LONG-TERM OUTCOMES OF LAPAROSCOPIC SLEEVE GASTRECTOMY FOR MORBID OBESITY SINGLE CENTER EXPERIENCE

Yousry Abo elwafa[1], Emad Hamdy[2], Ahmad M Sultan[3], Mohamed El Sorogy[4]

Article History: Received: 10.04.2023 **Revised:** 05.05.2023 **Accepted:** 11.05.2023

Abstract

Background: Good outcomes are usually reported by patients after laparoscopic sleeve gastrectomy (LSG), especially during the short- and intermediate-term follow-up. The long-term outcome is insufficiently in literatures. We conducted this study to determine the long-term outcomes of LSG regarding weight loss, weight regain, and the effect on obesity-associated comorbidities.

Patients and methods: This retrospective study presents the data of 517 patients who underwent LSG between 2012 and 2020. Data were collected regarding weight loss, weight regains, and changes in obesity-associated comorbidities at 2, 4, 6, 8, and 10 years after the procedure.

Results: The maximum weight loss was obtained at two-year follow-up. The mean %EWL had mean values of 69.14%, 63.71%, 58.86%, 53.13%, and 47.3% at the scheduled follow-up visits, respectively. The resolution and improvement of hypertension and diabetes showed good outcomes at the initial two follow-up visits. Nonetheless, recurrence of both diseases was notedat the subsequent visits. The incidence of worsening symptoms continued to increase throughout the follow-up visits. Revisional surgery was performed in 45 patients (8.7%), after a mean period of 5.98 years following the primary LSG procedure. The indications were weight regain (73.33%), failure of comorbidity resolution (20%), and intractable reflux (6.67%).

Conclusion: Although LSG is associated with great weight loss and comorbidity resolution at the short- and intermediate-term follow-up, long-term follow-up showed a weakening of these effects manifested in decreased %EWL, recurrence of comorbidities, weight regain, and need for revisional procedures.

Keywords: Sleeve gastrectomy; Long-term outcomes

[1]specialist of general surgery, Mansoura International hospital.
[2]Professor of General Surgery, Faculty of Medicine, Mansoura University.
[3]Professor of General Surgery, Faculty of Medicine, Mansoura University.
[4]Associate professor of General Surgery, Faculty of Medicine, Mansoura University

1. INTRODUCTION

Obesity is one of the main public health issues in Egypt, as about one-third of the adult Egyptian population suffers from obesity, according to the recent "100 million health" survey [1]. Laparoscopic sleeve gastrectomy (LSG) is one of the most common bariatric procedures performed in Egypt [2].

LSG was initially described as the first stage of biliopancreatic diversion with a duodenal switch procedure. It was originally indicated as an initial tool for decreasing weight before the second stage [3, 4]. Surprisingly, that operation was associated with effective weight loss and significant improvement of obesity-associated comorbidities. Also, it is technically easier and has less morbidity compared to other procedures [5]. The previous advantages have made LSG a primary bariatric procedure and one of the most commonly performed procedures for obesity around the world [6, 7].

Although LSG yields good outcomes in the short- and intermediate-term follow-up, the durability of its effectiveness is questioned in the long term [8]. Also, the existing studies handling long-term follow-up have low follow-up rates [9].

As there is an obvious lack of Egyptian studies handling the long-term outcomes after LSG, we conducted the current study to determine the long-term outcomes of LSG as a treatment for morbid obesity regarding weight loss, weight regain, and its effect on obesity-related comorbidities.

2. PATIENTS AND METHODS

This retrospective cohort study was conducted at Gastrointestinal Surgical Center, Mansoura University, Egypt following the approval from the

Institutional Review Board of our university. The study included the data of all patients that underwent LSG in the period between January, 2012 and January, 2020. All study cases0 were called for follow up at our outpatient clinics. This provided a 2 to 10-year follow up after performing this laparoscopic procedure. Patients with less than 2 years of follow up and whom we could not contact at follow-up time were excluded.

Before the procedure, all patients were clinically, endoscopically, and biochemically assessed. The LSG was performed over a 38-Fr bougie, starting 4 – 6 cm from the pylorus, with complete excision of the gastric fundus. An intraoperative leak test was done to ensure staple line integrity. Operative time and intraoperative blood loss were recorded.Patients were transferred to the ward after the operation, and oral fluid intake was often allowed on the first postoperative day unless complications were encountered.Early complications as leakage, bleeding, or wound infectionwere recorded. The patients were discharged with dietary recommendations and vitamin supplementation as recommended [10, 11].

Standard follow-up included visits to the outpatient clinic at 3-month intervals during the first postoperative year. Later follow-up visits were scheduled at 2, 4, 6, 8, and 10 years after the procedure. The data were either collected from the electronically preserved patient sheets or by a telephone call to the patient. Data regarding the percentage of excess weight loss (%EWL), weight regain, and comorbidity changes were collected. Weight regain was defined as an increase of body weight of > ten kg from the nadir [12, 13].

