Short-Term Metabolic Outcomes after Laparoscopic Sleeve Gastrectomy: A Retrospective Cohort Study from Oman

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Abstract

Objective: A major challenge worldwide, obesity increases the risk of various metabolic diseases, including type 2 diabetes mellitus (T2DM), hypertension (HTN), and dyslipidemia. Bariatric surgery, specifically a laparoscopic sleeve gastrectomy (LSG), is effective in inducing weight loss, thereby improving the rate of obesity-related metabolic diseases. The objective of this study was to assess the short-term effectiveness and metabolic effects of LSG procedures among patients in Oman. ***Methods:*** This retrospective cohort study was conducted at the Royal Hospital, Muscat, Oman. All patients who underwent LSG between January 1, 2017, and December 31, 2018, were included in the analysis. Demographic, clinical, and anthropometric data were collected from the hospital's computerized records pre-operatively and one year post-operatively. ***Results:*** A total of 168 patients were included in the study, of whom most were female (66.1%). Before surgery, the mean age was 36.2 years and mean body mass index (BMI) was 50.8 kg/m^2. In terms of comorbidities, 28.6% had T2DM, 28.6% had HTN, and 20.8% had dyslipidemia. Post-operatively, more than two-thirds of the cohort (n = 132; 78.6%) achieved a target percent excess weight loss (EWL) of >50%, including 89.5% and 73.0% of male and female patients, respectively (p = 0.014). Percent EWL was positively correlated to pre-operative BMI (p <0.001); however, no significant associations were observed with various comorbidities, including HTN, T2DM, dyslipidemia, and obstructive sleep apnea (p >0.05). ***Conclusions:*** The results of this study indicate that LSG is effective for the short-term achievement of percent EWL among Omani patients with morbid obesity. However, further studies are needed to assess the long-term effectiveness of LSG on percent EWL and its effect on obesity-related metabolic diseases.

Keywords: Obesity; Bariatric Surgery; Laparoscopic Sleeve Gastrectomy; Treatment Outcome; Weight Loss; Metabolic Diseases; Diabetes; Dyslipidemia; Hypertension; Obstructive Sleep Apnea; Oman.

Introduction

Obesity, defined as the abnormal accumulation of fat in the body, is an increasingly prevalent public health issue worldwide.[1] According to the World Health Organization,[2] adults aged 18 years or above are considered overweight and obese if they have a body mass index (BMI) of 25–29.9 and ≥30 kg/m^2, respectively. Globally, the prevalence of overweight/obesity has nearly tripled since 1975, with up to 39% and 14% of adults in 2019 considered overweight

and obese, respectively.[1,3] According to data from the Ministry of Health,[4] approximately 60% of adults in Oman, a Middle Eastern country located on the southeastern Arab Peninsula, were either overweight or obese in 2018.

Obesity can lead to a plethora of chronic and debilitating diseases, including type 2 diabetes mellitus (T2DM), hypertension (HTN), heart disease, stroke, dyslipidemia, and obstructive sleep apnea (OSA), potentially resulting in early mortality.[1,5-7] In addition, the treatment of obesity and obesity-related conditions creates a huge economic burden; for example, obesity alone cost the United States more than $1.4 trillion in 2016.[8] Hence, finding an effective and sustainable method for weight reduction is important. Compared to non-surgical interventions, bariatric procedures are reported to be the most effective strategy to induce weight loss.[9] In particular, laparoscopic sleeve gastrectomy (LSG) has been shown to result in excellent weight loss as well as the remission of most obesity-related comorbidities.[10,11]

