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RESEARCH ARTICLE

Short- and Long-term Effects of Laparoscopic Sleeve Gastrectomy on Body Weight and Glucose Homeostasis in Diabetic Patients

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ABSTRACT

Introduction: Laparoscopic sleeve gastrectomy (LSG) is being performed more frequently and is currently very "trendy" among laparoscopic surgeons involved in bariatric surgery. Laparoscopic sleeve gastrectomy is associated with a marked reduction of ghrelin secretion, which is produced by the gastric fundus involved in mealtime hunger regulation, and it is also known to extend several diabetogenic effects.

Aim: The aim of this study is to assess the short- and long-term effects of LSG on body weight and glucose homeostasis in morbidly obese diabetic patients.

Materials and methods: This is a prospective study that was conducted on 40 diabetic patients randomly selected suffering from morbid obesity that had type II diabetes mellitus (T2DM). Patients were managed by LSG in AL-Zahraa Hospital, Faculty of Medicine for girls, Al-Azhar University, from January 2012 to December 2015, to assess the short- and long-term effects of the procedure on glucose homeostasis.

Results: The study was conducted on 40 patients of morbid obesity that had T2DM. The preoperative mean fasting blood glucose (FBG) level was 209.3 ± 36.6 (156–299) mg/dL and postoperatively was 172.5 ± 29 (130–250) mg/dL, 125.6 ± 16.7 (99–169) mg/dL, 111.7 ± 20.9 (77–167) mg/dL, 105 ± 18.3 (73–137) mg/dL, and 102.9 ± 21 (70–145) mg/dL at 1 day and 3, 6, 9, and 12 months respectively. Postoperatively, the FBG levels were improved with significant declining at 1 day ($p < 0.001$), 3 months ($p < 0.001$), and 6 months ($p < 0.004$) but nonsignificant declining at 9 months ($p < 0.25$) and 12 months ($p = 1$).

Conclusion: Laparoscopic sleeve gastrectomy is an effective surgical treatment for most severely or morbidly obese patients with DM. Weight loss is effective treatment for patients with these medical problems. The SG is associated with a high rate of resolution of T2DM at 12 months after surgery in severely obese patients with T2DM.

Keywords: Body mass index, Laparoscopic sleeve gastrectomy, Morbid obesity, Type II diabetes mellitus.

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INTRODUCTION

Obesity is defined as body mass index (BMI) > 30 kg/m^2. Obesity is increasing in prevalence worldwide with economic costs. Obesity and its complications lead to other significant costs, such as missed days of work and a decrease in life expectancy.[1]

Body mass index is considered to represent the most practical measure of a person's adiposity. It is calculated by dividing the weight in kilograms by the height in meters squared (kg/m^2). Bariatric surgical procedures affect weight loss through two fundamental mechanisms: Malabsorption and restriction.[2] Selection and follow-up should be carried out by a team including surgeon, internist, dietitian, and psychiatrist.[3] Success includes weight loss of 25% or more, absence of major complications, and reversal of obesity-related diseases like type II diabetes mellitus (T2DM) and sleep apnea. Best results occur with gastric bypass and biliopancreatic diversion. Late weight regain was common with horizontal gastroplasty and is more common after vertical banded gastroplasty than gastric bypass.[4] Some surgeons advocate that a staged procedure is performed in which a sleeve gastrectomy (SG) is performed initially. Later, once some weight loss is achieved a completion gastrectomy is combined with a Roux reconstruction.[5] The laparoscopic sleeve gastrectomy (LSG) is being performed more frequently and is currently very "trendy" among laparoscopic surgeons involved in bariatric surgery. The LSG is not a new operation, as it is the restrictive part of a more complex malabsorptive bariatric procedure.[6]

Nutritional deficiencies can occur after gastric bypass. Deficiency of iron (6–52%), folate (22–63%), and vitamin B12 (3–37%) is common postoperatively and contributes to the development of anemia found in up to 54% of patients. Increased bone resorption after gastric bypass has also been demonstrated and patients should be counseled regarding this potential problem. Routine supplementation with iron, vitamin B12, folate, and calcium following gastric bypass will prevent the majority of these deficiencies. In SG, avoiding the intestinal bypass almost eliminates the chance of anemia, osteoporosis protein deficiency, and vitamin deficiency.[7] The aim of this study is to assess the short- and long-term effects of LSG on body weight and glucose homeostasis in morbidly obese diabetic patients.