Diabetes and hypertensive outcomes were defined as complete remission, partial remission, improvement, unchanged, and recurrence, while GERD assessment was subjectively classified as complete resolution, improvement, unchanged, or worsening. The previous definitions were previously published by Brethauer and his colleagues [14]. Denovo GERD was established when the patient developed reflux symptoms after the operation despite its absence before it, as reported by **Casella et al.** [15].

Our primary outcome was long-term weight loss and comorbidities outcomes. Secondary outcomes included early postoperative outcomes, weight regain rate and the need for revisional procedures.

The collected data were organized in SPSS software. Categorical variables were expressed as numbers and percentages, while numerical data were expressed as mean and standard deviation (if normally distributed) or median and range (if abnormally distributed). To compare data at different time points, we used the marginal homogeneity test for the former, while the repeated measures ANOVA was applied for the latter. In addition, McNemar's test was done for paired nominal data. A p-value less than 0.05 was considered statistically significant.

3. RESULTS

During the study period 604 patients underwent LSG as primary bariatric procedure, from them 87 patients were excluded because they had a follow up less than 2 years. Finally the study population comprised 517 patients.The mean age of the included cases was 36.82 years. Females represented 58% of the study population, whereas the remaining participants were men. Their mean preoperative body mass index (BMI)was 55.54 kg/m2. Regarding obesity-related comorbidities, diabetes mellitus was present in 67 patients (13%), while hypertension was present in 107 cases, whereas gastroesophageal reflux disease (GERD) was reported in 79 cases (15.3%) **Table (1).**

Table (1): Basic sociodemographic data among the studied cases

Items	**Study subjects n=517**
Age (years) Mean ± SD	36.82 ± 12.26
Sex	
Males	217 (42%)
Females	300 (58%)
BMI (Kg/m^2) Mean ± SD	57.26 ± 12.37
Comorbidities	
Diabetes	67 (13%)
Hypertension	107 (20.7%)
GERD	79 (15.3%)

The mean operative time was 105.49 minutes, while mean blood loss was 257.06 ml. regarding early postoperative complications, internal haemorrhage was encountered in 2.3% of cases, while leakage was encountered in 3.5% of them. In addition, port site infection occurred in 3.1% of cases **Table (2).**

Table (2): Operative data among the studied cases.

Items		**Study subjects n=517**
Operative time (min)	Mean ± SD	105.49 ± 43.35
Blood loss (ml)	Mean ± SD	257.06 ± 188.22
Early postoperative complications		
Internal hemorrhage		12 (2.3%)
Leak		18 (3.5%)
Wound infection		16 (3.1%)

As shown in **Table (3),** the maximum weight loss was obtained at the two-year follow-up. The mean %EWL had mean values of 69.14%, 63.71%, 58.86%, 53.13%, and 47.3% at two, four, six, eight, and ten-year follow-up visits, respectively. It was evident that the efficacy of LSG regarding weight loss significantly decreased with longer follow-ups.

Table (3): EWL changes in the study cases

	EWL at 2 years (N=517)	**EWL at 4 years (N=361)**	**EWL at 6 years (N=190)**	**EWL at 8 years (N=89)**	**EWL at 10 years (N=25)**	
Mean ± SD	69.14 ±10.63	63.71 ± 10.36	58.86 ± 10.02	53.13 ± 9.29	47.30 ± 9.14	
P_1		< 0.001**	< 0.001**	< 0.001**	< 0.001**	
P_2			< 0.001**	< 0.001**	< 0.001**	F= 63.454
P_3				< 0.001**	< 0.001**	P <0.001**
P_4					< 0.001**	

F: Repeated measures ANOVA; **P1:** Significance in relation to 2 years value; **P2:** Significance in relation to 4 years value; **P3:** Significance in relation to 8 years value; **P4:** Significance in relation to 10 years value.

Similar to the trend of drop in %EWL over time, weight regain also increased progressively during follow-up. Weight regain was present in 4.06 % at 2 years, 9.69 % at 4 years, 29.42 % at 6 years, 47.19% at 8 years and 76 % at 10 years as shown in **Figure (no.1).**

