Original Article

Adequacy of Dietary Nutrients Intake after Laparoscopic Gastric Plication Surgery: A Quasi-Experimental Study

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ABSTRACT

Background:
There is increasing evidence that surgical approaches to weight loss (bariatric surgery) are the most effective and steady treatment for morbidly obese patients. This study assessed the nutritional status of obese participants candidates for laparoscopic gastric plication (LGP) before and after the surgery.

Materials and Methods:
Our study was conducted on 38 participants aged 18 to 65, with a mean body mass index (BMI) of 41.45±5.68 kg/m^2, scheduled for LGP. BMI and Dietary intakes were assessed at baseline and 6 months after surgery. The mean daily energy intake and micro- and macronutrients were calculated and compared with the dietary reference intake each time.

Results:
The mean excess weight loss was 44.45±9.78%. The mean daily energy intake decreased to one-third of the baseline 6 months after surgery. All patients had a low intake of protein, vitamins A, D, and folic acid before and after LGP. After surgery, over 60% of patients had inadequate vitamin B1, B2, B3, B6, calcium, and iron levels.

Conclusion:
6 months after LGP, our results demonstrated dietary deficiencies, including inadequate protein and certain micronutrients. Some of these nutritional deficiencies existed before surgery and persisted or worsened after surgery. In order to ensure optimal health before and after surgery, patient care should place a strong emphasis on nutritional counseling and supplementation.

Keywords: Micronutrients, Bariatric surgery, Dietary intake, Laparoscopic gastric plication

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INTRODUCTION

The prevalence of obesity, including morbid obesity, is a growing global health concern and an epidemic in both developed and developing nations (1). There is increasing evidence that surgical approaches to weight loss (bariatric surgery) are the most effective and steady treatment for morbidly obese patients compared with lifestyle and therapeutic interventions (2). In addition to long-term weight loss, bariatric surgeries can help morbidly obese people eliminate health problems caused by their weight, such as metabolic syndrome and type 2 diabetes (3). The trends of bariatric operations in Asia showed an increase from 2005 to 2009 with an absolute growth rate of 449% (4). To minimize the invasiveness and complications of the surgery, different bariatric surgeries have been developed during the last decades. Although all bariatric surgeries are categorized into two fundamental mechanisms, including 1) malabsorption and 2) restriction, some procedures use a combination of both two methods (5). Laparoscopic gastric plication (LGP) is a new technique in a restrictive bariatric procedure that Talebpour first described in 2007 (6). Moreover, Tretbar initially suggested gastric plication with an open approach as a weight-loss operation in 1976 (6, 7). In LGP, restriction of the stomach is performed without the use of an implant and or gastric resection. Consequently, the potential complications associated with adjustable gastric banding (AGB) and vertical sleeve gastrectomy (VSG) have been reduced or eliminated in LGP. Mechanical restrictions of food intake, a decrease in the absorption of nutrients, or a combination of both, are the primary weight loss mechanisms in bariatric surgeries (8). However, non-mechanical mechanisms have been suggested for weight-reduction effects of bariatric surgeries, including modification in physical activity, resting energy expenditure, and hormonal regulation.

To the best of our knowledge, there is no study about the effects of LGP on dietary intake in Iran. Therefore, we aimed to evaluate the influence of LGP on dietary intake and nutritional status in patients with obesity.

MATERIALS AND METHODS

This study was conducted on 38 individuals aged 18 to 65 years with extreme obesity who were approved for LGP surgery. The surgeries were performed at Bariatric Surgery Clinic at Sina Hospital in Tehran. All participants completed their follow-up evaluations during their clinic visits. According to the criteria established by the National Health Institute of the United States for bariatric surgery, patients who underwent the procedure had a body mass index (BMI) > 40 kg/m^2 or ≥ 35 kg/m^2 with at least one comorbidity. Exclusion criteria were history or current psychological conditions that affect the perception of surgery or postoperative assessment and recommendations, type 1 and type 2 diabetes, prior gastric surgery, a positive pregnancy test, cancer, and current use of oral anticoagulants. All participants were fully aware of the study at the baseline, and a consent form was filled out. Study assessments were performed during preoperative and follow-up clinic visits one day before and 6 months after LGP surgery. Dietary intake and anthropometric measurements were performed at each visit for all participants. Details on postoperative follow-up care were reported in previous publications (9). Briefly, the postoperative diet of patients after the complete resolution of nausea and vomiting was as follows: Patients drank only clear liquids for the first 2 weeks after discharge (water or fruit juice). During the next 4 weeks, the concentration of foods gradually increased, and patients were permitted to consume liquids containing minute particles and softened foods. After that, according to the recommendations, the nutritionist started a regular diet in a limited amount. If necessary, prokinetic and antispasmodic medications, as well as proton pump inhibitors, were prescribed.