MATERIALS AND METHODS

This is a prospective study which was conducted on 40 diabetic patients randomly selected suffering from morbid obesity (BMI more than 35 kg/m^2). Patients were managed by LSG in Al-Zahraa Hospital, Faculty of Medicine for girls, Al-Azhar University, from January 2012 to December 2015, to assess the short- and long-term effects of the procedure on glucose homeostasis.

Operative Technique

All operative procedures were performed laparoscopically. The first step consists in opening the gastrocolic ligament attached to the stomach, usually starting 10 to 12 cm from the pylorus toward the lower pole of the spleen. Then the gastric greater curvature is freed up to the cardioesophageal junction close to stomach. Meticulous dissection is performed at the angle of His with full mobilization of the gastric fundus. The mobilization of the stomach continues dissecting the greater gastric curve toward the antrum up to 5 to 7 cm from the pylorus. At this time a 36-Fr orogastric tube is inserted direct toward the pylorus, proximal to the lesser curvature of the stomach. Then, the stomach is resected with linear staplers parallel to orogastric tube along the lesser curve starting 5 to 7 cm far from pylorus. The orogastric bougie is replaced by a nasogastric tube, i.e., positioned in the distal stomach to perform a methylene blue test. The transection line is inspected to search blue positively. In case of negative test, the resected stomach is removed by left midabdominal trocar usually without prolonging incision. The gastric residual volume ranged from 60 to 80 mL.

Statistical Analysis

Data were summarized using mean and standard deviation or median and percentile for quantitative variables and frequency and percentage for qualitative variables.

Relative % change was calculated to get the actual change in each time measure.

Relative % change = [(postmeasure – premeasure)/premeasure] × 100

Comparison between groups was done using independent sample t-test for quantitative variables.

Repeated measures analysis of variance test was conducted to compare different measures at different time situation with *post hoc* Bonferroni test for pairwise comparisons.

Pearson correlation coefficient (r) was calculated to test the association between quantitative variables; p-values ≤0.05 were considered significant.

RESULTS

The study was conducted on 40 patients of morbid obesity that had T2DM.

Patient age: The mean age of the studied group was 38.8 ± 7.0 years (25–50) as shown in Table 1.

From the table, 45% of patients' age ranged from 41 to 50, 40% ranged from 31 to 40, and 15% ranged 20 to 30.

Patient gender: 77.5% of patients were women and 22.5% were men as in Table 2.

Patient BMI: The BMI of patients were (35.0–39.9) 2.5%, (40.0–44.9) 22.5%, (45.0–49.9) 32.5%, (50.0–54.9) 40%, and (55.0–59.9) 2.5% as in Table 3.

Preoperatively, the mean fasting blood glucose (FBG) level was (209.3 ± 36.6) (156–299) mg/dL and postoperatively was (172.5 ± 29) (130–250) mg/dL, (125.6 ± 16.7) (99–169) mg/dL, (111.7 ± 20.9) (77–167) mg/dL, (105 ± 18.3) (73–137) mg/dL, and (102.9 ± 21) (70–145) mg/dL at 1 day and 3, 6, 9, and 12 months respectively as in Table 4.

The mean percentage of FBG changes postoperatively were (-16.8 ± 10.3)%, (-38.1 ± 14.1)%, (-45 ± 14.4)%, (–48.6 ± 12)%, and (-49.4 ± 13.8)% at 1 day and 3, 6, 9, and 12 months respectively, as in Table 5.

Postoperatively, the FBG levels were improved with significant declining at one day ($p < 0.001$), 3 months

Table 1: Age (range and mean) and age groups

	Range	*Mean ± SD*
Age (years)	25–50	38.8 ± 7.0
Males	31–50	42.7 ± 6.3
Females	25–49	37.6 ± 6.9
Age groups	n	%
20–30 years	6	15.0
31–40 years	16	40.0
41–50 years	18	45.0

SD: Standard deviation

Table 2: Sex distribution

	Description	
Sex	n	%
Male	9	22.5
Female	31	77.5

Table 3: The body mass index

BMI pre	*Frequency*	*Percentage*
35.0–39.9	1	2.5
40.0–44.9	9	22.5
45.0–49.9	13	32.5
50.0–54.9	16	40.0
55.0–59.9	1	2.5