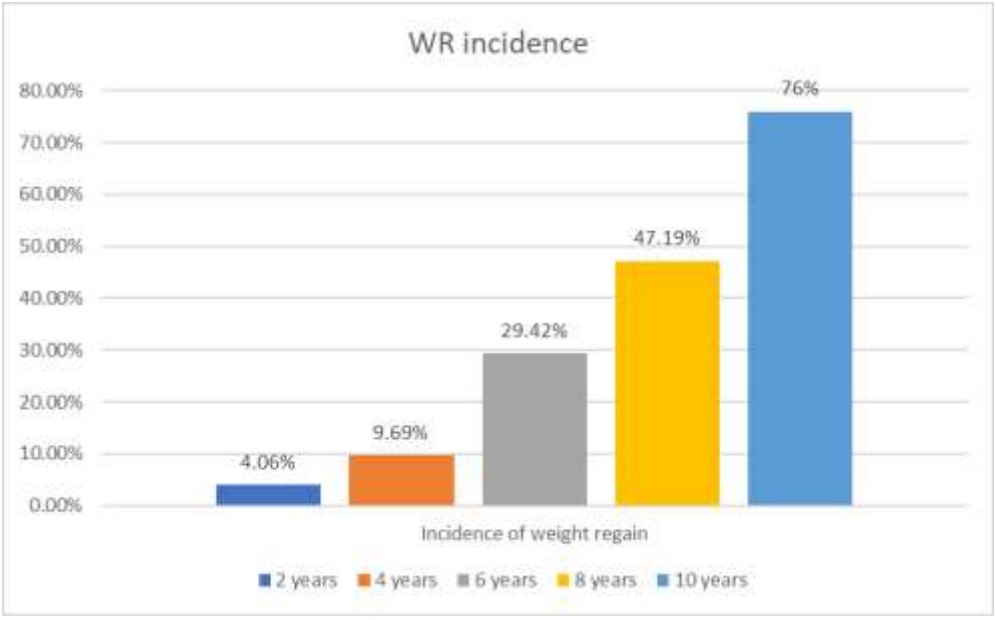

Figure (1): A chart showing the incidence of WR at the scheduled follow-up visits.

Diabetes remission and improvement showed good results at both two- and four-year follow-ups. However, at the subsequent visits, 15% and 20% of diabetic cases who presented at follow-up showed recurrence of their diabetic manifestations at six- and eight-year follow-up visits, respectively. Only three diabetic patients completed their ten-year follow-up, with no recurrence reported, mostly due to the limited patient sample **(Table 4).**

Table (4): Changes in diabetes mellitus in the study cases with pre-existing diabetes

	At 2 years (N=67)	At 4 years (N=42)	At 6 years (N=20)	At 8 years (N=10)	At 10 years (N=3)	
Complete remission	27 (40.3%)	12 (28.6%)	4 (20%)	2 (20%)	1 (33.3%)	MH= 2.548 P= 0.136
Partial remission	10 (14.9%)	9 (21.4%)	3 (15%)	2 (20%)	0 (0%)	
Improvement	13 (19.4%)	9 (21.4%)	4 (20%)	1 (10%)	1 (33.3%)	
Unchanged	17 (25.3%)	12 (28.6%)	6 (30%)	3 (30%)	1 (33.3%)	
Recurrence	0 (0%)	0 (0%)	3 (15%)	2 (20%)	0 (0%)	

MH: Marginal homogeneity test.

The resolution and improvement of hypertension showed good outcomes at the initial two follow-up visits. Nonetheless, recurrence of the hypertensive state was noted in 4.5%, 25%, and 28.6% of patients at the subsequent three follow-up visits, respectively **Table (5).**

Table (5): Changes in hypertension in the study cases with pre-existing hypertension

	At 2 years (N=107)	At 4 years (N=77)	At 6 years (N=44)	At 8 years (N=20)	At 10 years (N=7)	
Complete remission	21 (19.6%)	13 (16.9%)	4 (9.1%)	2 (10%)	0 (0%)	MH= 2.988 P= 0.092
Partial remission	20 (18.7%)	18 (23.4%)	13 (29.5%)	2 (10%)	1 (14.3%)	
Improvement	23 (21.5%)	12 (15.6%)	8 (18.2%)	3 (15%)	0 (0%)	
Unchanged	43 (40.2%)	34 (44.2%)	17 (38.6%)	8 (40%)	4 (57.1%)	
Recurrence	0 (0%)	0 (0%)	2 (4.5%)	5 (25%)	2 (28.6%)	

MH: Marginal homogeneity test.

Although some patients reported resolution or improvement of their GERD symptoms at the initial follow-up after the operation, the incidence of worsening symptoms continued to increase throughout the follow-up visits. The incidence of worsening GERD was 30.4%, 32.1%, 35.7%, 37.5%, and 67.7% at two, four, six, eight, and ten-year follow-up visits, respectively Table (6).
Worsening of GERD was in the form of increased frequency of symptoms, incidence of extraesophageal symptoms such as hoarseness of voice, and need for antacids or proton pump therapy. An endoscope was done at 2 years and every 2 years thereafter in patients with GERD revealed no esophagitis, grade I or grade II esophagitis with no Barrett's diagnosed in all patients. All cases were controlled with medical treatment except 3 cases that underwent revisional surgery.

