'Hondt *et al*. 2011 (8)	102	39.3	72	27 (26.5%)	81.4	Not specified
Himpens *et al*. 2010 (28)	53	39	72	41 (78%)	78	12 (four refused to cooperate. eight were unable to be contacted)
Bohdjalian *et al*. 2010 (42)	26	48.2	60	21 (80.7%)	84.6	Four converted to RYGB (one intractable reflux and three weight loss failures)
Total patients/mean	2.713	46.9	-	1.626	68.4	

BMI=body mass index; RYGB=Roux-en-Y gastric bypass

Author	% EWL				
	Five years (n)	Six years (n)	Seven years (n)	Eight years (n)	11 years (n)
Arman *et al*. 2016 (23)	–	75.9 (47)	–	–	62.5 (47)
Alexandrou *et al*. 2015 (34)	56.4 (25)	–	–	–	–
Liu *et al*. 2015 (35)	57.2 (44)	–	–	–	–
Musella *et al*. 2014 (7)	68.1 (102)	–	–	–	–
Lemanu *et al*. 2014 (32)	40 (55)	–	–	–	–
Zhang *et al*. 2014 (31)	63.2 (27)	–	–	–	–
Abd Ellatif *et al*. 2014 (36)	61 (859)	59 (731)	57 (519)	–	–
Prevot *et al*. 2013 (37)	43 (52)	–	–	–	–
Sieber *et al*. 2013 (24)	57.4 (37)	–	–	–	–
Catheline *et al*. 2013 (30)	50.7 (45)	–	–	–	–
Brethauer *et al*. 2013 (38)	49.5 (23)	–	–	–	–
Eid *et al*. 2012 (39)	51 (69)	52 (19)	43 (13)	46 (21)	–
Saif *et al*. 2012 (25)	48 (30)	–	–	–	–
Rawlins *et al*. 2012 (40)	86 (49)	–	–	–	–
Abbatini *et al*. 2012 (9)	56 (13)	–	–	–	–
Strain *et al*. 2011 (26)	48 (23)	–	–	–	–
Sarela *et al*. 2011 (41)	–	–	–	69 (13)	–
D'Hondt *et al*. 2011 (8)	71.3 (27)	55.9 (23)	–	–	–
Himpens *et al*. 2010 (28)	–	53.3 (30)	–	–	–
Bohdjalian *et al*. 2010 (42)	55 (21)	–	–	–	–
Mean	58.4 (1501)	59.4 (850)	56.6 (532)	56.4 (34)	62.5 (47)

%EWL=percentage of excess weight loss

TABLE 3. Percentage of excess weight loss at different time intervals

the Bariatric Analysis and Reporting Outcome System were 6.5, 5 and 3.13, respectively, which is equivalent to very good and good results. Zhang *et al* (31) used the modified Moorehead-Ardelt questionnaire with a mean score of 1.33, which corresponded to a good result. Strain *et al* (26) used the Medical Outcome Study Short Form-36 questionnaire. Physical role functioning, general health, energy, body pain and social and physical role functioning showed considerable improvements in their study.

3. Anthropometric measurement (weight loss)

The reporting of follow-up time and short-term follow-up is defined as occurring after an intervention (38). The average surplus excess weight loss (EWL%) following the LSG procedure was between 50% and 60% (43). According to a study of 12,129 individuals, the mean %EWL was almost 60% at one year and 65% at two years after surgery (44). Midterm (three years) weight loss (WL) results varied from 46% to 84.5% (32, 45). Long-term (> five years) evidence indicates that despite patients gaining weight with LSG, they nevertheless achieve a "durable" weight loss. An analysis of 277 long-term studies with 2,713 patients found a mean %EWL of 58.4%, 59.5%, 56.6%, 56.4% and 62.5% at 5, 6, 7, 8, and 11 years, respectively (46). When comparing the WL outcomes of LSG with those of other restrictive procedures, LSG performed better than laparoscopic adjustable gastric banding (LAGB), contributing to greater WL. For instance, LSG produced a considerably greater EWL% than LAGB in a study of 33 trials (4109 individuals), where the mean difference was −16.67% at 12 months, −19.63% at 24 months and −19.28 at 36 months after surgery (47).