Table 4: Pre- and postoperative mean FBG

					Percentile		
	Minimum	*Maximum*	*Mean*	*SD*	*25th*	*Median (50th)*	*75th*
FBG 1 day pre	156	299	209.3	36.6	185.3	200.5	229.3
FBG 1 day post	130	250	172.5	29	150.3	170	190
FBG 3 months	99	169	125.6	16.7	115.0	123.0	139.3
FBG 6 months	77	167	111.7	20.9	99.3	104.5	132.0
FBG 9 months	73	137	105.0	18.3	90.5	103.0	119.8
FBG 12 months	70	145	102.9	21.0	87.5	96.0	122.3

SD: Standard deviation

Table 5: Percentage changes of FBG

					Percentile		
	Minimum	*Maximum*	*Mean*	*SD*	*25th*	*Median (50th)*	*75th*
% FBG change 1	–43.5	–2.2	–16.8	10.3	–20.9	–16.4	–8.4
% FBG change 2	–61.5	7.6	–38.1	14.1	–49.1	–38.6	–31.4
% FBG change 3	–66.6	–0.6	–45.0	14.4	–56.8	–44.3	–39.0
% FBG change 4	–69.8	–12.7	–48.6	12.0	–56.3	–50.0	–42.1
% FBG change 5	–74.7	–8.9	–49.4	13.8	–58.7	–50.3	–42.8

SD: Standard deviation

($p < 0.001$) and 6 months ($p < 0.004$) but nonsignificant declining at 9 months ($p < 0.25$) and 12 months ($p = 1$) as in Table 6.

The mean postprandial blood glucose (PPBG) level was (280.7 ± 45.4) (216–406) mg/dL and postoperative values were (240.3 ± 30.9) (201–301) mg/dL, (172.7 ± 37.4) (106–270) mg/dL, (144.5 ± 30.7) (93–224) mg/dL, (133 ± 32) (92–214) mg/dL, and (128.5 ± 36.4) (91–231) mg/dL at 1 day and 3, 6, 9, and 12 months respectively, as in Table 7.

The postoperative levels of PPBG showed an improvement with a significant declining at 1 day ($p < 0.01$) and 3 ($p < 0.001$), 6 ($p < 0.001$), and 9 ($p = 0.02$) months but nonsignificant at 12 months ($p = 1.0$), as in Table 8.

Table 6: Improvement of FBG by time

FBG	*Mean ± SD*	*Step p-value*	*Global p-value*
1 day pre	209.3 ± 36.6		<0.001
1 day post	172.5 ± 29	<0.001	HS
3 months	125.6 ± 16.7	<0.001	
6 months	111.7 ± 20.9	0.004	
9 months	105.0 ± 18.3	0.25	
12 months	102.9 ± 21.0	1.0	

SD: Standard deviation; HS: Highly significant

Postoperative improvement of glycated hemoglobin levels was observed with a significant declining at 1 day ($p < 0.001$), 3 months ($p < 0.001$), 6 months ($p < 0.001$), 9 months ($p < 0.001$) and nonsignificant at 12 months ($p = 0.16$), as in Table 9.

Table 7: Mean postprandial blood glucose

					Percentile		
	Minimum	*Maximum*	*Mean*	*SD*	*25th*	*Median (50th)*	*75th*
PPBG 1 day pre	216	406	280.7	45.4	241	296.5	307
PPBG 1 day post	201	301	240.3	30.9	217.5	229	260
PPBG 3 months	106	270	172.7	37.4	144.5	170.0	198.3
PPBG 6 months	93	224	144.5	30.7	125.8	138.5	155.0
PPBG 9 months	92	214	133.0	32.0	111.3	128.5	139.3
PPBG 12 months	91	231	128.5	36.4	105.0	116.5	135.8

SD: Standard deviation

Table 8: Improvement of PPBG by time

PPBG	*Mean ± SD*	*Step p-value*	*p-value*
1 day pre	280.7 ± 45.4	–	<0.001
1 day post	240.3 ± 30.9	<0.001	HS
3 months	172.7 ± 37.4	<0.001	
6 months	144.5 ± 30.7	<0.001	
9 months	133.0 ± 32.0	0.02	
12 months	128.5 ± 36.4	1.0	