An LSG procedure involves the removal of approximately 70–80% of the greater curvature of the stomach, resulting in the creation of a narrow gastric tube with a volume capacity of ~60–80 mL, thereby aiding weight loss both by physically restricting food intake as well as by affecting gut hormones to enhance satiety.[10,11] Overall, LSG has multiple advantages compared to other types of bariatric surgery, as the procedure results in immediate EWL, does not interfere with the gastrointestinal anatomy and physiology, avoids dumping syndrome, does not require the insertion of a foreign body at the surgical sites, involves an easy surgical technique, and allows for the possibility of conversion to other bariatric procedures if necessary. On the other hand, there are some disadvantages that should be mentioned, including the irreversibility of the procedure and the possibility of leakage or bleeding at the stapling site.[11] The LSG surgery has evolved dramatically over the last two decades, with more than 300,000 procedures conducted annually.[11] Its worldwide popularity increased from 4.5% of all bariatric procedures in 2008 to 42.1% in 2013 and, as of 2015, it was the most popular bariatric procedure in the United States.[11-13]

Various studies have investigated the outcomes of LSG with regards to both weight loss and metabolic changes. In Kuwait, AlKhaldi *et al*.[14] found that LSG resulted in a decrease in mean BMI from 47.1 to 34.3 kg/m^2 within 5–8 years of surgery. Roa *et al.*,[10] reported a percentage excess weight loss (EWL) of up to 52.8% at 6 months following LSG in the United States; even higher percent EWL was recorded in another study,[15] peaking at 81.8% and 78.7% at 1 and 5 years, respectively. A study of morbidly obese patients in Egypt,[16] concluded that the surgery helped correct metabolic disturbances associated with obesity, such as T2DM, within the immediate postoperative period (i.e., 3–6 months). Kowalewski *et al*.,[17] reported a mean percent EWL of 51.1% over a median follow-up period of 8 years following LSG. Golomb *et al*.,[18] reported EWL percentages of 76.8%, 69.7%, and 56.1% at 1, 3, and 5 years of follow-up, respectively; they concluded that LSG-induced efficient weight loss and a major improvement in obesity-related comorbidities, although there was a significant rate of weight regain and a decrease in remission rates of T2DM and, to a lesser extent, other comorbidities, over time.

The current study aimed to evaluate the effect of LSG on percent EWL in an obese Omani population at 12 post-operative months, as well as the effect of the surgery on metabolic parameters and the remission of various comorbidities, including T2DM, HTN, dyslipidemia, and OSA. Additionally, the study attempted to identify patient characteristics influencing remission in order to determine patient groups most likely to benefit from this procedure. To the best of the authors' knowledge, this is the first retrospective cohort study in Oman seeking to identify the short-term effects of LSG on EWL and metabolic outcomes. This study may pave the way for future research on the long-term effects of LSG and enable researchers to compare outcomes with other types of bariatric surgeries.

Methods

This retrospective cohort study was carried out at the Royal Hospital, a tertiary care institution in Muscat Governorate, Oman. This hospital is the main bariatric center in the country to which patients from all over Oman are referred. All obese Omani adult patients aged 18 years and above of both genders who underwent LSG between January 1, 2017, and December 31, 2018, were recruited for the study. Patients with BMIs of ≥40 kg/m^2 scheduled to undergo the surgery were considered eligible for inclusion in the study, regardless of the presence of any comorbidities. Meanwhile, those with major psychiatric diseases were excluded from the study, as were known drug abusers, female patients who became pregnant in the first year following the surgery, those lost to follow-up during the study period, and those with major post-operative complications.

The necessary sample size was calculated to be 44 using G*Power software, version 3.1.9.2, based on a Cohen's d effect size of 0.50 (medium), alpha error of 5%, and at a power of 90%. The adequacy of the sample size was deemed sufficient, considering that approximately 200 LSG procedures are performed at the Royal Hospital annually.