In Class I obesity (< 30 BMI), a meta-analysis of 12 trials, encompassing 697 Asians, indicated that at 12 months after surgery, BMI and waist circumference were decreased by 2.88 kg/m^2 and 12.92 cm, respectively, for patients with BMI < 30 kg/m^2 (48). In the short and medium term, there was a considerable improvement in lipid profiles, β-cell function and glycemic management (6–24 months) (49). In a randomized controlled trial regarding Class II obesity (BMI < 35 kg/m^2), in which 34% of patients had a BMI <35 kg/m^2, WL and diabetes remission were higher following

LSG than after standard therapy and were comparable to RYGB (40).

The weight reduction after SG falls between that of LAGB and LRYGB in the majority of studies that provide long-term data; however, other authors have reported that weight loss after SG can be comparable to or even better than that after LRYGB (40). In our analysis, the mean %EWL five years after SG was 58.4% (range 40%–86%). Recently, Li *et al* (51) conducted a meta-analysis of 6,526 patients who underwent SG and LRYGB; those in the LRYGB group had a higher percentage of EWL than those in the SG group one year after surgery, although the difference was not statistically significant. Zhang *et al* (7) compared the efficacy of SG and LRYGB in 64 randomly assigned patients. They found that LRYGB was more efficient in terms of %EWL (76.2% *vs*. 63.2%, P=.02). In a retrospective study from Italy, involving 520 patients who had undergone SG, LAGB or LRYGB, %EWL five years after surgery was 68.1%, 53.7% and 79.5%, respectively (2). A prospective study conducted by Himpens *et al* (40) reported that %EWL six years after SG was 53.3%; however, a significant weight regain was noted between postoperative years 3 and 6 (28). A retrospective study by Rawlins *et al* (40) reported surprising results, with a mean %EWL of 86% being found five years after surgery; such weight loss results are rarely achieved even after LRYGB or BPD/DS.

4. Comorbidities

Five years after SG, 77.8% of patients had their type 2 diabetes resolved or improved, while 68.0%, 65.9%, 75.8%, 30.6% and 55.7% of subjects had arterial hypertension, dyslipidaemia, OSA, GERD and degenerative joint disorders, respectively. Long-term changes in GERD-related symptoms were reported in nine studies. Only two studies observed GERD symptom improvement (39, 40), while eight studies (range 10–23%) documented the emergence of new GERD symptoms (8, 28). In people aged over 60 years, the majority of older individuals have many comorbidities, which are worsened by the presence of extreme obesity. With higher mortality risks from cardiovascular disease, obesity raises their risk of developing cancer, heart disease, diabetes, lower extremity arthritis, sleep apnoea and stroke (52). Patients over 65 years old who receive LSG experience considerable WL, comorbidity remission and better QoL (53, 54). For those aged 65 years and over (with a median BMI of 43 kg/m^2), LSG revealed little problems; the median hospital stay was five days, only 3.7% of patients suffered stomach leaks, no mortality was recorded, the subjects' BMI fell to 35, 32.9 and 30.7 kg/m^2 at 6, 12 and 24 months after LSG, respectively, and the mean EWL was 76.3% at two years. Moreover, one and two years following LSG, type 2 diabetes mellitus (T2DM), hypertension, dyslipidaemia, obstructive sleep apnoea (OSA) and arthralgia exhibited significant remission. Patients' physical health, mental health (social function), overall health perception and vitality scores improved, which also led to a significant improvement in their QoL (23).

