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ORIGINAL CONTRIBUTIONS

Analysis of Medium-Term Weight Regain 5 Years After Laparoscopic Sleeve Gastrectomy

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Abstract

Objective Some patients fail to maintain weight loss after bariatric surgery. Weight regain (WR) disturbs the patients due to possible reappearance of obesity-related comorbidities. This study aimed to assess WR 5 years after laparoscopic sleeve gastrectomy (LSG).

Patients and Methods This retrospective study included 100 adults who underwent LGS. The percentage of excess weight loss (%EWL) was recorded. WR was defined as an increase of at least 10% of the lowest postoperative weight. Patients with WR were subjected to CT gastric volumety. Eating behavior was assessed by the Three-Factor Eating Questionnaire-Revised 18-Items (TFEQ-R18).

Results Preoperative comorbidities improved in 89.5% of the patients. Twenty-five females (32.5%) got pregnant within 3 years after surgery. Age, maximum weight loss, and uncontrolled and emotional eating scales of the TFEQ-R18 were independently affecting %EWL. Also, pregnancy negatively affected %EWL. Fourteen patients regain weight: 11 females and three males. CT volumetry of the 14 patients showed a median stomach volume of 515 mL (range 172–1066 mL). CT estimated gastric volume was negatively correlated with % EWL ($r = -0.674$, $p = 0.008$). Patients who developed WR were significantly older ($p = 0.006$), with lower maximum weight loss, and having higher scores of uncontrolled and emotional eating scales of TFEQ-R18.

Conclusion Medium-term postsurgical weight regain and unsuccessful weight loss in patients who had undergone LSG is associated with older age, maladaptive eating behavior, larger residual stomach, and pregnancy.

Keywords Sleeve gastrectomy · Weight regain · CT volumetry

Introduction

Obesity is a complex, chronic disease that is associated with many comorbidities [1]. Bariatric surgery is currently the most efficient and long-lasting weight loss treatment modality available to patients [2]. Nevertheless, not all patients can maintain weight loss after bariatric surgery. Weight regain can be disturbing to the patient owing to the possible reappearance of obesity-related comorbidities that already resolved with weight loss [3]. Moreover, weight regain may have a significant psychological effect because patients feel they failed their last chance which may lead to frustration, annoyance, and even depression [2].

Laparoscopic sleeve gastrectomy (LSG) was introduced as a new approach to bariatric surgery which gained increasing in popularity to be one of the most commonly performed bariatric procedures [4]. However, nearly 30% of patients require revision surgery after LSG due to many reasons including

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inadequate weight loss or weight regain [5]. A recent systematic review revealed that weight-regain after LSG ranges from 5.7% at 2 years to 75.6% at 6 years [6].

This study aimed to assess weight regain (WR) after 5 years of follow-up after laparoscopic sleeve gastrectomy and the possible factors that may contribute to this problem.

Patients and Methods

This retrospective study included 100 patients who underwent laparoscopic sleeve gastrostomy (LGS) for the treatment of morbid obesity in Cairo University Hospital, KasrAlAiny, between 2011 and 2013. Adult patients 22–60 years of age of both genders were included in the study. Patients who performed other bariatric procedures or redo bariatric surgeries for weight regain were excluded from the study.

The long-term outcomes were analyzed in terms of percentage of excess weight loss (%EWL) which is considered successful if the patient achieved 50% after 5 years. %EWL = weight loss/excess weight × 100, where excess weight = total weight pre-bariatric surgery − ideal weight.

Weight regain (WR) was defined as an increase of at least 10% of the lowest postoperative weight [7]. Weight loss failure (WLF) was defined as the inability to achieve 50% (%EWL) after five postoperative years. Patients with WR or WLF were subjected to multi-detector computed tomographic (CT) scan and CT volumetric study to measure the remaining gastric volume.

Other analyzed outcomes included changes in comorbidities, eating behavior, and occurrence of pregnancy. These factors were tested for correlation with weight regain.

Eating behavior was described using the Three-Factor Eating Questionnaire-Revised 18-Items (TFEQ-R18) [8] which is a shortened and revised version of the original 51-item TFEQ. It refers to current dietary practice and measures three different aspects of eating behavior: restrained eating, uncontrolled eating, and emotional eating (increase in food intake in response to negative emotion). Higher scores are indicative of greater cognitive restraint, uncontrolled, or emotional eating [9]. Preoperative comorbidities were followed up postoperatively and assessed if it is a motivation factor for weight loss. CT volumetry was scheduled for patients who regain weight and weight loss failure.