All patients underwent LSG procedures performed by the same surgical team and following the same surgical technique. The surgery was performed by opening 5 port incisions in different areas of the abdomen before the abdominal cavity was inflated, aiming for the pneumoperitoneum. This allowed for clear visualization and assessment of the cavity for any adhesions prior to removal. The first dissection was performed through the gastrocolic ligament approximately 2 cm off the pylorus of the stomach up until the gastro-esophageal junction. Subsequently, the stomach was sleeved, starting from 2 cm off the pylorus up until 1 cm off the gastro-esophageal junction. Thereafter, the remaining portion of the stomach was stapled together. Prior to closure, a leaking test was conducted to check for any oozing or bleeding through the staple line. Finally, the sleeved part of the stomach was removed along with the ports and small stitches were applied to the site of the incisions.[14,16]

All patients received the same pre-and post-operative care, including dietary advice and a recommended exercise program. Patients were admitted to the hospital one day prior to the procedure and discharged on the second day, provided that no major complications occurred. All patients received baseline blood work-ups, including a complete blood count (CBC), glycated hemoglobin (HbA1C) measurements, and total lipid profile 1–3 months pre-operatively, with a repeat CBC and coagulation profile performed on the day of admission. All patients were discharged on daily proton pump inhibitors and multivitamins. Subsequently, they were followed-up as outpatients at 3, 6, and 12 months post-operatively. At each outpatient visit, changes in weight or improvement in comorbidities were assessed and recorded.

Relevant data were obtained from the patients' electronic health records. The following outcomes were considered during the analysis. Satisfactory weight loss was set at >50% percent EWL for a target BMI of 25 kg/m^2.[17] Complete remission of T2DM was defined as a normal HbA1C level of <6.5% without antidiabetic medications, while partial remission was defined as a reduction in the number or dosage of medications necessary.[19] Complete remission of HTN was defined as the cessation of antihypertensive medications with normal blood pressure readings (<140/90 mmHg over multiple readings, if available), while partial remission was defined as a reduction in the number or dosage of medications necessary.[20]

Complete remission of dyslipidemia was defined as the cessation of lipid-lowering medications with normal laboratory results (total cholesterol <5.18 mmol/L, high-density lipoprotein [HDL]-cholesterol >1 mmol/L, low-density lipoprotein [LDL]-cholesterol <4.1 mmol/L), while partial remission was defined as a reduction in the number or dosage of medications necessary, or cessation of medication use despite abnormal laboratory findings.[21] Complete remission of OSA was defined as major symptomatic relief reported by the patient, without the need for further treatment if the patient had previously been on oxygen or continuous positive airway pressure (CPAP) therapy.[14] Partial remission was defined as a mild improvement of symptoms with no or only occasional need for treatment using CPAP (i.e., at nighttime or for a few hours in the daytime) or a generally reduced need for treatment compared to before surgery.[14]

All study variables were analyzed using the Statistical Package for the Social Sciences (SPSS) software (IBM Corp., Armonk, NY). Continuous variables were expressed as means and standard deviations, while categorical variables were presented as numbers or percentages. As appropriate, Chi-squared tests were used to compare differences in proportion between groups. Cross-tabulation was performed to explore the relationship between two or more categorical variables by recording the frequency distribution. A *P* value of <0.05 was considered statistically significant.

This study received ethical approval from the Research and Ethical Review and Approval Committee (RERAC) of the Centre of Studies and Research at the Ministry of Health, Muscat, Oman. Informed consent was not necessary because the study was retrospective in nature and did not involve direct intervention or contact with the participants.

Results

A total of 223 patients underwent LSG procedures at the hospital during the study period, of which 168 (75.3%) fulfilled the inclusion criteria and were included in the study. Overall, 55 patients (24.7%) were excluded as 31 did not receive proper post-operative follow-up care within the first year of surgery, 13 had a BMI of <40 kg/m^2, nine female patients became pregnant within the first year of surgery, one was of non-Omani nationality, and one had major bleeding and leakage from the surgical site on the second post-operative day.

Of the 168 patients included in the study, the majority were female (n = 111; 66.1%). The mean age at the time of surgery was 36.2 years and mean BMI was 50.81 kg/m^2. At baseline, 70 patients (41.7%) had obesity-related co-morbidities, including T2DM (n = 48; 28.6%), HTN (n = 48; 28.6%), and dyslipidemia (n = 35; 20.8%). A total of 72 patients (42.9%) were diagnosed with OSA (Table 1).