SD: Standard deviation; HS: Highly significant

Table 9: Improvement of HbA1C “H” by time

HbA1C “H”	*Mean ± SD*	*Step p-value*	*p-value*
1 day pre	10.3 ± 0.9	…	<0.001
1 day post	9.1 ± 0.9	<0.001	HS
3 months	7.0 ± 0.8	<0.001	
6 months	6.3 ± 0.7	<0.001	
9 months	6.0 ± 0.7	0.001	
12 months	5.8 ± 0.6	0.16	

SD: Standard deviation; HS: Highly significant; HbA1C: Glycated hemoglobin

Table 10: The BMI (minimum, maximum, mean ± SD, and percentile)

	Minimum	*Maximum*	*Mean*	*SD*	*Percentile*		
					25th	*Median (50th)*	*75th*
BMI 1 day pre	39.8	56.1	48.4	3.5	45.0	49.4	50.7
BMI 3 months	34	43.5	39.2	2.6	37.0	39.8	41.0
BMI 6 months	30.2	39.1	34.9	2.3	32.6	35.8	36.3
BMI 9 months	27	37.2	32.1	2.3	30.2	32.0	34.0
BMI 12 months	25	35.8	30.2	2.3	29.0	30.0	32.3

SD: Standard deviation

Table 11: Improvement of BMI by time

BMI	*Mean ± SD*	*Step p-value*	*p-value*
1 day pre	48.4 ± 3.5	…	<0.001
3 months	39.2 ± 2.6	<0.001	HS
6 months	34.9 ± 2.3	<0.001	
9 months	32.1 ± 2.3	<0.001	
12 months	30.2 ± 2.3	<0.001	

SD: Standard deviation; HS: Highly significant

Preoperatively, the mean BMI was (48.4 ± 3.5) (39.8–56.1) kg/m^2 and postoperative values were (39.2 ± 2.6) (34–43.5) kg/m^2, (34.9 ± 2.3) (30.2–39.1) kg/m^2, (32.1 ± 2.3) (27–37.2) kg/m^2, and (30.2 ± 2.3) (25–35.8) kg/m^2 at 3, 6, 9, and 12 months respectively, as in Table 10.

Postoperative improvement of BMI occurred with a significant declining (weight loss) at 3, 6, 9, and 12 months (p < 0.001) as in Table 11.

DISCUSSION

The risk of developing DM increases with the severity and duration of obesity and a central distribution of body fat.[8] Currently, bariatric surgery is the only interventional method proved to induce significant long-term weight reduction.[9] Studies have demonstrated that Roux-en-Y gastric bypass,[10] vertical banded gastroplasty,[11] and laparoscopic adjustable gastric banding[12] can result in significant clinical improvement in DM after weight loss. Other studies have compared the different types of bariatric surgery options and their efficiencies in the management of obesity-related T2DM.[13] Limited data are available evaluating the effect of SG on the control of DM. Some studies have even suggested that SG is as effective as gastric bypass in inducing remission of T2DM and the metabolic syndrome (MS).[14]

Recent studies have shown that LSG is associated with a marked reduction of ghrelin secretion, which is produced by the gastric fundus involved in meal time hunger regulation and it is also known to extend several diabetogenic effects (increase in growth hormone, cortisol, and epinephrine); therefore, its suppression could contribute to improved homeostasis.[15] The LSG is a safe procedure in terms of nutritional status at odds with malabsorptive or mixed surgical procedures, which often lead to multiple nutritional consequences due to the bypass of duodenum and Jejunum.[16]

Several studies done on effect of LSG on amelioration of T2DM, in 2011, Nosso et al[17] with 25 obese T2DM patients with a mean age (45 ± 9 years) and in 2010, Rizzello et al[18] with 17 obese T2DM patients with a mean age 51.1 ± 8.6 years (38–64) were submitted to LSG. While in our study the number of subjects was 40, patients with a mean age of 38.8 ± 7 years (25–50) were submitted to LSG.

