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Effect of Laparoscopic Sleeve Gastrectomy on Calcium Homeostasis: A Single-Center Study

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ABSTRACT

Background: Treatment of obesity includes medical and surgical options. Bariatric surgery is a relatively new and successful therapy for obesity. The laparoscopic sleeve gastrectomy (LSG) is one of the most common operations done to manage obesity.

Objective: This study aimed to assess calcium, phosphorus, and vitamin D levels in patients who performed LSG.

Subjects and method: This retrospective study included 64 cases. The cases were divided into two major groups. Group 1 included obese patients who underwent LSG and took vitamin D and calcium supplements and group 2 that included obese patients who underwent LSG and did not take supplements. Anthropometric measures were performed for all participants. Routine lab investigations and calcium and phosphorus levels were determined by spectrophotometry.

Results: In group 1, there were highly significant increases in calcium and vitamin D levels at 3 months after LSG when compared to before LSG (P<0.001). However, phosphorus levels showed no significant differences (P=0.242). In group 2, there were highly significant decreases in the levels of serum calcium, and vitamin D at 3 months after LSG when compared to before LSG (P<0.001, for each). Additionally, phosphorus levels showed a significant decrease (P=0.006).

Conclusion: The anthropometric measures, lipid profile, and fasting and two hours post-prandial blood glucose levels showed marked decreases mediated by weight loss by LSG. In addition, calcium, phosphorus, and vitamin D showed a marked decline after LSG by 3 months, which was compensated by supplementation.

Keywords: Laparoscopic sleeve gastrectomy, Calcium, Vitamin D.

INTRODUCTION

There is a massive increase in overweight and obesity globally. Increased body mass index (BMI) is a predisposing factor for multiple chronic diseases such as ischemic heart diseases, diabetes mellitus (DM), renal diseases, some cancers, and several musculoskeletal problems **(1)**.

Among adult Egyptian females, there was a decline in overweight from 31.3 % to 26.9 % and a rise in obesity from 20.5 % to 48.2%, according to surveys between 1995 and 2004. The mean BMI for females was 30.8 **(2)**.

Weight reduction has many beneficial effects. It can delay the development of type 2 DM in diabetics and is helpful in the management of type 2 DM **(3)**. Bariatric surgery is effective in decreasing body weight, with a subsequent decrease in cardiovascular events, thus decreasing mortality. Also, it is effective in lowering blood pressure, lipid and glucose levels. Moreover, it improves insulin resistance and β cell function **(4)**. So, many obese diabetic patients, are opting for diabetic surgeries **(5)**.

One of the most popular bariatric treatments for morbid obesity nowadays is laparoscopic sleeve gastrectomy (LSG) **(6)**. However, bariatric surgeries are incriminated by a severe decrease in bone mass, in spite of minerals and vitamin supplements **(7)**. Following bariatric surgery, vitamin D deficiency is frequently observed in obese individuals, necessitating significant supplementation to attain adequate levels **(8)**. It is recommended to receive post-operative vitamin D supplements (at least 3000 IU/day) after sleeve gastrectomy until serum 25(OH) vitamin D level reaches > 70 nmol/L **(9)**.

This study aimed to evaluate calcium, phosphorus, and vitamin D levels in patients undergoing LSG with and without calcium and vitamin D supplementation.

SUBJECTS AND METHODS

This retrospective study was carried out on 64 cases in the Obesity Outpatient Clinic, Endocrinology Unit, Internal Medicine Department, and the Bariatric Surgery Unit, General Surgery Department in Zagazig University Hospitals in collaboration with the Medical Biochemistry and Molecular Biology Department, Faculty of Medicine, Zagazig University.

Inclusion criteria: The age of the included cases ranged from 18 to 45 years old for both genders. All cases were with BMI > 35.

Exclusion criteria: Patients with liver impairment, renal impairment, post-menopausal women, endocrinal disorders (hypothyroidism, hyperthyroidism, and Cushing), and bone metabolic disorders (osteoporosis and osteomalacia).

The patients were divided into two main groups: Group 1 included 32 obese patients who underwent LSG and received oral vitamin D 4000 IU /day + calcium 1500 mg/day. Group 2 included 32 obese patients who underwent LSG (did not take vitamin D3 or calcium supplement).

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All the participants of the study were subjected to full history taking and complete clinical examination. Also, assessment of BMI, waist circumference, waist-to-hip ratio, and waist-to-height ratio were performed for all participants. Routine lab investigations including liver function tests, kidney function tests, fasting and 2 hours post-prandial blood glucose level, and complete lipid profile were performed. Calcium and phosphorus levels were determined by spectrophotometry. Vitamin D levels were estimated by enzyme-linked immunosorbent assay (ELISA).

