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ORIGINAL ARTICLE

Evaluating Postoperative Weight Loss Patterns and Nutritional Deficiencies in Bariatric Surgery Patients: A 12-Month Follow-Up

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ABSTRACT

Background: Bariatric surgeries and most commonly sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) are an effective treatment for obesity and its associated comorbidities. Despite the significant weight loss achieved, due to their alteration in different physiological processes, the surgeries also tend to impact the absorption and concentration of different minerals, necessitating long-term monitoring.

Objectives: To evaluate the postoperative weight loss patterns, chnages in body mass index and the occurrence of mineral deficiencies among patients who underwent bariatric surgery.

Method: This was retrospective observational cohort study examined the postoperative weight and BMI changes over a 12-month period in 192 patients who underwent bariatric surgery. The patients underwent surgery at Nawa Hospital, Sulaymaniyah, Iraq, between 2023 and 2024. Data were extracted on variables such as age, sex, type of surgery, Body mass index (BMI) and postoperative mineral levels.

Results: The mean weight loss at 12 months was significant, with a decrease in BMI from 44.1 ± 5.3 to 33.0 ± 4.7 ($p < 0.05$). A significant weight and BMI differences across the first 12 postoperative months ($p < 0.05$). Nutritional deficiencies were reported, among the available investigated parameters, deficiency of vitamin D, magnesium, zinc and ferritin was found in 18.6% , 42.1%, 35.7% and 16% , respectively.

Conclusion: Bariatric surgery results in significant weight loss and improvements in BMI over 12 months. However, these surgeries also increase the risk of nutritional deficiencies, particularly in minerals such as magnesium and vitamin D, making postoperative follow-ups and monitoring necessary.

Keywords: *Bariatric Surgery, Sleeve Gastrectomy, Roux-en-Y Gastric Bypass, Weight loss, Nutritional Deficiencies, Postoperative Monitoring*

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1. INTRODUCTION

Obesity is accumulation of excessive fat in a way that negatively impacts health [1]. Although fundamentally, a long-term imbalance between energy intake and expenditure is what leads to obesity, the actual etiology of obesity is known to be complex and multifactorial [2]. Clinically, a patient with a BMI of over 30 is considered obese [1]. The consequences of the disease are multiorgan, ranging from mild limitations to catastrophic outcomes and mortality [3]. The condition is associated with more than 50 different medical conditions, including cardiovascular diseases, musculoskeletal disorders, cancers and mental disorders [4]. The disease has a prevalence of 890 million worldwide, implicating a disease rate of 1 out of each 8 individuals globally [1]. Due to the vast majority of its negative health impacts and growing incidence of the disease, many studies assess the different management modalities of obesity [5]. With regards to treatment, the major categories include behavioral interventions, nutrition, physical activity, pharmacotherapy and finally, bariatric surgeries [6]. These can be more broadly classified into conservative and surgical interventions. With all the different management options, it is very essential to keep the approach patient centered and tailored to the individual needs of the patient [6]. Although Roux-en-Y gastric bypass (RYGB), Sleeve gastrectomy, bilio-pancreatic diversion and adjustable gastric banding are all types of bariatric surgeries, sleeve gastrectomy and RYGB are the most commonlyperformed surgeries [7]. They are reserved for patients with either a BMI of over 35, a BMI of over 30 but with an obesity associated comorbidity or when there is inadequate response to other less invasive treatment approaches [6]. This is because despite their more superior weight loss compared to non-surgical approaches, they are associated with a greater remission rate of type 2 diabetes and metabolic syndrome [8]. Moreover, patients tend to return to their maladaptive behaviors following surgery and regain a clinically significant percentage of weight [9]. Furthermore, apart from the risks associated with surgery and weight regain, patients who underwent bariatric operations were found to have long-term nutritional deficiencies and bone health, making long term monitoring and close follow ups necessary [6]. For these reasons, we conducted this study to investigate the long-term weight loss patterns of patients across the months and investigate the possible nutritional deficiencies that may develop.

2. METHODOLOGY

Study Design

The study is an observational cohort study aimed at assessing the outcomes of bariatric surgery over a period of one year. It focuses on postoperative weight loss patterns, BMI changes, and mineral deficiencies in bariatric surgery patients, all to determine the need for frequent postoperative follow-ups.