Table (6): Follow-up of GERD in patients with pre-existing GERD

	At 2 years (N=79)	At 4 years (N=53)	At 6 years (N=28)	At 8 years (N=8)	At 10 years (N=3)	
Resolution	8 (10.1%)	6 (11.3%)	5 (17.9%)	1 (12.5%)	0 (0%)	MH= 3.265 P= 0.076
Improvement	15 (19%)	17 (32.1%)	3 (10.7%)	1 (12.5%)	0 (0%)	
Unchanged	32 (40.5%)	13 (24.5%)	10 (35.7%)	3 (37.5%)	1 (33.3%)	
Worsened	24 (30.4%)	17 (32.1%)	10 (35.7%)	3 (37.5%)	2 (67.7%)	

MH: Marginal homogeneity test.

The incidence of denovo GERD was 2.5%, 2.9%, 3.7%, 6.1%, and 18.2% at two, four, six, eight, and ten-year follow-up visits, respectively. The incidence of this problem continued to increase throughout the long-term follow-up **Table (7).**

Table (7): The development of de novo GERD in patients without pre-existing GRED.

	At 2 years (N=438)	At 4 years (N=308)	At 6 years (N=163)	At 8 years (N=81)	At 10 years (N=22)	
Denovo GERD	11 (2.5%)	9 (2.9%)	6 (3.7%)	5 (6.1%)	4 (18.2%)	McN= 4.681 P= 0.005*

McN: McNamar's test.

Weight regain was reported in 22.43% of patients at follow-up. Revisional surgery was performed in 45 patients (8.7%) after a mean period of 5.98 years following the primary LSG procedure. The most common indication for revision was weight regain (73.33%), followed by failure of comorbidity resolution (20%) and intractable GERD (6.67%). The most common procedure performed was roux-en-y gastric bypass RYGB (66.7%), followed by minigastric bypass (28.9%), and resleevegastrectomy (4.4%) **Table (8).**

Table (8): Weigh regain and revisional surgery data among the studied cases.

Items		**Study subjects n=517**
Weight regain		116 (22.43%)
Revision surgery		
• **Revision**		45 (8.7%)
• **No revision**		472 (91.3%)
Indication for revision		
• **Weight regain**		33 (73.33%)
• **Failure of comorbidity improvement**		9 (20%)
• **GERD**		3 (6.67%)
Type of Revision (N= 45)		
• **Roux-on -Y**		30 (66.7%)
• **Mini gastric bypass**		13 (28.9%)
• **Resleeve**		2 (4.4%)
The interval between primary surgery and revision (Years)	Mean ± SD	5.98 ± 1.45

4. DISCUSSION

This study was done to evaluate the long-term outcomes after LSG. As there is a paucity of Egyptian studies handling the same concept, this poses an advantage in favour of our research.

In our study, the operative time ranged between 30 and 300 minutes (mean = 105.49 minutes). Gentileschi reported that the median operative time was 102 minutes (range, 64 - 180 minutes) [16], which is near to our findings. However, **Bobowicz et al.** reported that the mean operative time was 61 min (range 30–140 min) [17], which is lower than ours. Some differences are accepted between studies regarding the previous parameter. That would differ due to surgeon experience, place ergonomics, and the performance of concomitant procedures like cholecystectomy.

Staple line leakage was encountered in 3.5% of our participants, and that incidence rate lies within the reported global incidence of leakage after LSG, which ranges between 1.1% and 5.3% [18].

Internal hemorrhage occurred in 2.3% of our patients. This incidence is in accordance with the previous range in the literature (1.16 – 4.94%) [19, 20].

Regarding surgical site infection in the current study, it occurred in 3.1% of cases. Other previous studies reported that this complication could occur in up to 4% of patients following laparoscopic bariatric procedures [21, 22], which is in line with our findings.

Regarding weight loss outcomes in our study, the % EWL had mean values of 69.14%, 63.71%, 58.86%, 53.13%, and 47.3% at two, four, six, eight, and ten-year follow-up visits, respectively. Similar to the trend of drop in %EWL over time, weight regain also increased progressively during follow-up. Weight regain was present in 4.06 % at 2 years, 9.69 % at 4 years, 29.42 % at 6 years, 47.19% at 8 years and 76 % at 10 years.

It was evident that the efficacy of LSG regarding weight loss significantly decreased with longer follow-ups.

Multiple factors could contribute to the waning effects of LSG with time. These include dilatation of the gastric pouch, inadequate fundus resection, increased ghrelin secretion from the previously silent gastric glands, a sedentary lifestyle, and poor adherence to dietary recommendations [12, 23-25].

In the study conducted by **Rodríguez** and his co-workers, the % EWL had mean values of 72.7%, 66.3%, and 53.8% at three, five, and ten years following LSG [26]. Additionally, **Sarela et al.** reported an EWL of 86%, 79%, and 69% after two, three, and eight years respectively [27]. A previous systematic review including 16 previous studies handling LSG outcomes stated that the %EWL had mean values of 62.3%, 53.8%, 43%, and 54.8% after five, six, seven, and eight years after LSG, respectively [28]. Also, **Arman et al.** reported that six-and eleven-year %EWL had mean values of 75.9% and 62.5%, respectively [24].