In teenagers, comorbidities like hypertension, T2DM, sleep apnea, reduced QoL, fatty liver disease and cardiovascular mortality in adulthood are all associated with severe obesity in adolescence (56). Due to similar WL results and morbidity resolution to RYGB, LSG has become the most popular operation for adolescents with extreme obesity (26). Moreover, LSG has a lesser risk of medical and nutritional issues (57, 58). The signs of bariatric surgery (BS) in teenagers mostly correspond with the advice for adults (56). There is no evidence that BS has a negative impact on a teen's ability to go through puberty or linear growth. In a study by Alqahtani *et al*, children who underwent LSG grew more linearly than the matched controls (59). Significant WL resulted from LSG, with EWL% at one year ranging from 49% to 81%. (58, 60) and a long-term persistent WL of 78% (five years) (60). Adolescents with significant obesity and T2DM who underwent surgery had a better glycaemic control in terms of comorbidities than those who received medication in terms of comorbidities. A comparison of the glycemic control data from two distinct studies – the Teen-Longitudinal Assessment of BS (Teen-LABS) and the Treatment Options of Type 2 Diabetes in Adolescents and Youth (TODAY) study – showed that, at two years, the mean hemoglobin A_{1c} concentration in Teen-LABS decreased from 6.8% to 5.5% and increased from 6.4% to 7.8% in TODAY study (57). Insulin resistance and T2DM had 100% and 87% remission rates, respectively, at five years after LSG (60). Laparoscopic SG also has a positive impact on the progression of non-alcoholic steatohepatitis (NASH) (61). NASH totally reverted in every adolescent who underwent LSG, and 90% of patients no longer had stage 2 hepatic fibrosis (61). In addition, LSG led to noticeable and long-lasting increases in health related (HR QoL), weight-related QoL (WR QoL) and body image satisfaction (57, 62).

In patients with T2DM and extreme obesity, BS encourages significant and long-lasting improvement in the clinical symptoms of diabetes. However, compared to Caucasians, Asians are more at risk for T2DM and cardiovascular diseases (63). The conventional criteria for obesity surgery do not apply to patients with a BMI <35 kg/m^2 who have uncontrolled and life-threatening comorbidities. In potential surgical candidates who have mild to moderate obesity and insufficiently managed T2DM, surgery may be an appropriate alternative treatment (BMI 30–35 kg/m^2) (63).

In a study of 25 Asians with T2DM and a BMI between 23.23–29.97 kg/m^2, the rates of complete remission of T2DM at 3, 6 and 12 months after surgery were 40%, 60% and 68%, respectively. The rates for hypertension were 22.2%, 50% and 75%; hypertriglyceridaemia was 66.7%, 66.7% and 100%; and the rates for hypercholesterolaemia were 41.7%, 60% and 100%, respectively (64). Three years of midterm follow-up on 252 patients with a BMI of 35 kg/m^2 revealed an EWL of 75.8%. Conditions that improved included insulin resistance (89.4%), dyslipidaemia (52%), NAFLD (84.6%), hypertension (75%) and gastroesophageal reflux disease (GERD) (65%) (65). Type 2 diabetes mellitus showed 40% progression and 60% full recovery (66). No leaks or deaths were observed, although there was a 2.4% morbidity rate and two patients needed second surgeries (65). This implies that LSG is a safe and effective procedure in patients with BMI < 35 kg/m^2 and that BMI should not be the only parameter to take into account BS. There is a need for additional research with a longer follow-up period.

Weight change was the only variable of interest in bariatric or metabolic surgery. Many studies have demonstrated that comorbidities such as T2DM, arterial hypertension, dyslipidemia, OSA, GERD and degenerative joint illnesses can be resolved as a result of weight loss following bariatric surgery (38). In the previously mentioned randomized study by Zhang *et al* (31), the effectiveness of SG and LRYGB in reducing or improving comorbidities was comparable. Long-term data are scarce, despite the fact that there is evidence that SG produces excellent short-term diabetes control. Our analysis found that the mean rate of T2DM improvement or resolution was 77.8% (range 61%-100%), while total remission was reported in 58.9% of patients. Type 2 diabetes remission and improvement rates are greatly influenced by the selection criteria (66).

Many studies demonstrate increased diabetes recurrence rates following SG over time (35, 38). Nevertheless, only two of the studies that were analyzed included data on the frequency of recurrence (35, 38). The reported rate of T2DM improvement or resolution after SG in the short-term ranges from 47% to 98%; higher outcomes are related to a shorter duration of diabetes, more frequent follow-up, and better glycemic management prior to surgery (38, 67). According to a systematic review of the effects of SG on arterial hypertension, 58% of patients experienced resolution and 75.7% of subjects experienced improvement. However, most of the included studies had a short follow-up period (68).