Table 1: Baseline characteristics and prevalence of co-morbidities among Omani patients prior to undergoing laparoscopic sleeve gastrectomy (N = 168).

	Males (n = 57)	**Females (n = 111)**	**Total (N = 168)**
Mean age (SD), years	34.98 (7.97)	36.79 (9.13)	36.18 (8.8)
Mean BMI (SD), kg/m^2	50.77 (9.3)	50.77 (9.3)	50.81 (8.8)
Mean weight (SD), kg	145.46 (28.04)	126.09 (21.75)	132.66 (25.68)
T2DM, n (%)	16 (28.1)	32 (28.8%)	48 (28.6)
HTN, n (%)	20 (35.1)	28 (25.2%)	48 (28.6)
Dyslipidemia, n (%)	13 (22.8)	22 (19.8%)	35 (20.8)
OSA, n (%)	29 (50.9)	43 (38.7)	72 (38.7)

Abbreviations: SD: standard deviation; BMI: body mass index, T2DM: type 2 diabetes mellitus, HTN: hypertension, OSA: obstructive sleep apnea.

Most patients achieved significant weight reduction in the first year post-operatively. The mean BMI decreased from 50.81 kg/m^2 pre-operatively to 34.77 kg/m^2 12 months post-operatively. The mean percent EWL was 64.7%, with more than two-thirds of patients (n = 132; 78.6%) achieving the target percent EWL of >50%. Overall, 51 male patients (89.5%) and 81 female patients (73.0%) achieved the target percent EWL of >50% (p = 0.014) (Figure 1). Percent EWL was positively correlated to pre-operative BMI (p <0.001).

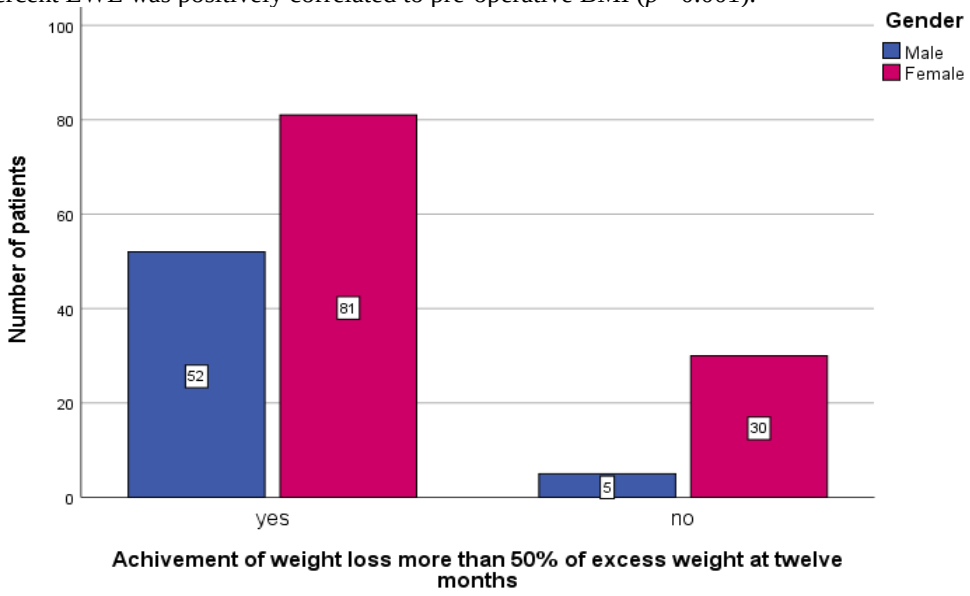

Figure 1: Achievement of target percent excess weight loss (>50%) 12 months post-operatively among Omani patients undergoing laparoscopic sleeve gastrectomy (N = 168).