Liu et al. reported that the proportions of patients having successful weight loss (%EWL>50 %) were 79.7, 71.7, 58.4, 55.8, and 54.5 % from 1 to 5 years respectively and similar to the trend of drop in %EWL over time, weight regain also increased

progressively during follow-up. Weight regain was not evident in the first two year but was present in 1.0 % at 2 years, 11.6 % at 3 years, 19.2 % at 4 years, and 29.5 % at 5 years [10].

One could also notice the heterogenicity of reported %EWL among studies. That may denote that weight loss after LSG is also affected by other parameters, including preoperative weight, postoperative exercise, and postoperative dietary management [29].

In the current study, revisional surgery was performed in 45 patients (8.7%) after a mean period of 5.98 years following the primary LSG procedure. Indications for revision were weight regain (73.33%), failure of comorbidity resolution (20%), and intractable GERD (6.67%). The most common procedure performed was RYGB (66.7%), followed by minigastric bypass (28.9%) and resleeve (4.4%).

Lazzati et al. reported that revision rates after LSG were 4.7%, 7.5%, and 12.2% after five, seven, and ten years respectively. The revision was indicated for obesity persistence and GERD. The performed operations were RYGB (75.2%) and resleeve gastrectomy [30].

AbdEllatif et al. reported a low revision rate (4%), which was needed for inadequate weight loss after LSG. Revisional procedures included resleevegastrectomy, RYGB, and banding [31].

The change in revision rates between studies could be explained by different factors, including the difference in the incidence and definition of weight regain after LSG, the different incidence of GERD, patient seek for weight loss, and the economic status of the patient, along with insurance coverage for bariatric procedures between different countries.

Weight regain, which is the major etiology of revision after LSG, ranges from 19.2% to 75.6%, according to long-term studies in the current literature [15, 32, 33]. Our incidence of weight regain lies within the previous range.

This heterogenicity in incidence could be due to different definitions used for weight regain after such a procedure. Some authors defined it as more than 10 kg from nadir weight [12], while others defined it as rebound excess weight loss > 25% [32].

In our study, diabetes remission and improvement showed good results at both two- and four-year follow-ups. However, at the subsequent visits, 15% and 20% of diabetic cases who presented at follow-up showed recurrence of their diabetic manifestations at six- and eight-year follow-up visits, respectively. Likewise, **Conte et al.** reported that diabetes relapse could occur in 13 – 20% of individuals after temporary improvement following bariatric surgery [34]. Another study reported a higher relapse rate (44%) [35].

Other studies reported favorable long-term diabetic outcomes after LSG [25, 36]. **Eid et al.** reported a 40% improvement rate, along with a 37.1% remission rate at the five-year follow-up [36]. The difference in the definition of remission and improvement, as well as the difference in the duration of follow-up, could be responsible for heterogenicity between studies.

In the current study, resolution and improvement of hypertension showed good outcomes at the initial two follow-up visits. Nonetheless, recurrence of the hypertensive state was noted in 4.5%, 25%, and 28.6% of patients at the subsequent three follow-up visits, respectively. **Rodríguez** and his associates reported improvement of hypertension in 75.8%, 68.9%, and 48.2% of their participants after three, five, and ten years following LSG [26]. One could notice the decreasing efficacy of LSG in controlling individual blood pressure over time.

In our study, although some patients reported resolution or improvement of their GERD symptoms at the initial follow-up after the operation, the incidence of worsening symptoms continued to increase throughout the follow-up visits. The effect of LSG on GERD is still contradictory. Worsening of GERD could be explained by the formation of a high-pressure tube, disruption of the angle of His, decreased ghrelin secretion, and subsequent dysmotility. However, other theories could explain improvement after LSG. Gastric resection leads to the decline of the parietal cell mass, leading to a marked decrease in acid production. Also, weight loss itself with the subsequent decline in intrabdominal pressure and enhanced gastric emptying [37].

Eid et al. reported that remission and improvement of GERD manifestations were reported in 8.96% and 22.9% of patients, respectively. Worsening was reported only in 8.6% of their participants [36].

In the current study, the incidence of denovo GERD was 2.5%, 2.9%, 3.7%, 6.1%, and 18.2% at two, four, six, eight, and ten-year follow-up visits, respectively. This is in accordance with **Pilone et al.,** who reported that denovo GERD could be encountered in up to 20% of patients after LSG [38]. Moreover, **AbdEllatif et al.** reported an incidence of 11.4% for the same complication one year after LSG. That incidence significantly declined to 2% at four-year follow-ups [31].

Additionally, in a study evaluating longterm effect of sleeve gastrectomy on GERD on a total of 315 patients, **Braghetto & Korn** exclude patients with preoperative GERD, all patients with reflux symptoms after sleeve are ‘de novo’ refluxers. They reported that at late follow up, (mean 7.07 ± 2.26 years) an increased incidence of symptoms was observed compared to patients evaluated early after surgery (mean 65.1% v/s 28.1%, respectively) (P = 0.0001). Only 26.9% were treated with PPIs at early follow-up while 57.7% of patients needed PPI treatment due to reflux symptoms late after surgery (P = 0.0001). These results suggest worsening of reflux symptoms with time [39].