Table 1 Age and clinical characteristics of the whole studied group ($n = 100$)

	Mean ± SD	Median (range)
Age (years)	38.2 ± 9.9	36.5 (22.0–60.0)
Preoperative BMI (kg/m^2)	51.8 ± 8.1	50.0 (38.0–74.0)
Maximum WL (kg)	61.7 ± 23.5	55.0 (26.0–167.0)
Current BMI (kg/m^2)	35.3 ± 8.3	34.0 (23.0–64.0)
%EWL after 5 years	63.2 ± 25.2	66.0 (0.0–100.0)

Table 2 Effect of comorbidity and pregnancy on %EWL

		n	%EWL after 5 years mean ± SD	p value
Comorbidity	Yes	38	66.5 ± 26.1	0.314
	No	62	61.2 ± 25.0	
Pregnancy	Yes	25	54.2 ± 24.7	0.028
	No	52	64.1 ± 24.1	

CT Volumetric Assessment of the Stomach

Plain abdominal CT was performed on a Multislice CT 64-section detector scanner after 4-h fasting. Before the CT examination, two packs of effervescent granules were added to 10 mL of water and administered orally to each patient. Patients were placed on the scanning in the supine position. A scout projection was then obtained showing the stomach fully distended by gas. If the stomach was inadequately distended, one more pack was administered orally to ensure adequate distension. A delay of 10–15 s was needed to ensure complete distention of the stomach.

Images were obtained during a single breath hold from a level 1–2 cm below the dome of the diaphragm to the lower pole of the right kidney. The helical CT data acquisition parameters were 120 kVp, 600–700 mA, 1.25-mm collimation, 5-mm reconstruction interval, and rotation time of 0.7 s. To complete imaging within the breath-hold period, all image acquisition was completed within 30 to 40 s. The 1.25-mm, transverse CT, sections were reconstructed at 0.5-mm intervals, performed at a commercially available workstation.

The contours of all stomach sections were traced using a built-in cursor. During 3D reconstruction for volumetry, the first section started from the most proximal radiodense staple until the pyloric ring. The manufacturer's workstation with a specific software automatically calculated the number of pixels included within the traced contours on each section and provided the cross-sectional area of the

Table 3 Results of Three-Factor Eating Questionnaire-Revised 18-Items for assessment of the three different aspects of eating behavior

	Mean ± SD	Median (range)
Cognitive restraint (%)	52.6 ± 14.1	58.0 (10.0–72.0)
Uncontrolled eating (%)	37.8 ± 13.3	35.5 (13.0–64.0)
Emotional eating (%)	42.1 ± 13.7	39.0 (19.0–80.0)

Table 4 Factors affecting %EWL after 5 years in the whole studied group

	r	*p*
Age	− 0.236	0.018
Maximum WL	0.391	> 0.001
Cognitive restraint (%)	0.627	> 0.001
Uncontrolled eating (%)	− 0.633	> 0.001
Emotional eating (%)	− 0.640	> 0.001

stomach on a section-by-section basis. The circumscribed areas were then automatically multiplied by the CT section thickness, yielding an approximate volume for each stomach section, and the volumes of all sections were summed to give the selected stomach volume.

The Statistical Methods

All data were described in terms of mean± standard deviation (± SD), and range, or frequencies and percentages as appropriate. Comparison of numerical variables between the two groups was made using Student's *t* test for independent samples of the Mann-Whitney test. Correlation between various variables was done using Pearson product moment correlation equation for normally distributed variables and Spearman rank correlation for non-normal variables. Multivariate linear regression analysis was used to define the significant effectors of %EWL. A p value < 0.05 was considered statistically significant. Statistical analyses were done using the computer program IBM SPSS (IBM Corp, Armonk, NY, USA) release 22 for Microsoft Windows.

Results

The patients' ages ranged from 22 to 60 years with a mean of 38.2 ± 9.9 years. Out of 100 patients, 77 were females and 23 were males. Preoperative BMI ranged from 38 to 74 kg/m^2 with a mean of 51.8 ± 8.1 kg/m^2. Table 1 shows the age and clinical characteristics of the studied group (n = 100). Preoperative comorbidities were recorded in 38 patients, namely diabetes mellitus (n = 23), hypertension (n = 18), osteoarthritis (n = 4), cardiovascular (n = 2), and depression (n = 1). Improvement of these comorbidities was achieved in 34 patients (89.5%). Among the studied females, 25 (32.5%) got pregnant within a median period of 1.5 years after surgery (range 0.5–3.0 years).

%EWL after 5 years was negatively correlated with age (r = − 0.236, p = 0.018). It was positively correlated with maximum weight loss (r = 0.391, p < 0.001). There was no significant impact of the presence of preoperative comorbidity on %EWL after 5 years (p = 0.314). But, pregnancy negatively affected %EWL (Table 2). Among the 25 females who got pregnant, there is a strong positive correlation between time of pregnancy relative to surgery and %EWL (r = 0.419, p = 0.037).