For the 48 patients with T2DM at baseline, 31 (64.6%) demonstrated complete remission and 15 (31.3%) partial remission; only one patient (2.1%) showed no change to their medication regimen 12 months post-operatively. Among the 48 patients with HTN at baseline, 26 (54.2%) and 16 (33.3%) demonstrated complete and partial remission after LSG, respectively, while three patients (6.3%) had no changes to their medication regimen. With regards to dyslipidemia, 10 (28.6%) of the 35 affected patients were in complete remission at 12 months post-operatively, while two (5.7%) were in partial remission, and 21 (60.0%) experienced no changes to their lipid-lowering medication regimens (Table 2). At 12 months following the surgery, 29.2% of the 72 patients with pre-operative OSA showed improvement in their condition based on their apnea-hypopnea index (AHI) scores; however, a large number of patients had missing data regarding OSA status. Overall, no significant associations were observed between percent EWL and the remission status of any comorbidity (p >0.05).

Table 2: Remission rates of co-morbidities 12-months post-operatively among Omani patients undergoing laparoscopic sleeve gastrectomy (N = 168).

Comorbidity	Complete remission	Partial remission	No change	Missing data
T2DM, n (%)	31 (64.6)	15(31.3)	1 (2.1)	1 (2.1)
HTN, n (%)	26 (54.2)	16 (33.3)	3 (6.3)	3 (6.3)
Dyslipidemia, n (%)	10 (28.6)	2 (5.7)	21 (60.0)	2 (5.7)

Abbreviations: T2DM: type 2 diabetes mellitus, HTN: hypertension.

Discussion

The mean age and male-to-female ratio for the patients included in our study were comparable to those reported in other relevant studies.[14,22] However, the mean pre-operative BMI in our study was much higher (50.81 kg/m^2) than the average reported in the literature. For instance, Khalaj *et al.*[22] and Kikkas *et al.*[23] reported mean pre-operative BMIs of 44.6 and 46.5 kg/m^2 among morbidly obese patients undergoing LSG in Iran and Estonia, respectively. Similarly, AlKhaldi *et al.*[14] and Turgut *et al.*[24] reported mean pre-operative BMIs of 47.1 and 45.5 kg/m^2, respectively, among similar populations in Kuwait and Turkey. With regards to weight loss outcomes, the mean percent EWL for our population at 12 months post-operatively was 64.7%, which is lower than previously reported findings within a similar timeframe (range: 72.8–83.7%).[22,24,25] Such variations may be due to the selection of patients with higher BMIs during the initial selection process for bariatric procedures. The higher mean pre-operative BMI in our study may explain the lower percent EWL.

In our study, the T2DM remission rate at 12 months following LSG was 64.6%. This falls in line with the outcomes reported in various studies. According to Murshid *et al.*,[26] 75% of patients undergoing LSG in Saudi Arabia achieved target HbA1c levels of ≤6.5% within one year of surgery. Moreover, Lechea *et al.*[27] found that requirements for antidiabetic medical treatment decreased by 69% in a Romanian population; comparably, Al Khayat *et al.*[28] observed a remission rate of 70% among patients with T2DM in Kuwait within the immediate post-operative period (i.e., within one month of LSG). In contrast, McTigue *et al.*[29] found that the adjusted cumulative remission rate for adult patients with T2DM was only 55.9% (95% confidence interval: 53.9–57.9%) at 12 months of follow-up after LSG. This discrepancy in results could be due to study variations in the clinical characteristics of diabetic patients included in the analysis.

Using continuous glucose monitoring, Capoccia *et al.*[30] found that up to 40% of obese T2DM patients who underwent LSG achieved complete remission in hyperglycemia based on an evaluation of glucose variability. The researchers concluded that T2DM duration plays a major role in the achievement of complete remission of T2DM post-operatively, as patients with a longer duration of T2DM were found to have lower remission rates after the bariatric surgery. Similar results were reported by Li *et al.*[31] in a meta-analysis of studies assessing the metabolic effects of bariatric surgery among obese T2DM patients. Based on the analysis of 13 trials involving 357 patients, only 66.35% of patients achieved complete remission along with an approximate loss of one-fifth of their body weight when a BMI of <35 kg/m^2 was used as an inclusion criterion. On the other hand, 84% of patients with BMIs of >35

kg/m^2 achieved complete glycemic remission with a loss of almost one-third of their weight.[31] Furthermore, 37% of diabetic patients did not receive any medication for diabetes after the surgery and 21% had their doses reduced.