Ethical approval: The Ethics Committee of Zagazig University's Faculty of Medicine gave its approval to the project (ZU-IRB # 4326/4-2-2018). A detailed description of the study's objectives was given to all participants before they complete informed consent forms. The Helsinki Declaration was adhered to at every stage of the investigation.

Statistical analysis

To analyze the collected data, SPSS version 18.0 was utilized. The quantitative data for parametric (normal) data were expressed as mean ± SD. Using the independent samples t-test, the significance of the differences between groups was evaluated. The proportions were compared using the X^2-test. P values ≤ 0.05 were regarded as statistically significant.

RESULTS

There were no significant differences between the two studied groups regarding sex or age (P = 0.723 and 0.463, respectively) (Table 1).

Table (1): Demographic data in both groups

		Groups		*P*
		Group 1 Vitamin D Supplement N=32	**Group 2 Non-Vitamin D Supplement N=32**	
Sex	**Female**	8 (50%)	8 (50%)	0.723
	Male	8 (50%)	8 (50%)	
Age (years)		29.1 ± 9.2	31.4 ± 8.4	0.463

Table (2) showed that there was a highly significant body weight loss at 3 months after LSG in both groups (P<0.001, for each). Also, both studied groups showed highly statistically significant decreases in waist circumference, weight-to-height ratio, and waist-to-hip ratio at 3 months after surgery compared to before surgery (P<0.001, for each). Regarding blood indices, the only measure that showed a significant difference in the two groups before and after surgery was hemoglobin (P=0.041 in group 1 and 0.019 in group 2). In both groups, no significant differences regarding white blood cell count (P=0.111 and 0.669, respectively) or platelet count (P=0.241 and 0.6, respectively) were detected. Regarding liver function tests, none of the studied parameters (total bilirubin, direct bilirubin, ALT, AST and ALP or albumin) showed a significant difference after surgery compared to before surgery in the two studied groups. Also, creatinine didn't show a significant difference in the two studied groups (P=0.348 and 0.382, respectively). Regarding lipid profile, HDL cholesterol didn't show significant differences in the studied groups (P=0.457 and 0.183, respectively). However, total cholesterol, LDL cholesterol, and triglycerides showed significant decreases in the two groups (P<0.001, for each). Fasting (P<0.001, for each) and two hours post-prandial blood glucose (P= 0.005 and 0.017, respectively) showed significant decreases in the two groups, as well.

In group 1, there were significant increases in calcium levels (from 9.1 ± 0.6 to 9.8 ± 0.5, P <0.001) and in vitamin D (from 31.3 ± 3.6 to 61.6 ± 5.6, P <0.001), before and after sleeve gastrectomy. However, phosphorus levels didn't show any differences (P=0.242) (Table 2). While, in group 2, there were highly significant decreases in the levels of serum calcium (from 9.5 ± 0.5 to 8 ± 0.4), and vitamin D (from 33.3 ± 5.6 to 15.3 ± 3.7) after sleeve gastrectomy by 3 months (P<0.001, for each). Additionally, phosphorus levels showed a significant decrease (from 3.4 ± 0.6 to 2.9 ± 0.4, P=0.006) (Table 2).

Table (2): The anthropometric measures and biochemical profile in the studied groups before and after sleeve-gastrectomy