Table 3 shows the results of the TFEQ-R18 questionnaire. There is a strong positive correlation between cognitive restraint scale of the TFEQ-R18 questionnaire and %EWL, while uncontrolled eating and emotional eating scales were negatively correlated with %EWL (Table 4, Fig. 1).

Multivariate linear regression analysis showed that age, maximum weight loss, and uncontrolled and emotional eating scales were independently affecting %EWL (Table 5).

After 5 years, 14 patients regain weight, 11 females and three males. CT volumetry of the 14 patients showed a median stomach volume of 515 mL (range 172–1066 mL). In this small group of patients with WR, CT-estimated gastric

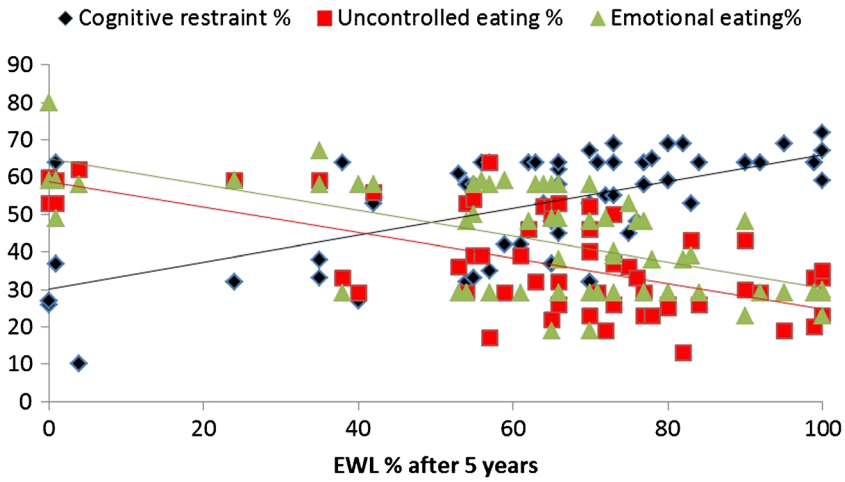

Fig. 1 Correlation between %EWL at 5 years and cognitive restraint, uncontrolled eating, and emotional eating scales of the TFEQ-R18 questionnaire

Table 5 Regression model for independent factors affecting %EWL after 5 years in the whole studied group ($n = 100$)

Model	Regression coefficient (B)	p value	95.0% CI for B	
			Lower bound	Upper bound
Age	− 0.574	0.003	− 0.942	− 0.206
Maximum WL	0.279	0.001	0.124	0.434
Cognitive restraint %	0.180	0.320	− 0.177	0.537
Uncontrolled eating %	− 0.564	0.004	− 0.943	− 0.184
Emotional eating%	− 0.443	0.015	− 0.800	− 0.087

CI confidence interval

volume was negatively correlated with %EWL ($r = -0.674$, $p = 0.008$). Patients who developed WR were significantly older ($p = 0.006$), with lower maximum weight loss, and having higher scores of uncontrolled and emotional eating scales of TFEQ-R18 (Table 6).

Discussion

This study demonstrated that after 5 years of LSG, the frequency of weight regain was 14%. Weight regain was significantly associated with older age ($p = 0.006$), and lower maximum weight loss ($p = 0.010$). The patients with WR had significantly higher scores of uncontrolled and emotional eating scales of TFEQ-R18. Weight regain was not affected by the patient's sex or preoperative BMI. CT gastric volumetry showed a negative correlation between residual gastric volume and %EWL ($r = -0.674$, $p = 0.008$). The %EWL was independently affected by age, maximum weight loss, and negative eating behavior.

Therefore, the factors that were associated with inadequate weight loss or weight regain in this study were older age and limited postoperative weight loss in addition to inferior eating behavior. The etiology of WR is complex and multifactorial. A combination of technical (sleeve dilation), physiological (regulation of gut hormones), and psychological factors (nutritional behavior) may interact to produce weight regain or inadequate degrees of weight loss following LSG [10].

In a prospective study, CT gastric volumetry was used to measure residual gastric volume (RGV) in 76 patients with more than 2 years of follow-up after LSG. It was found that large RGV was a significant risk factor for failure of weight loss defined as %EWL < 50% [10]. Also, Vidal et al. reported a negative correlation between the increase in RGV and a weight loss after LSG [11]. In the current study, the median stomach volume of patients with WR was 515 mL (range 172–1066 mL). However, Baumann et al. [12] found gastric dilatation as a normal finding after LSG which was not correlated with inadequate weight loss or WR. More recently, it was shown that RGV did not affect weight loss at 1 year after LSG [13].