A systematic analysis by Sarkhosh *et al* (69) investigated how SG, LAGB, and BPD on OSA. After LAGB, OSA improved or resolved in 77, 86 and 99% of patients with SG and BPD, respectively. The mean rate of OSA improvement or resolution in our sample five years after SG was 75.8%, which was consistent with the findings of earlier studies. Controversy exists regarding GERD-related symptoms after SG. While some authors claim that GERD has improved or disappeared, the bulk of research shows that GERD symptoms have worsened or developed into new symptoms as a result of SG. In our analysis, only two studies showed an improvement in GERD symptoms five years after SG (39, 40), while eight studies (ranging from 10% to 23%) showed the emergence of new GERD symptoms (7, 28). The causes of GERD may hypothetically include reduced lower oesophageal sphincter pressure brought on by surgically adjusting the gastroesophageal junction as well as the pharyngoesophageal ligament. Other potential causes include narrower antrum, tightening of the incisura angularis, and increased intragastric pressure. On the other hand, quicker gastric emptying, lower intra-abdominal pressure, and reduced acid production may be responsible for GERD symptoms (70). GERD-related symptoms were examined in a recent meta-analysis from the Netherlands encompassing 8092 individuals who had undergone SG. It has been shown that between 0% and 34.9% of GERD symptoms were new (71); however, their findings were mainly based on short-term data. With the knowledge that worsening or onset of new GERD symptoms is a frequent finding after SG, patients should be carefully evaluated for preoperative GERD-related complaints, and these findings should be considered when selecting the appropriate bariatric surgical procedure.

According to the Surgical Review Corporation, it is desirable that follow-up evaluates at least 75% of patients five years after bariatric surgery (72). In the studies analyzed by us, the mean five-year follow-up rate was 68% (range 58%–100%) and only 14 studies reported a follow-up rate of >75%; therefore, there is a high concern for bias. Moreover, only 18 studies defined their follow-up method: 15 used in-person follow-up only, three gathered data by in-person examinations combined with information received by phone, while the follow-up was undefined in the two remaining studies. Our analysis was limited by the source data, which were not randomized. In some studies, the sample size was rather small, and a mean follow-up rate of 68% at five years was considered unacceptable. Only one study was randomly controlled. Most studies did not assess data regarding the QoL, and in the remaining studies, data were collected using different assessment tools. The resolution or improvement criteria varied among the series, while eight studies did not evaluate the alteration of comorbidities.

5. Quality of life (QoL)

Obesity-related disorders and morbid obesity have a negative effect on the QoL. In addition to lowering mortality and morbidity, BS improves the quality of life over the long term. Substantial enhancements in social, physical and sexual quality of life have been observed after LSG. One to two years after LSG, QoL and general health dramatically improved (73, 74). Additionally, this benefit persisted over the long run. For example, follow-up research conducted after 10 years found a considerable improvement in overall quality of life prior to and after LSG (75). Over a period of ten years, the global physical health QoL improved from 45.6 20.7 to 62.3 ±23; the global QoL for mental health grew from 49.5 ± 17.7 up to 62.2 ± 17.8; and the overall total QoL score, which was 48.3 20.6 prior to surgery, rose to 65.1 to 21.4 after 10 years (74).

6. Safety and complications

Several studies have directly compared the safety of LVSG operations to a procedure that is considered the gold standard for bariatric procedures such as RYGB. Significant problems after LSG occur at a rate of 0-6% (75, 76). Leak, symptomatic stenosis, bleeding, deep vein thrombosis/pulmonary embolism (DVT/PE), portomesenteric venous thrombosis, and dehydration are some of the early consequences. Malnutrition, strictures, and weight gain are examples of late-onset adverse consequences. ❑

CONCLUSION

This literature review suggests that sleeve gastrectomy is a safe and efficient technique with no mortality or comorbidity resolution and fewer complications. Simple anatomical alterations in the gastrointestinal tract have both intentional and unintentional consequences. Laparoscopic vertical sleeve gastrectomy has been shown to cause significant weight loss, and many patients maintain weight loss over time. Although long-term statistics are still being developed, information also shows progress in the conditions associated with comorbid obesity. The more we learn about these alterations, the more it becomes evident that metabolic surgery is more than just a method for reducing body weight. Whether it can be recommended as a treatment for obesity-related comorbidities such as non-alcoholic fatty liver disease and cancer remains controversial. Studying these operations not only helps to improve the effects of surgery, but also provides wider insights into understanding integrated physiology to harness the benefits of surgery without using the scalpel. ❑

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