Anthropometry

Weight and height were measured using a Seca scale (Seca725 GmbH & Co. Hamburg, Germany) while subjects wore light clothes and no shoes in standing posture. The accuracy of weight and height was 0.1 kg and 0.5 cm, respectively. BMI was calculated as weight (kg) divided by height squared (m^2). The dietary intake of all patients was measured using a 24-recall questionnaire for 3 days, which was filled by the same trained dietitian. Nutritionist 4 (N4) software (First Databank, San Bruno, CA, USA) adapted for Iranian foods was used to analyze the dietary intake and calculate energy, protein, carbohydrate, and fat intake.

Statistical analysis

All statistical analyses were conducted using Statistical Package for Sciences Software version 19 (SPSS Inc., Chicago, Illinois, United States). Continuous data were presented as mean±SD. Categorical data, such as physical activity level, were summarized as frequencies and percentages. Normal distributions of variables were evaluated using the Kolmogorov-Smirnov test. A paired *t* test was used to compare weight, BMI, and dietary intake before and after the LGP surgery.

RESULTS

In this study, 38 subjects participated. All of the participants were females. Follow-up was 100% at 6 months after surgery. Before surgery, the mean weight of morbidly obese patients was 110.69±14.79 kg (range from 86.00 to 142.00 kg), for a mean BMI of 41.45±5.68 kg/m^2 (from 35.36 to 55.44 kg/m^2). The mean age of participants was 34.33±8.55 years. 6 months after the LGP surgery, the mean weight and BMI reached 88.30±12.86 kg and 32.77±34.29 kg/m^2, respectively. The decrease in weight and BMI were statistically significant 6 months after surgery compared with baseline. The patients had lost an average of 22.38±4.00 kg, corresponding to a loss of 20.26±3.07 kg of their initial weight. They reached a mean excess weight loss of 44.45±9.78%. 6 months after the surgery, the decrease of patients with a BMI range of 35 to 39.9 kg/m^2 compared with baseline was 18.5%, and of patients with a BMI range of 30 to 34.9 kg/m^2 was 23.9%. Two patients (9.5%) still had a BMI>40 kg/m^2. The mean daily dietary intake, including total energy, macro, and micronutrients of patients at baseline and 6 months after surgery, are shown in Table 1.

As expected, total energy consumption was lower 6 months after the surgery. In addition, the absolute intake of macronutrients (g/day) showed a statistically significant reduction from baseline. However, dietary composition revealed differences between baseline and 3 months after surgery. A percentage of energy from carbohydrates and fat decreased, and protein increased from pre- to postoperation. The mean energy intake of subjects in the control group was 1860.47±324.30 kcal/day, with 25.44% of energy from fat, 58.08% of energy from carbohydrates, and 17.81% of energy from protein. The results showed that the percent of energy from fat and carbohydrate was lower and protein was higher in patients after surgery than in controls. These differences were statistically significant for the percent of energy from carbohydrates and protein.

The mean vitamins and minerals intake were lower after surgery compared with the baseline regarding micronutrients. To complete the analysis of the dietary intake, we compared the daily intake of some of the micronutrients for each participant compared with the estimated average recommended (EAR) and adequate intake (AI) of the dietary reference intake. Table 2 shows the percentage of participants not reaching the EAR or AI before and after the surgery. Results showed 100% deficiency in vitamin A, vitamin D, vitamin E, and folic acid and magnesium intake before and for those in addition to calcium after the surgery. The prevalence of patients with insufficient dietary intake of all micronutrients (Table 2) increased 6 months after LGP surgery compared with the baseline.