In a review of longterm results of sleeve gastrectomy, **Felsenreich et al.** showed that short-term studies report an improvement (or even remission) of reflux

symptoms in many of their patients, which may very well be caused by a decrease of intra-abdominal pressure as patients lose large amounts of weight [40]. **Spivak et al.,** for example, were able to show that reflux was cured in 73.7% of patients, who had had preoperative reflux, after 1 year [41].

Chiu et al. analyzed 15 studies with follow-ups between 6 and 60 months after SG in a systematic review and found that 4 of them reported higher rates of reflux and 7 showed improvement of reflux [42].

Mid- and long-term studies, however, show an increase in patients needing proton pump inhibitors (PPIs) and severe reflux symptoms that often stem from de novo reflux [43,44,45]. **Boza et al.,** for example, found new-onset reflux in 26.7% of their SG patients after 5years in a study of 161 patients with a follow-up rate of 70% [46]. **Himpens et al.** studied 53 SG patients at a follow-up of 6+years and 21% were suffering from new-onset reflux at that point [43]. A reason for de novo reflux at this stage may be an increased intra-abdominal pressure caused by weight regain, which often also leads to hiatal hernia development and/or intra-thoracic migration of the sleeve, which is a high-pressure system [40].

Our study has some advantages including the respectable sample size with long-term follow up. However, our study has several limitations. First, the retrospective nature of our data. Second, the follow up rate beyond 8 years was relatively low, a common problem seen in bariatric literature. Third, the impact on comorbidities was analyzed only by changes in therapy, prescribed by other physicians. Fourth, we were not able to perform invasive tests regarding GERD, could only base our results on presented symptoms, and declared pharmacotherapy. We did not assess objectively the severity and frequency of GERD symptoms. More studies including more patients from different bariatric centers should be conducted in the near future.

5. CONCLUSION

According to the previous findings, although LSG is associated with great weight loss and comorbidity resolution at the short- and intermediate-term follow-up, long-term follow-up showed a weakening of these effects manifested in decreased %EWL, recurrence of comorbidities, weight regain, and need for revisional procedures.

Conflict of interest: Nil.

6. REFERENCES

1. **Aboulghate M, Elaghoury A, Elebrashy I, Elkafrawy N, Elshishiney G, Abul-Magd E, et al.** The Burden of Obesity in Egypt. Front Public Health. 2021;9:718978.
2. **Hussein AH, Khaled I, Faisal M.** The role of the surgical resection distance from the pylorus after laparoscopic sleeve gastrectomy: a prospective cohort study from an academic medical center in Egypt. Patient Saf Surg. 2020;14(1):42.
3. **Chung AY, Thompson R, Overby DW, Duke MC, Farrell TM.** Sleeve Gastrectomy: Surgical Tips. J Laparoendosc Adv Surg Tech A. 2018;28(8):930-7.
4. **Landreneau JP, Strong AT, Rodriguez JH, Aleassa EM, Aminian A, Brethauer S, et al**. Conversion of Sleeve Gastrectomy to Roux-en-Y Gastric Bypass. Obes Surg. 2018;28(12):3843-50.
5. **Kheirvari M, Dadkhah Nikroo N, Jaafarinejad H, Farsimadan M, Eshghjoo S, Hosseini S, et al.** The advantages and disadvantages of sleeve gastrectomy; clinical laboratory to bedside review. Heliyon. 2020;6(2):e03496.
6. **Sheetz KH, Woodside KJ, Shahinian VB, Dimick JB, Montgomery JR, Waits SA.** Trends in Bariatric Surgery Procedures among Patients with ESKD in the United States. Clin J Am Soc Nephrol. 2019;14(8):1193-9.
7. **Ozsoy Z, Demir E.** Which Bariatric Procedure Is the Most Popular in the World? A Bibliometric Comparison. Obes Surg. 2018;28(8):2339-52.
8. **Cottam D, Zaveri H, Surve A, Cottam A.** Revision After Sleeve Gastrectomy. In: Lutfi R, Palermo M, Cadière G-B, editors. Global Bariatric Surgery : The Art of Weight Loss Across the Borders. Cham: Springer International Publishing; 2018. p. 171-83.
9. **Wilson RL, Aminian A.** Expected Weight Loss After the Sleeve. In: Al-Sabah S, Aminian A, Angrisani L, Al Haddad E, Kow L, editors. Laparoscopic Sleeve Gastrectomy. Cham: Springer International Publishing; 2021. p. 385-91.
10. **AlTarrah D.** Postoperative Diet Progression for Laparoscopic Sleeve Gastrectomy. In: Al-Sabah S, Aminian A, Angrisani L, Al Haddad E, Kow L, editors. Laparoscopic Sleeve Gastrectomy. Cham: Springer International Publishing; 2021. p. 365-71.
11. **Sánchez Santos R, Molina López A, López Otero M.** Chapter 10 - Nutritional recommendations after sleeve gastrectomy. In: Ruiz-Tovar J, editor. Nutrition and Bariatric Surgery: Academic Press; 2021. p. 129-39.
12. **Bohdjalian A, Langer FB, Shakeri-Leidenmühler S, Gfrerer L, Ludvik B, Zacherl J, et al.** Sleeve gastrectomy as sole and definitive bariatric procedure: 5-year results for weight loss and ghrelin. Obes Surg. 2010;20(5):535-40.
13. **Langer FB, Bohdjalian A, Shakeri-Leidenmühler S, Schoppmann SF, Zacherl J, Prager G.** Conversion from sleeve gastrectomy to Roux-en-Y gastric bypass--indications and outcome. Obes Surg. 2010;20(7):835-40.
14. **Brethauer SA, Kim J, El Chaar M, Papasavas P, Eisenberg D, Rogers A, et al.** Standardized outcomes reporting in metabolic and bariatric surgery. Obes Surg. 2015;25(4):587-606.
15. **Casella G, Soricelli E, Giannotti D, Collalti M, Maselli R, Genco A, et al.** Long-term results after laparoscopic sleeve gastrectomy in a large monocentric series. Surg Obes Relat Dis. 2016;12(4):757-62.
16. **Gentileschi P.** Laparoscopic sleeve gastrectomy as a primary operation for morbid obesity: experience with 200 patients. Gastroenterol Res Pract. 2012;2012:801325.
17. **Bobowicz M, Lehmann A, Orlowski M, Lech P, Michalik M.** Preliminary outcomes 1 year after laparoscopic sleeve gastrectomy based on Bariatric Analysis and Reporting Outcome System (BAROS). Obes Surg. 2011;21(12):1843-8.
18. **Iossa A, Abdelgawad M, Watkins BM, Silecchia G.** Leaks after laparoscopic sleeve gastrectomy: overview of pathogenesis and risk factors. Langenbecks Arch Surg. 2016;401(6):757-66.
19. **Shikora SA, Mahoney CB.** Clinical Benefit of Gastric Staple Line Reinforcement (SLR) in Gastrointestinal