This study demonstrated complete remission of HTN in 54.2% of patients, with 33.3% achieving partial remission. Lechea *et al.*[27] reported that the need for antihypertensive treatment was reduced by 60% post-LSG, while Turgut *et al.*[24] reported a similar remission rate (61%). Another study,[22] reported that 52.2% of patients undergoing LSG achieved HTN remission at 12 months. According to Kowalewski *et al*.,[17] 28% of 49 hypertensive patients in Poland did not require pharmacological therapy for HTN after LSG, while 31% had their doses reduced, 33% experienced no changes in treatment, and 8% required increased doses of anti-hypertensives.

In this study, 26.8% of patients with dyslipidemia at baseline experienced complete remission after 12 months, which is comparable to the rate reported by Khalaj *et al.*[22] among Iranian patients (27.7%). In contrast, Yin *et al.*[32] found that a much higher percentage of 60 morbidly obese patients in China were cured of their dyslipidemia within a year following surgery (86%). Lechea *et al*. [27] noted that requirements for lipid-lowering treatment reduced by 21% following LSG, although 78% of patients still required chronic treatment with statins. The researchers also found that triglycerides and LDL cholesterol decreased by 37% and 9% respectively, while HDL cholesterol increased by 18% at 12 months following the surgery; although HDL levels increased significantly, the decline in total cholesterol and LDL was not statistically significant.[27] As the continuation of cholesterol-lowering drugs is directed to a greater degree by the patient's total cholesterol and LDL levels than HDL levels, this may account for the decline in the percentage of complete remission of dyslipidemia in our study. Ruiz-Tovar *et al*.[15] similarly concluded that 21.4% and 100% of patients in Spain achieved complete remission of hypercholesterolemia and hypertriglyceridemia, respectively, 12 months post-operatively. In addition, Hussein[33] and Vigilante *et al.*[34] reported substantial improvement in all lipid profile parameters one year after LSG in Egyptian and Italian populations, respectively.

Regarding rates of resolution of OSA in the present study, the lack of follow-up data limited the study's ability to determine the effect of LSG on this co-morbidity in the short-term post-operative period. A study conducted by Kikkas *et al.*[23] concluded that the remission rate of OSA at 5 years' post-surgery was approximately 61.5%. Further research is recommended to better determine whether LSG is effective in resolving OSA in the Omani population. Such studies should utilize the AHI to record the number of apnea- and hypopnea-related events per night during sleep studies to determine whether the surgery resolves or reduces OSA severity.[35]

This study was subject to several limitations. As the study was conducted at an earlier time and at a single hospital in Oman and did not include other bariatric centers in the country (e.g., the Armed Forces Hospital or private centers and hospitals), the results of this study might not be generalizable. Moreover, there was a considerable amount of missing data regarding AHI scores; based on the retrospective analysis of the hospital records, a sleep study was not performed for all patients at baseline and, if performed pre-operatively, was not repeated post-operatively. Therefore, the OSA findings were based on the patients' subjective assessment of their symptoms which might not be reliable. Finally, the study focused only on the short-term effects of LSG on weight loss and comorbidity status and detailed information on patient's dietary habits and physical activity post operatively were not gathered and thus their effect on comorbidities remission rates is unknown. Future studies are required to assess the long-term consequences of LSG on weight and metabolic parameters.

Conclusions

This study showed that LSG play an important role in the achievement of significant excess weight loss in Omani patients with morbid obesity; however, there was no statistically significant improvement in the resolution or remission of various comorbidities in relation to the level of EWL. Further studies are needed to determine the long-term effect of LSG on weight loss and obesity-related metabolic diseases.

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