	Group 1 Vitamin D Supplement (N=32)			Group 2 Non-Vitamin D Supplement (N=32)		
	Before gastrectomy	**3 months after gastrectomy**	*P*	**Before gastrectomy**	**3 months after gastrectomy**	*P*
Body mass index (BMI)	49 ± 5.1	32.2 ± 2.1	<0.001**	48.3 ± 5.4	33 ± 3	<0.001**
Waist circumference (cm)	101.9 ± 6	68.9 ± 5.2	<0.001**	111.4 ± 12.5	75.4 ± 8.5	<0.001**
Weight-to-height ratio	0.7 ± 0.1	0.5 ± 0.1	<0.001**	0.8 ± 0.1	0.6 ± 0.1	<0.001**
Waist-to-hip ratio	1.6± 0.6	0.9 ± 0.2	<0.001**	1.5 ± 0.3	0.9 ± 0.7	<0.001**
White blood cell count	8.9 ± 1.3	8.2 ± 1.5	0.111	8.9 ± 1.8	8.6 ± 1.4	0.669
Hemoglobin (gm/dL)	13.4 ± 1.2	12.4 ± 0.9	0.041*	13.6 ± 1.2	12.5 ± 1.7	0.019*
Platelet count	292.4 ± 70.6	315.6 ± 74.3	0.241	297.2 ± 73.3	316.8 ± 72.5	0.6
Total bilirubin (mg/dL)	1.2 ± 0.1	1 ± 0.1	0.432	1.1 ± 0.1	0.9 ± 0.1	0.051
Direct bilirubin (mg/dL)	0.4 ± 0.1	0.3 ± 0.06	0.05	0.4 ± 0.1	0.4 ± 0.1	1
Alanine transaminase (U/L)	25.6± 6.3	20.3±4.2	0.057	31.6±6.4	28.4±5.9	0.382
Aspartate transaminase (U/L)	32.1± 4.6	32.3±7.6	0.945	36.9±6	35.9±5.1	0.62
Albumin (gm/dL)	4±0.4	3.7±0.3	0.051	4±0.3	3.8±0.4	0.194
Alkaline phosphatase (U/L)	80.6±20.1	77.7±12.2	0.055	87.3±10.2	74.6±8.1	<0.051
Creatinine (mg/dL)	1 ± 0.2	0.9 ± 0.2	0.348	0.8 ± 0.2	1 ± 0.1	0.382
Total cholesterol (mg/dL)	416.1 ± 71.4	137.7 ± 14	<0.001**	428.6 ± 98.1	137.1 ± 8.7	<0.001**
HDL cholesterol (mg/dL)	74.6 ± 7.9	76.4 ± 6.1	0.457	84.3 ± 6.9	81.3 ± 7.6	0.183
LDL cholesterol (mg/dL)	200.2 ± 45	45.9 ± 5.3	<0.001**	217.3 ± 42.5	44.6 ± 5.4	<0.001**
Triglycerides (mg/dL)	336.8 ± 69.3	158.3 ± 20.3	<0.001**	345.3 ± 8.4	153.8 ± 16.6	<0.001**
Fasting blood glucose (mg/dL)	104.4 ± 14.3	80.4 ± 9.8	<0.001**	103.3 ± 14	78.2 ± 6	<0.001**
2h post prandial blood glucose (mg/dL)	153.6 ± 8.9	141.3 ± 12.3	0.005*	159.4 ± 10.3	146.8 ± 9.4	0.017*
Calcium (mg/dL)	9.1 ± 0.6	9.8 ± 0.5	<0.001**	9.5 ± 0.5	8 ± 0.4	<0.001**
Phosphorus (mg/dL)	3.2 ± 0.4	3.3 ± 0.5	0.242	3.4 ± 0.6	2.9 ± 0.4	0.006*
Vitamin D (ng/mL)	31.3 ± 3.6	61.6 ± 5.6	<0.001**	33.3 ± 5.6	15.3 ± 3.7	<0.001**

*: a significant difference**;** **: a highly significant difference

On comparing the delta values (changes in each value) before and after intervention in both groups**,** there were highly significant differences between weight to height ratio (P=0.001), serum calcium and serum vitamin D (P<0.001, for each), and serum phosphorus (P=0.004) (Table 3).

Table (3): Comparison between delta values (changes in each value) before and after intervention in both groups

	Group 1 Vitamin D Supplement	Group 2 Non-Vitamin D Supplement	p
Weight to height ratio	-0.1 ± 0.6	0.5 ± 0.3	0.001*
Calcium (mg/dL)	0.6 ± 0.1	-1.5± 0.1	<0.001**
Phosphorus (mg/dL)	0.1± 0.01	-0.5 ± 0.02	0.004*
Vitamin D (ng/mL)	30 ± 2	-18 ± 1.9	<0.001**

*: a significant difference; **: a highly significant difference.

DISCUSSION

Obesity increases the risk of several conditions, such as hypertension, DM, and CVD [(10)]. Right now, bariatric surgery is the most successful treatment for morbid obesity. One of the most prevalent side effects of bariatric surgeries is nutritional deficiencies. Thus, this study's goal was to evaluate the calcium homeostasis (calcium, phosphorus, and vitamin D levels) in patients undergoing LSG with and without calcium and vitamin D supplementation.

In our study, there was a significant decrease in all anthropometric measures at 3 months after LSG in both groups. These results are in line with a prior study conducted by **Sjöström *et al.*** [(11)]. They also reported that the effectiveness of bariatric surgery was higher than other weight reduction measures with sustained effect reaching 20 years, with decreased mortality rate compared to other non-surgical measures [(11)].

In our study, significant declines in total cholesterol, TG and LDL were observed after surgery. These results are consistent with **Flegal *et al.*** [(12)]. However, the participants in their study were with normal lipid profile pre-operatively. Also, HDL showed significant differences in their study in contrast to our results [(12)]. **Perathoner *et al.*** [(13)] reported only significant variations in TG and HDL. Similarly, **Ruiz-Tovar *et al.*** [(14)] found that TG and HDL levels of individuals who had LSG and physical exercise and were followed for a year showed statistically significant changes. The discrepancy in results of lipid profile is attributed to short duration of monitoring, small sample size, or a heterogeneity without randomization [(15)].