Surgery: a Meta-analysis. Obes Surg. 2015;25(7):1133-41.
20. **Janik MR, Walędziak M, Brągoszewski J, Kwiatkowski A, Paśnik K.** Prediction Model for Hemorrhagic Complications after Laparoscopic Sleeve Gastrectomy: Development of SLEEVE BLEED Calculator. Obes Surg. 2017;27(4):968-72.
21. **Higa KD, Boone KB, Ho T.** Complications of the laparoscopic Roux-en-Y gastric bypass: 1,040 patients--what have we learned? Obes Surg. 2000;10(6):509-13.
22. **Schauer PR, Ikramuddin S, Gourash W, Ramanathan R, Luketich J.** Outcomes after laparoscopic Roux-en-Y gastric bypass for morbid obesity. Ann Surg. 2000;232(4):515-29.
23. **Karamanakos SN, Vagenas K, Kalfarentzos F, Alexandrides TK.** Weight loss, appetite suppression, and changes in fasting and postprandial ghrelin and peptide-YY levels after Roux-en-Y gastric bypass and sleeve gastrectomy: a prospective, double blind study. Ann Surg. 2008;247(3):401-7.
24. **Arman GA, Himpens J, Dhaenens J, Ballet T, Vilallonga R, Leman G.** Long-term (11+years) outcomes in weight, patient satisfaction, comorbidities, and gastroesophageal reflux treatment after laparoscopic sleeve gastrectomy. Surg Obes Relat Dis. 2016;12(10):1778-86.
25. **Hoyuela C.** Five-year outcomes of laparoscopic sleeve gastrectomy as a primary procedure for morbid obesity: A prospective study. World J Gastrointest Surg. 2017;9(4):109-17.
26. **Rodríguez J, Zerrweck C, Inzunza EA, Rodríguez J, Urbina D, Palomares C, et al.** Laparoscopic Sleeve Gastrectomy: Results at 10 years. Surgery for Obesity and Related Diseases. 2016;12(7):S8-S9.
27. **Sarela AI, Dexter SP, O'Kane M, Menon A, McMahon MJ.** Long-term follow-up after laparoscopic sleeve gastrectomy: 8-9-year results. Surg Obes Relat Dis. 2012;8(6):679-84.
28. **Diamantis T, Apostolou KG, Alexandrou A, Griniatsos J, Felekouras E, Tsigris C.** Review of long-term weight loss results after laparoscopic sleeve gastrectomy. Surg Obes Relat Dis. 2014;10(1):177-83.
29. **Chang WW, Hawkins DN, Brockmeyer JR, Faler BJ, Hoppe SW, Prasad BM.** Factors influencing long-term weight loss after bariatric surgery. Surg Obes Relat Dis. 2019;15(3):456-61.
30. **Lazzati A, Bechet S, Jouma S, Paolino L, Jung C.** Revision surgery after sleeve gastrectomy: a nationwide study with 10 years of follow-up. Surg Obes Relat Dis. 2020;16(10):1497-504.
31. **Abd Ellatif ME, Abdallah E, Askar W, Thabet W, Aboushady M, Abbas AE, et al.** Long-term predictors of success after laparoscopic sleeve gastrectomy. Int J Surg. 2014;12(5):504-8.
32. **Liu SY, Wong SK, Lam CC, Yung MY, Kong AP, Ng EK.** Long-term Results on Weight Loss and Diabetes Remission after Laparoscopic Sleeve Gastrectomy for A Morbidly Obese Chinese Population. Obes Surg. 2015;25(10):1901-8.
33. **Braghetto I, Csendes A, Lanzarini E, Papapietro K, Cárcamo C, Molina JC.** Is laparoscopic sleeve gastrectomy an acceptable primary bariatric procedure in obese patients? Early and 5-year postoperative results. Surg Laparosc Endosc Percutan Tech. 2012;22(6):479-86.