Study Settings

The study was conducted at Nawa Hospital, Sulaymaniyah, Kurdistan, Iraq. The hospital's database was used for data collection. Variables extracted from the database included the likes of patient demographics, types of surgery, and postoperative follow-up information. The study duration spans from 2023 to 2024, and only patients who provided full consent and had complete follow-up data were included.

Study Participants

The study included 192 patients who underwent bariatric surgery during the study period. Their mean age was 38.3 ± 10.8 years. All participants had a BMI of over 30 and the majority of patients (79.7%) were female. Patients were enrolled based on availability of both preoperative and postoperative follow-up data. At one-year after surgery, only 64 patients had avaialble data on their BMI, and 116 patients did not, these 116 patients were excluded from the pairwise comparison at one-year after surgery.

Inclusion Criteria:

1. Patients who underwent sleeve gastrectomy or Roux-en-Y gastric bypass (RYGB)
2. Complete preoperative and postoperative data on weight and BMI to be tracked

Exclusion Criteria:

1. Patients who refused to participate
2. Patients with either missing postoperative data or incomplete follow-up (≤1 follow-up visit)
3. Patients with pre-existing hematological disorders (e.g., anemia, thalassemia)

Data collection

Data were collected from Nawa Hospital's database. Extracted variables included demographic and clinical data (Age, sex, BMI before and after surgery, type of bariatric surgery, preoperative weight, and postoperative weight and BMI across 12 months), postoperative mineral data (Levels of Vitamin D, Magnesium, Ferritin, and Zinc were measured post-surgery to assess for nutritional deficiencies).

Data management and analysis

Normality test for scale variables was performed using Shapiro-Wilk test for weight, BMI, and mineral levels. After confirmation of normality, the parametric tests were used in comparison of different scale variables; paired t-test used to evaluate the statistical significance of the difference in weight and BMI before and 12 months after surgery. One-Way ANOVA used to assess the significance of difference in weight and BMI across the months. Moreover, post hoc Tukey's HSD test was performed for pairwise multiple comparisons to determine the specific months that had the most significant change. The descriptive statistics were used to classify postoperative vitamin and mineral levels into categories (normal, insufficient, deficient, and severe deficiency) based on reference intervals [10-12]. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS)Version 26.0. The significance level was set at a p-value of < 0.05 for all tests.

Limitation

Since the study had a retrospective design, this introduced potential biases, such as missing data and incomplete follow-up. Furthermore, since the data were extracted from a single-center hospital database, the results may not be generalizable to other populations or healthcare settings. For these reasons, we advocate for prospective multicenter studies with larger sample sizes to further confirm these findings.

3. RESULTS

A total of 192 patients who underwent bariatric surgery were included in the study. A clear female predominance, accounting for 79.7% of the patients was observed. The average age of the participants was 38.3 ± 10.8, however, patients aged 31-40 where the most common age group, accounting for 30.7% of the patients population whereas patients aged above 60 years

and below 20 years were equally the least common age groups, each accounting for only 4 (2.1%) patients. Females were dominant, making up 79.7% of the patient population. Sleeve gastrectomy, was the most common performed surgical procedure, accounted for 89.1% of operations, (**Table 1**)

Preoperatively, the mean weight was 116.5 kg, and 172 out of the 180 patients (95.6%), had a BMI within the morbidly obese category. At one months, postoperatively, 6 patients with morbid obesity loss weight and reclassified as severly obese, therefore, at one month the total number of severely obese patients increased to 14. However, one year after the surgery, BMI was available in only 64 patients, of them 14 (21.9%) still morbidely obese, (**Table** 2).

Investigations for vitamins and minerals were not available for all patients; amongst the 97 patients who had their vitamin D analyzed postoperatively, 44 (45.4%) had a less than normal vitamin D levels with 18 (18.6%) patients having deficiency. This is despite patients receiving vitamin D supplementation. Furthemore, 42.1% of 19 patients who had their magnesium analyzed, 35.7% of (112) patients who had their zinc analyzed and 16% of 125 patients who had their ferritin analyzed, had deficient post-operative levels, indicating the need for careful biochemical analysis in postoperative follow ups to prevent long term complication and deficiencies, (**Table 3**).