Many studies previously confirmed a positive effect of younger age on weight loss after bariatric surgery. Contreras et al. reported higher %EBMIL in patients < 45 years of age compared with those ≥ 45 years of age 1 year after surgery. The older age group had a significantly higher frequency of

Table 6 Factors associated with weight regain

	Weight regain ($n = 14$)	Stable weight ($n = 86$)	p value
Age (years)	44.8 ± 9.2	37.2 ± 9.5	0.006
Sex			
Female	11 (14.3%)	66 (85.7%)	0.880
Male	3 (13.0%)	20 (87.0%)	
Preoperative BMI (kg/m^2)	49.4 ± 6.4	52.1 ± 8.3	0.249
Maximum WL (kg)	46.9 ± 12.0	64.2 ± 24.0	0.010
Presence of comorbidity			
Yes	7 (18.4%)	31 (81.6%)	0.319
No	7 (11.3%)	55 (88.7%)	
TFEQ-R18			
Cognitive restraint (%)	45.4 ± 15.8	53.7 ± 13.5	0.094
Uncontrolled eating (%)	53.4 ± 9.1	35.2 ± 12.1	< 0.001
Emotional eating (%)	55.9 ± 15.0	39.8 ± 12.1	< 0.001

EBMIL < 50% [14]. Another study reported similar findings after 2 years of surgery [15]. Binda et al. confirmed the beneficial effect of younger age in terms of weight loss 12 months after surgery [16]. Other reports did not confirm this finding [17].

There is a growing literature suggesting that postoperative loss-of-control (LOC) eating is associated with less weight loss after bariatric surgery [18]. In a prospective follow-up study over 24 months, postoperative LOC significantly predicted poor weight loss after bariatric surgery [18]. A more recent study of 234 adolescents undergoing bariatric surgery confirmed these findings. The authors reported that rates of LOC eating decreased from before surgery to 6 months after, but increased after that [19]. Postoperative loss-of-control eating was shown to be associated with poorer weight loss after sleeve gastrectomy [20]. It is emphasized in the literature that careful assessment of loss-of-control eating following bariatric surgery is an essential part of the follow-up of these patients. This may minimize the rate of weight regain with its adverse psychosocial consequences.

However, the diagnosis of eating disorders following bariatric surgery is not an easy task and, therefore, is not common [19]. Limited attention of practitioners to the problem leads to limited diagnosis as they are unlikely to assess the diagnostic criteria of eating disorders [21–23].

A diagnosis of binge-eating disorder episodes requires detection of eating an unusually large quantity of food in a distinct period while feeling a sense of loss-of-control [24]. Eating large amounts following surgery is quite difficult owing to surgery-induced physical restriction. Thus, there is no recognized definition of objectively large amounts of food after bariatric surgery [25]. In the current study, we used the TFEQ-R18 for assessment of eating behavior of the studied group. It is one of the most widely used measures of eating behavior research. It was based on psychometric analyses to test the three factors: cognitive restraint, uncontrolled eating, and emotional eating. Uncontrolled eating denotes a tendency to binge eating with the sense of being out of control. Emotional eating refers to eating in response to negative emotions [26]. In the current study, weight regain and diminished loss of weight 5 years after surgery showed a definite correlation with high scores of these two factors.

Different groups studied the effect of pregnancy on weight loss following bariatric surgery with conflicting results. Froylich et al. studied the effect of pregnancy on weight loss 43 months following three different bariatric procedures (Roux-en-Y bypass—LSG—adjustable gastric band) and reached a conclusion that pregnancy before bariatric surgery had a more negative effect on weight loss compared with patients who had never been pregnant [27]. On the contrary, Rottenstreich et al. stated that pregnancy after LSG does not affect long-term weight results [28]. Similarly, Quyen Pham et al. reported that pregnancy after bariatric surgery slows down postoperative weight loss but does not affect weight results at 5-year follow-up [29]. In our study, 5 years after LSG, pregnancy had a forthright negative effect on %EWL ($p = 0.028$); we also found a strong positive correlation between time of pregnancy relative to surgery and %EWL ($r = 0.419$, $p = 0.037$).

We agree with Nedelcu and colleagues that using an increase of a fixed number of kilograms is not appropriate. They found that an increase of at least 10 kg from nadir weight does not add much to define a significant weight regain. In the current study, we preferred a relative measure which is a 10% increase from nadir. In conclusion, these authors found it unacceptable to have a large number of definitions, and therefore, we need standardization of the definition [30].

Therefore, we can conclude that medium-term postsurgical weight regain and unsuccessful weight loss in patients who had undergone LSG is correlated to older age and maladaptive eating behavior after surgery. The enlarged residual stomach may contribute to the development of weight regain as it was correlated to limited weight loss after surgery. The occurrence of pregnancy has a negative impact on weight loss; the earlier the pregnancy, the worse its effect of weight loss. Assessment of eating behavior after bariatric surgery is justified to be included as an integral part of long-term postoperative follow-up. The Three-Factor Eating Questionnaire -R18 appears to be an efficient method to be used for this purpose.

Compliance with Ethical Standards

The study protocol was approved by the local ethical committee.

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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