34. **Conte C, Lapeyre-Mestre M, Hanaire H, Ritz P.** Diabetes Remission and Relapse After Bariatric Surgery: a Nationwide Population-Based Study. Obes Surg. 2020;30(12):4810-20.
35. **Aminian A, Brethauer SA, Andalib A, Punchai S, Mackey J, Rodriguez J, et al.** Can Sleeve Gastrectomy "Cure" Diabetes? Long-term Metabolic Effects of Sleeve Gastrectomy in Patients With Type 2 Diabetes. Ann Surg. 2016;264(4):674-81.
36. **Eid GM, Brethauer S, Mattar SG, Titchner RL, Gourash W, Schauer PR.** Laparoscopic sleeve gastrectomy for super obese patients: forty-eight percent excess weight loss after 6 to 8 years with 93% follow-up. Ann Surg. 2012;256(2):262-5.
37. **Nocca D, Nedelcu M.** Sleeve in Patients with GERD. In: Gagner M, Cardoso AR, Palermo M, Noel P, Nocca D, editors. The Perfect Sleeve Gastrectomy: A Clinical Guide to Evaluation, Treatment, and Techniques. Cham: Springer International Publishing; 2020. p. 177-94.
38. **Pilone V, Tramontano S, Renzulli M, Zulli C, Schiavo L.** Gastroesophageal Reflux After Sleeve Gastrectomy: New Onset and Effect on Symptoms on a Prospective Evaluation. Obes Surg. 2019;29(11):3638-45.
39. **Braghetto, I., &Korn, O.** Late esophagogastric anatomic and functional changes after sleeve gastrectomy and its clinical consequences with regards to gastroesophageal reflux disease. Diseases of the Esophagus. 2019; 32(6), doz020.
40. **Felsenreich DM, Langer FB, Prager G.** Weight Loss and Resolution of Comorbidities After Sleeve Gastrectomy: A Review of Long-Term Results. Scandinavian Journal of Surgery. 2019;108(1):3-9.
41. **Spivak, H., Rubin, M., Sadot, E., Pollak, E., Feygin, A., &Goitein, D.** Laparoscopic sleeve gastrectomy using 42-French versus 32-French bougie: the first-year outcome. Obesity surgery.2014; 24(7), 1090-1093.
42. **Chiu, S., Birch, D. W., Shi, X., Sharma, A. M., &Karmali, S.** Effect of sleeve gastrectomy on gastroesophageal reflux disease: a systematic review. Surgery for Obesity and Related Diseases. 2011; 7(4), 510-515.
43. **Himpens, J., Dobbeleir, J., &Peeters, G.** Long-term results of laparoscopic sleeve gastrectomy for obesity. Annals of surgery. 2010; 252(2), 319-324.
44. **DuPree CE, Blair K, Steele SR, Martin MJ.** Laparoscopic Sleeve Gastrectomy in Patients with PreexistingGastroesophageal Reflux Disease: A National Analysis. JAMA Surg. 2014;149(4):328–334.
45. **Samakar, K., McKenzie, T. J., Tavakkoli, A., Vernon, A. H., Robinson, M. K., &Shikora, S. A.** The effect of laparoscopic sleeve gastrectomy with concomitant hiatal hernia repair on gastroesophageal reflux disease in the morbidly obese. Obesity surgery. 2016; 26(1), 61-66.
46. **Boza, C., Daroch, D., Barros, D., León, F., Funke, R., &Crovari, F.** Long-term outcomes of laparoscopic sleeve gastrectomy as a primary bariatric procedure. Surgery for obesity and related diseases. 2014;10(6), 1129-1133.