DISCUSSION

In the present study, morbidly obese patients who underwent LGP presented a significant reduction (excess weight loss (EWL) %: 44.45±9.78%) during the first 6 months after surgery. In terms of weight loss, our results showed a similar percentage of excess weight loss after LGP surgery to other previously published studies. The mean EWL% was 55% in Talebpour et al (6), 48% in Romas et al (8), 49.9% in Brethauer et al (10), 32% in Gebelli et al (11), and 54.2% in Niazi et al (9) studies.

The consistency of other restrictive bariatric surgeries, compulsory dietary restrictions, including a decrease in appetite, reasonable control of hunger, the experience of gastroesophageal reflux after eating food, and experience nausea and vomiting after consuming large meals have been proposed as potential mechanisms of weight loss in LGP. However, there is no study on the nutritional status of patients after LGP (10).

Macronutrients dietary deficiency

Regarding dietary intake, data from our study show that patients' protein intake is below the current recommendation (≥60 g/day) (12) up to 6 months after

Table 1. Total daily dietary intake of patients at baseline (before the surgery) and at 6 months after laparoscopic gastric placation surgery (n=38)

Variables	Baseline	6 months after surgery	*P* value
Energy (kcal)	1876.22±621.33	666.49±339.09	<0.001
Fat (g)	66.57±32.43	24.94±20.33	<0.001
Carbohydrate (g)	262.95±176.28	75.38±54.96	<0.001
Protein (g)	85.55±36.58	41.48±23.08	<0.001
Dietary fiber (g)	9.79±4.77	3.90±3.55	0.58
Energy from fat (%)	31.06±8.64	35.18±25.42	0.46
Energy from Carbohydrate (%)	54.81±20.03	44.34±14.59	0.056
Energy from protein (%)	18.57±5.72	26.24±9.83	<0.001
Vitamin A (RE)	244.64±131.37	183.66±78.48	0.78
Vitamin E (mg)	2.03±0.20	1.70±0.53	0.86
Vitamin D (µg)	0.25±0.15	0.41±0.18	0.96
Vitamin C (mg)	60.75±47.29	43.69±50.84	0.20
Thiamin (B_1) (mg)	1.44±0.41	0.67±0.49	<0.001
Riboflavin (B_2) (mg)	1.18±0.50	0.84±0.59	0.02
Niacin (B_3) (NE)	22.32±6.93	10.36±6.41	<0.001
Vitamin B_6 (mg)	1.13±0.44	0.70±0.35	<0.001
Vitamin B_{12} (µg)	1.82±0.22	1.36±0.18	0.07
Folic acid (µg)	99.39±56.51	66.50±48.52	<0.001
Calcium (mg)	588.55±254.82	484.96±221.89	0.18
Mg (mg)	175.39±75.41	91.69±63.77	0.09
Iron (mg)	17.57±12.21	5.50±4.10	<0.001
Zinc (mg)	7.99±3.61	3.55±2.22	<0.001
Copper (mg)	0.99±0.63	0.40±0.29	<0.001
Sodium (mg)	1844.83±792.93	942.65±679.32	<0.001
Potassium (mg)	1391.27±551.93	992.93±517.88	0.002

Data are expressed as mean±standard deviation (SD); $P<0.05$ is statistically significant.

LGP surgery. Although, the percent of energy from protein significantly increased after surgery compared with the baseline. A low protein intake has previously been described following other bariatric surgery. A recent meta-analysis of other bariatric surgery effects on protein intake showed that protein intake is compromised because of reduced gastric capacity and aversion to certain foods. Only a tiny percentage of patients get the minimum 60 g of daily protein that is advised (13). Moize and colleagues reported a mean total daily protein ranging from 45.6±14.2 g/day at 3 months and 58.5±17.1g/day at 12 months after gastric bypass (14). Previous studies have suggested that consuming a larger daily protein intake following restrictive energy diets after all types of bariatric surgeries were associated with lesser loss of free fat mass (FFM) (15). Andreu and co-workers showed that the percentage of subjects with protein consumption<60 g/day was 5% at baseline and 45%, 35%, and 37% at 4, 8, and 12 months after surgery, respectively. In contrast, they found a significant association between daily protein intake and FFM loss at four months post-operation only in men (16). Moreover, it has previously been reported that after weight loss interventions, the average loss of FFM is higher in men than women (17). The prevalence of protein deficiency is more common in malabsorptive (13.4-18%) (18) compared with restrictive (0-2%) (14) bariatric procedures. The leading cause of this difference is bypassing the mid ileum in malabsorptive methods,