A statistically significant decrease was observed in both mean pre-operative weight and mean pre-operative BMI where they reduced from 116.6 kg and 44.1 kg/m² respectively, to 87.1 kg and 33.0 kg/m² respectively, 6 months post-operatively (**Table 4**).

The results of one-way ANOVA tests comparing postoperative weight and BMI changes across time are demonstrated in (**Table 5**). Both differences between and within groups were significant, ($P<0.05$). A statistically significant decrease in weight and BMI was observed across time. Furthermore, posthoc analysis indicated that the greatest difference was seen for weight between the second and tenth month with a mean difference of 22.6 kg and the first and 11th month for BMI with a mean difference of 8.3, both emphasizing the importance of monthly follow ups.

Table 1. Distribution of Age, gender and type of surgery among the studied group

Variables	No.	%
Age (year)		
<20	4	2.1
21-30	41	21.4
31-40	59	30.7
41-50	54	28.1
51-60	18	9.4
> 60	4	2.1
N/A	12	6.3
Mean (SD): 38.3 (10.8)		
Total	**192**	**100.0**
Gender		
Male	39	20.3
Female	153	79.7
Total	**192**	**100.0**
Type of surgery		
Sleeve gastrectomy	171	89.1
Roux-en-Y-Gastric-Bypass	8	4.1
N/A	13	6.8
Total	**192**	**100.0**
SD: standard deviation		

Table 2. Distribution of Pre and postoperative BMI of the patients

Variables	No.	%
Pre-Operative BMI*		
Normal	0	0.0
Overweight	0	0.0
Moderately Obese	0	0.0
Severely Obese	8	4.2
Morbid Obese	172	89.6
N/A	12	6.2
Total	**192**	**100.0**
Post-Operative BMI within 1 month		
Normal	0	0.0
Overweight	0	0.0
Moderately Obese	0	0.0
Severely Obese	14	7.3
Morbid Obese	35	18.2
N/A	143	74.5
Total	**192**	**100.0**
Post-Operative BMI within 6 months		
Normal	2	1
Overweight	0	0.0
Moderately Obese	23	12
Severely Obese	29	15.1
Morbid Obese	28	14.6
N/A	110	57.3
Total	**192**	**100.0**
Post-Operative BMI within 12 months		
Normal	5	2.6
Overweight	0	0.0
Moderately Obese	26	13.5
Severely Obese	19	9.9
Morbid Obese	14	7.3
N/A	128	66.7
Total	**192**	**100.0**
* Mean Pre-Operative Weight (SD): 116.5 (18.5); N/A: not available		

Table 3. Postoperative levels of vitamins and minerals of the patients

Variables	No.	%
Vitamin D		
Normal	53	54.6
Insufficient suboptimal	26	26.8
Deficiency	15	15.5
Severe deficiency	3	3.1
Total	**97**	**50.5**
N/A	**95**	**49.5**
Magnesium		
Low	8	42.1
Normal	11	57.9
High	0	0.0
Total	**19**	**9.9**
N/A	**173**	**90.1**
Ferritin		
Low	20	10.4
Normal	85	**68.0**
High	20	**16.0**
Total	**125**	**65.1**
N/A	**67**	**34.9**
Zinc		
Low	40	35.7
Normal	68	60.7
High	4	3.6
Total	**112**	**58.3**
N/A	**80**	**41.7**
N/A; not available		

Table 4. Comparison pre-operative and 6 months post-operative changes in weight and BMI of the studied group

Variables	Pre-Operative	Post-Operative 6 months	P. value
Weight, (Kg), mean ± SD	116.6 ± 18.5	87.1 ± 15.8	< 0.01
BMI (kg/m^2), mean ± SD	44.1 ± 5.3	33.0 ± 4.7	< 0.01
Paired t-test used in both comparisons			

Table 5. Analysis of Variance (ANOVA) Results for Postoperative Weight and BMI Changes Across Time.