In 2009, Rosenthal et al[2] had 30 obese patients, 21 (70%) were women and 9 (30%) were men, and in Nosso et al[17] had 25 (obese T2DM) patients, of which 15 (60%) were women and 10 (40%) were men and all were submitted to LSG. While in our study the number of patients were 40, 31 (77.5%) were women and 9 (22.5%) were men and were submitted to LSG. In 2008, Vidal et al[14] had 39 (obese T2DM) patients with a mean BMI (51.9 ± 1.2) submitted to LSG and had 52 (obese T2DM) patients with a mean BMI (47.7 ± 0.7) submitted to GBP. At 12 months after surgery the % estimated weight loss (EWL) was (63 ± 2.89%) (66.06 ± 2.34%); p = 0.413 respectively, and in 2011, Nosso et al[17] had 25 (obese T2DM) subjects with a mean BMI was (48.8 kg/m^2) and were submitted to LSG. The mean BMI decreased to (39 ± 8 kg/m^2) (p < 0.001) and (34 ± 6 kg/m^2) (p < 0.001) at 3 months and (9–15) months after surgery respectively. While in a comparison with our study, the mean of the BMI was (48.4 ± 3.5 kg/m^2) at the baseline and decreased to (39.2 ± 2.6 kg/m^2) at 3 months and (30.2 ± 2.3 kg/m^2) at 12 months postoperatively (p < 0.001), and the % EWL was (36.5 + 3.1%) and (65.6 ± 3.1%) respectively. Serum insulin levels showed a sharp and significant reduction at postoperative 1 day (13.5 ± 2.2 uU/mL) (p < 0.001) and at 3 months (4.4 ± 1.8 uU/mL) (p < 0.001), but a nonsignificant changes occurred at 6 months (5.3 ± 1.5 uU/mL) (p = 0.51), 9 months (5.2 ± 1.3 uU/mL) (p = 1), and 12 months (4.8 ± 1 uU/mL) (p = 0.85). The improvement in insulin sensitivity is primarily due to weight loss, reduction in inflammatory mediators, and decreased calorie intake, although the contribution of weight independent mechanisms seems very likely, rapid improvement of glucose hemostasis before substantial weight loss has occurred.[19] Our study showed that the PPBG levels had a significant declining at 1 day postoperative (240.3 ± 30.9) mg/dL ($p < 0.001$) compared with the baseline (280.7 ± 45.4) mg/dL independent from the weight loss. At 3, 6, 9 months after surgery, a significant declining in PPBG, $p < 0.001$, occurred but it was associated with significant reduction of BMI. After 12 months, a significant reduction of BMI occurred ($p < 0.001$) with nonsignificant decline in the PPBG level. (By researching we did not find a published data about PPBG levels after SG for comparing with our results.)

CONCLUSION

Surgical procedure of LSG resulted in marked weight loss, BMI, improved glucose homeostasis, and remission of T2DM. Our study has found that LSG is an effective surgical treatment for most severely or morbidly obese patients with DM. Weight loss is an effective treatment for patients with these medical problems. Our results open the gate for MS in patients with normal BMI to control MS different components, such as cardiac events, polycystic ovary syndrome. The SG is associated with a high rate of resolution of T2DM at 12 months after surgery in severely obese patients with T2DM. The rate of T2DM resolution in patients undergoing SG in our study is similar to that reported in previous case series following this surgical technique.

SUMMARY

Bariatric surgery is known to be a highly effective and long-lasting treatment for morbid obesity and many related conditions, including T2DM and MS.

Laparoscopic sleeve gastrectomy is emerging as a new promising therapy for the treatment of morbid obesity. This procedure, originally conceived as a first stage for achieving weight loss in superobese patients before performing GBP or BPD, has revealed to be effective on its own and a potential competitor with these operations. Laparoscopic sleeve gastrectomy is a feasible and safe bariatric surgery procedure for morbid obesity, although evaluation of long-term outcome will be necessary to determine whether it yields durable results. Few studies have examined the effects of LSG on glucose control and comorbidities in obese T2DM patients, and limited information is available on the long-term efficacy of this procedure. Our study showed that the LSG is effective to achieve weight loss and resolve T2DM, and the resolution T2DM in this study was better in comparison with the results of other studies, so this study evaluated the short and long-term effects (1 day, 3, 6, 9, and 12 months) of LSG on body weight and glucose homeostasis in morbid obese T2DM subjects not adequately controlled with medical therapy.

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