Table 2. Percentage of participants within a period below the estimated average requirement or adequate intake (n=38)

Variables	Baseline (%)	6 months after surgery (%)
Protein (g)	0	100
Vitamin A (RE)	100	100
Vitamin E (mg)	100	100
Vitamin D (µg)	100	100
Vitamin C (mg)	71.4	85.7
Thiamin (B_1) (mg)	14.3	71.4
Riboflavin (B_2) (mg)	33.3	66.7
Niacin (B_3) (NE)	9.5	71.4
Vitamin B_6 (mg)	42.9	71.4
Vitamin B_{12} (µg)	47.6	66.7
Folic acid (µg)	100	100
Calcium (mg)	85.7	100
Magnesium (mg)	100	100
Iron (mg)	23.3	90.5
Zinc (mg)	57.1	90.5

which is the leading site of protein absorption. The lack of proper mastication and reduction in gastric secretion lead to intolerance of red meat ingestion and, consequently, a deficiency in protein intake. On the other hand, if the consumption of the alternative dietary source of protein, including milk, yogurt, eggs, fish, and poultry, is not enough, the risk of protein malnutrition can increase in the short- and long-term after bariatric surgeries (19).

Micronutrient dietary deficiency

In our study, approximately 90% of patients had dietary iron deficiency 6 months after LGP surgery. Iron deficiency is the most common micronutrient deficiency following all types of bariatric surgeries, with a higher risk of more malabsorptive than restrictive procedures (20). Inherent with diminishing iron stores in the body is an extension and increase of iron deficiency after bariatric surgeries (21). In patients who undergo bariatric surgeries, the risk of iron deficiency is higher in women of reproductive age and patients with anemia or disease with chronic blood loss before surgery (20). Published reports after bariatric surgeries showed dietary iron deficiencies in 20% to 49% of the patients after gastric bypass surgery (22).

Several factors contributed to the dietary iron deficiency after restrictive bariatric surgeries. First, patients following bariatric surgery commonly experience intolerance to red meat as a rich source of iron. Second, the low PH of the stomach environment by reducing iron from the Ferric ($Fe3+$) to ferrous ($Fe2+$) state solubilizes it for absorption in the small intestine. In restrictive types of bariatric surgeries, including LGP, the capacity of hypocaloric acid decreases by reducing the volume of the stomach (23).

We found in our study that the prevalence of dietary vitamin B12 (cobalamin) deficiency increased post - compared with pre-surgery (66.7% versus 47.6%). Patients undergoing restrictive and malabsorptive bariatric operations are at risk of developing dietary B12 deficiency, with more prevalence in malabsorptive surgeries (24). The prevalence of dietary vitamin B12 deficiency has been reported at 33% at 1 year (23), 36% at 2 years (25), 33% at 3 years (19), and 33% at 4 years after Roux-en-Y gastric bypass (RYGBP) surgery in several studies. On the other hand, meat and dairy products are the primary dietary source of vitamin B12 less tolerated in patients after bariatric surgery. Monitoring and treating vitamin B12 deficiency are essential both before and after surgeries due to the vital role of vitamin B12 in deoxyribonucleic acid (DNA) synthesis and neurological function.