Concerning albumin, no significant differences in both groups were detected. Different from our results, **Stroh *et al.*** [(16)] found that albumin decreased after LSG in follow-up for 3 months and occurred mostly due to defects in absorption from gastrointestinal tract.

Although there were significant decreases in hemoglobin in the two studied groups, there was no significant anemia after LSG. This comes in agreement with **Weng *et al.*** [(17)]. Although LSG has only a mild influence on the nutritional status, iron deficiency and anemia are still observed after LSG with decreased frequency compared to other type of bariatric surgeries, when an iron supplement is given after surgery [(18)].

In our study, group 2 (did not take vitamin D or calcium supplementation) showed highly significant decreases in the levels of calcium, vitamin D, and phosphorus after LSG by 3 months. These results agree with a previous study where 48.7% of patients had vitamin D deficiency. Also, phosphate deficiency was detected in 5 to 10 % of the patients [(19)]. These results also agree with **Muschitz *et al.*** [(20)] **and Luger *et al.*** [(21)] who revealed that baseline of vitamin D levels were 15 to 20 ng/mL after LSG. Also, **Chkhtoura *et al.*** [(22)] suggested that vitamin D deficiency is frequent after LSG because of decreased vitamin D absorption. Additionally, **Rosenthal *et al.*** [(23)] revealed that changes in calcium and vitamin D levels after LSG can induce bone loss and increase fracture risk.

To explain our results, bariatric surgery changes the structure of gastrointestinal tract with decreasing the bioavailability of all nutrients involving calcium and vitamin D. In LSG, it leads to decreased acid secretion, which affects the solubility of nutrients. Also, it makes a longer bilio-pancreatic bypass interfering with the absorption of vitamin D by retarding the combination of biliary and pancreatic secretions and lipids. Other causes include preoperative changes in vitamin D status, non-exposure to the sun, neglecting dietary and supplement recommendations, sites of vitamin D absorption bypass including the duodenum and proximal ileum, reduced dietary vitamin D, absorption problems related to vomiting, reduced time available for food digestion, reduced contact time with the intestinal mucosa for nutrient absorption and bacterial overgrowth [(24)].

In our study, we found that patients in group 1 (with supplementation of vitamin D and calcium) had normal levels of vitamin D and calcium after 3 months of follow-up postoperatively. Similar to our results, vitamin D deficiency could be prevented after LSG with low-dose vitamin D supplementation [(25)]. Moreover, in their 3-months follow-up study, **Strushkevich *et al.*** [(26)] reported that vitamin D deficiency had a strong relationship to malabsorption and that vitamin D should be replaced together with calcium supplementation.

So, it is recommended to monitor trace elements and vitamins regularly postoperatively, and their possible deficiencies should be corrected in time. The doses of supplementation in our study were vitamin D 4000 IU /day and calcium 1500 mg/day, which gave a good result. However, the optimal vitamin D and calcium supplementation doses are still controversial. According to the National Health Service England Obesity Clinical Reference Group 2016 and Ontario Bariatric Network 2016, all patients should have preoperative vitamin D assessment and treatment and should receive postoperative supplements of 3000 IU/day at least. Also, follow up of calcium and vitamin D should be done 3 ,6 and 12 months post-operatively. Furthermore, good oral calcium intake is essential. After LSG, the British Obesity & Metabolic Surgery Society recommends 800–1200 mg calcium supplement [(27)].

The Turkish Endocrinology and Metabolism Association recommends that vitamin D levels should be between 35 and 50 ng/mL and that the supplement dose is 4000 IU/day or 100,000 IU per week for 4 to 8 weeks. After treatment period, monitoring of serum vitamin D, calcium and phosphorus is also required [(28)]. Other literature recommends that the ideal vitamin D levels should range from 30 to 35 ng/mL, 20 ng/mL and higher is acceptable. 40 IU of daily vitamin D increases vitamin D levels about 0.28 ng/mL. However, a previous study stated that 400 IU was not sufficient, and 32.77% of the patients needed a higher dose of vitamin D [(29)].

The European Association for Endoscopic Surgery (EAES) recommendations include 3-8 patient visits in the 1st postoperative year, 1-4 visits in the 2nd year, and once or twice the year after. The American Society for Metabolic and Bariatric Surgery stated that a vitamin D supplement of 3000 IU/day at least and a calcium supplement of 1200 mg/day at least are essential after bariatric surgery [(9)].

CONCLUSION

The anthropometric measures, lipid profile, and fasting and two hours post prandial blood glucose showed marked decreases as a result of weight loss by bariatric surgery. In addition, calcium, phosphorus and vitamin D showed a marked decline after bariatric surgery by 3 months, which was compensated by supplementation.

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