Sources of Variation		Sum of Squares	df	MS	F	p. value
Weight	Between Groups	52496.15	11	4772.4	22.9	<0.001
	Within Groups	178046.9	850	209.5		
	Total	230543	861			
BMI	Between Groups	6703.1	11	609.4	29.4	<0.001
	Within Groups	17589.3	850	20.7		
	Total	24292.4	861			
df: Degrees of Freedom; MS: Mean Square (MS), F: F. statistic						

4. DISCUSSION

Any patient with a BMI of over 35 or over 30 but with obesity related comorbidities can be considered for bariatric surgery; however, majority of the patients undergoing bariatric surgeries are those who either do not respond or have inadequate responses to conservative management. Welbourn et al. conducted a study analyzing the results of over a 150 thousand bariatric surgeries where they revealed that the median pre-operative BMI was 41.7 kg/m2. Similarly, the patients included in this study had an average pre-operative BMI of 44.1 kg/m2 ± 5.3. Following the patterns observed in many countries worldwide, females also predominated the population in this study, accounting for 79.3% of the patients; however, worldwide, this female predominance tends to vary from 57.7% in India to 79.4% in netherlands [13]. Although bariatric surgery typically has a median age of 41.7 years, other studies have found the indication and benefit of bariatric surgery in relatively younger individuals, perhaps even patients under 20 [14]. The average age of patients undergoing surgery in this study was 38.3 ± 10.8 years. As previously aforementioned, sleeve gastrectomy and RYGB are the commonly performed bariatric surgeries; however, amongst the two, sleeve gastrectomy, although associated with a smaller decrease in weight, is the most common subtype [7,15]. This could perhaps be due to the smaller risk of complications associated with

sleeve gastrectomy when compared to RYGB [16]. Sleeve gastrectomy, performed for 89% of the patients in the study, was also the most common type of bariatric surgery in this study.

Despite the more invasive nature of the management, bariatric surgeries are still the best for weight loss. Both RYGB and sleeve gastrectomy yield statistically significant weight loss following surgery with sleeve gastrectomy resulting in an excess BMI loss of 58.8% and RYGB resulting in an excess BMI loss of 67.1% [17]. A statistically significant reduction in both average weight and BMI was observed in this study, with average weight falling from 116.6 ± 18.5 kg to 87.1 kg ± 15.8 and BMI falling from 44.1 kg/m2 ± 5.3 to 33.0 kg/m2 ± 4.7. According to Boustani et al., patients undergoing bariatric surgery tend to reach a plateau in weight loss, with each type of bariatric surgery having a different weight loss pattern [18]. The one-way ANOVA test conducted in this patient population for both BMI and weight loss showed a statistically sigificant decrease in both parameters across time. Furthermoe, the post hoc analysis revealed that with a mean difference of 22.6 kg, the greatest difference in weight loss was seen between the second and tenth month postoperatively. With this being said, although the surgeries can result in significant weight loss and a decrease in the rates of diseases and complications associated with obesity, due to the alteration of the anatomy and physiology of the gastrointestinal tract, they have also been demonstrated to impair mineral absorbtion and subsequently result in postoperative nutritional deficiences [19]. Of note, both microcytic anemia due to decreased iron absorbton and impairment of bone health due to decreased vitamin D absorbtion have been established [19]. In this study, 16% of those who had their ferritin analyzed and 18.6% of those who had their vitamin D analyzed were found to have a deficiency. This raised alarms since patients were deficient despite being on vitamin D supplementation. Moreover, 42.1% of the patients who had their magnesium analyzed and 35.7% of the patients who had their zinc analyzed similarly showed deficiency, rasing concern for long-term nutritional deficiecnies and emphasizing on the importance of nutrional analysis with the weight loss and BMI tracking following surgery.

Although the study revealed statistically significant weight loss across time and shed light on certain possible postoperative nutritional deficiencies, it is not free from limitations. Most stem from its retrospective characteristic which can include bias in terms of missing data and

incomplete follow-up and its single-center nature which limits generalizability of the results. However, due to the increasing incidence of obesity and the lack of another line of management with similar weight loss patterns, we recommend fellow colleagues to conduct multicenter, perhaps prospective studies to further validate the results

5. CONCLUSIONS

Bariatric surgery significantly reduces weight and BMI over a 12-month period, showing its effectiveness as a long-term treatment for obesity. However, this study also highlights the risk of nutritional deficiencies, particularly in vitamin D and magnesium, among postoperative patients. Therefore, these deficiencies demonstrate the importance of regular monitoring and supplementation to prevent long-term health complications.

Ethical Approval:

All ethical issues were approved by the author. Data collection and patient's enrollment were in accordance with Declaration of Helsinki of World Medical Association, 2013 for the ethical principles of researches involving human. Data were kept confidentially.

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