We observed in our study that all participants had dietary deficiencies in vitamins A, D, E, folic acid, and magnesium before the LGP surgery that continued at 6 months follow-up. Dietary folate deficiency is less common than vitamin B12 and iron because it can be absorbed throughout the small intestine. In addition, in contrast to vitamin B12, the body has very little storage of folic acid. The absorption of folic acid in the small intestine is mediated by an active carrier transport mechanism dependent on PH. Therefore, reduced gastric acid and upper small intestine elimination are the leading causes of dietary folate deficiency in restrictive and malabsorptive bariatric surgeries (26). In general, dietary vitamin B12 and folic acid deficiencies are more widely associated with malabsorptive surgeries compared with purely restrictive ones (27).

It is noticeable that in obese patients, particularly those who suffer from morbid obesity, there is a high prevalence of nutritional deficiencies, including vitamin D, folic acid, and iron, manifested with high serum levels of parathyroid hormone (PTH) and anemia, respectively (28, 29). Schweiger and colleagues showed a 15-fold risk of folic acid deficiency amongst subjects with BMI > 50 kg/m^2 (30). Our findings regarding an absolute deficiency in dietary vitamin D and folic acid before surgery were consistent with other observations. All of the patients in our study had a deficiency in dietary intake of vitamin D before and after the LGP surgery. Despite the different serum level cutoffs for the definition of vitamin D deficiency, obese patients are predisposed to vitamin D deficiency (31). Previous studies reported vitamin D deficiency, ranging from 21% to 81% in morbidly obese patients before the bariatric surgeries (32, 33). Suggested mechanisms for describing vitamin D deficiency in obese patients are sequestration of vitamin D in adipose tissue that decreases the availability of vitamin D, inadequate sunlight exposure, and hepatic feedback inhibition by increased serum level of 1,25 (OH)2D (34). Therefore, the emphasis on improving vitamin D status is essential.

Monitoring and treating these dietary nutritional deficiencies are vital before the surgery. Treatment of these nutritional deficiencies is more difficult after bariatric surgery because of vomiting, food intolerance, decreased dietary intake, and bypassing of the areas of absorption in the gastrointestinal (GI) after surgery (35).

This study contained several limitations. The first limitation of our study is its small sample size, and the second is the observational nature of this study. In addition, because all the people who participated in our study were women, there is a potential for gender bias, especially concerning the prevalence of iron deficiency after surgery. Based on our knowledge, no previous study has been performed to evaluate the nutritional intakes of the patients before and after LGP surgery. So, more studies with more noteworthy participants and long-term follow-ups are needed to estimate the nutritional intake of patients after the LGP surgery.

CONCLUSION

In conclusion, our results show dietary deficiencies 6 months after LGP surgery, such as insufficient protein and some micronutrients. It appears that some of these nutritional deficiencies existed before surgery and persisted or worsened afterward. Therefore, routine nutritional monitoring, clinical assessments, pre-and postoperatively, and the recommendation of appropriate supplementations might be considered for health promotion after LGP. Also, dietary counseling must be emphasized in pre-and post-surgery patient care.

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AUTHOR CONTRIBUTION

Hasani M: conceptualization (equal), data curation (lead), investigation (equal), project administration (lead) and writing-original draft (lead); Mirahmadian M: data curation (equal), investigation (equal), project administration (equal) and writing-review and editing (equal); Salehi P: investigation (equal), project administration (equal), methodology (equal) and writing-original draft (equal); Heshmati J: investigation (equal), methodology (equal), validation (equal) and writing-review and editing (equal); Qorbani M: data curation (equal), formal analysis (equal), methodology (equal), writing-review and editing (equal); Jafari A: methodology (equal), investigation (equal), writing-review and editing (equal); Talebpour M: conceptualization (equal), data curation (equal), investigation (equal) and writing-review and editing (equal); Hosseini S: conceptualization (equal), funding acquisition (equal), validation (equal) writing-review and editing (equal).

CONFLICT OF INTERESTS

The authors declare no conflict of interest related to this work.

CONSENT FOR PUBLICATION AND ETHICAL APPROVAL

Informed consent was obtained from all subjects involved in the study. Ethics Committee of Tehran University of Medical Sciences reviewed and approved this research (IR.TUMS.REC.1391,299).

DATA AVAILABILITY STATEMENT

The data presented in this study are available on request from the corresponding author. The data are not publicly available to maintain the patient's privacy.

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