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Original Article

The short-term influence of gastric bypass surgery on dietary intakes in morbidly obese patients

Mehri Mirahmadian[a], Motahareh Hasani[a], Ehsaneh Taheri[b], Abbasali Keshtkar[c], Saeed Hosseini*[d], Abdol Reza Pazooki[e]

[a] Department of Clinical Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran
[b] Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[c] Osteoporosis Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[d] Department of Clinical Nutrition, School of Nutritional Sciences and Dietetics, AND Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[e] Minimally Invasive Surgery Research & Training Center of Excellence, Iran University of Medical Sciences, Tehran, Iran

Article History
Received:
18/01/2015
Revised:
09/04/2015
Accepted:
29/05/2015

Keywords:
Gastric bypass surgery,
Food intake,
Morbid obesity

A B S T R A C T

Background: Obesity is recognized as a major public-health problem, which has reached epidemic proportions, in both developed and developing countries. The purpose of this survey is to study effects of gastric bypass surgery at micronutrients and macronutrients intake on patients with morbid obesity.

Methods: This quasi-experimental study was conducted on 21 patients. Anthropometry information (weight, height, age, and gender) and three 24-hour recall questionnaires were completed for each participant: Before surgery and 3 months after surgery.

Results: The total intake of macronutrients including carbohydrate, protein and fat decreased between baseline at 3 months post-surgery that was statistically significant for all of the macro-nutrients ($p < 0.001$). There was a reduction of energy intake from carbohydrate (54.81% ± 20.03% to 44.34% ± 14.59%, $p = 0.059$) and the energy intake from protein (18.57% ± 5.73% to 26.24% ± 9.83%, $p = 0.001$) and fat (31.06% ± 8.64% to 35.18% ± 25.41%, $p = 0.460$) along the prospective follow-up period compared to previous values. The mean intake of all micronutrients had decreased during follow-up that was statistically significant for B group vitamins (B1, B2, B3, and B6), float, iron, zinc and copper ($p < 0.017$ for vitamin B2, $p < 0.001$ for others).

Conclusion: Our data demonstrate that low dietary intake of energy, micro- and macro-nutrients absolute values and relative to the recommended dietary allowances and estimated average requirements, are highly prevalent after Roux-en-Y gastric bypass (RYGB) surgery. Therefore dietary counseling, clinical assessments, and the recommendation of supplements if needed in pre- and post-operatively, might be considered for health promotion after RYGB surgeries.

Citation: Mirahmadian M, Hasani M, Taheri E, Keshtkar A, Hosseini S, Pazooki AR. **The short-term influence of gastric bypass surgery on dietary intakes in morbidly obese patients**. J Nutr Sci & Diet 2015; 1(3): 134-40.

Corresponding author:
Saeed Hosseini, Ph.D.
Address: Department of Clinical Nutrition, School of Nutritional Sciences and Dietetics, AND Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran.
Email: saeedhmdphd@hotmail.com

Introduction

Obesity is recognized as a major public-health problem, which has reached epidemic proportions, in both developed and developing countries. Obesity is an independent risk factor for developing other chronic diseases [1]. The primary causes of obesity are genetic factors, unlimited access to high-calorie foods and modern industrial lifestyle, which leads to reduced physical activity [2]. In 2008, it was estimated that 146 billion adults globally were overweight or obese (body mass index [BMI] ≥ 25 kg/m^2) that was included 205 million men and 297 million women with obesity. It was reported that people in the United States had the highest mean BMI among high-income countries [3]. The overall prevalence rates of obesity and overweight in Iran were reported 42.8% of men and 34.8% of women in 2005 [4]. Bariatric surgery is recognized as a long-term treatment of morbid obesity. The number of Bariatric surgery procedures performed in America increased from about 200,000 to 220,000 cases in the period between 2003 and 2008 [5]. Among all kinds of Bariatric surgery, Roux-en-Y gastric bypass (RYGB) is the most common procedure in the USA. Bypass surgery can reduce about 60% of excess body weight by restricting energy intake and decreased in the absorption of nutrients [6]. The RYGB operation, which is commonly used, is recognized as the gold standard Bariatric procedure in the world. This method involves both restrictive and malabsorptive methods of Bariatric surgeries. In the RYGB design, the stomach is divided into the unequal portion. The upper stomach pouch with 15-30 ml in volume is connected to the jejunum through a gastrojejunal anastomosis by Roux limb with 75-15 cm in length [2]. Therefore, the lower stomach pouch and the proximal portion of the small intestine are bypassed. Due to the severe restriction of food consumption following gastric bypass surgery, this surgery has the side effects such as protein malnutrition and deficiency of other micronutrients [7, 8]. According to our knowledge, this is the first study to examine the influence of RYGB operation on the dietary intake of the morbidly obese patients in Iran. As we know, each population has specific dietary characteristics. Therefore, we aimed to determine the potential nutrient deficiency in patients, who undergoing RYGB surgery.

Methods

This quasi-experimental study was conducted on 21 patients, aged 18-60 years with severe obesity scheduled to undergo RYGB surgery at the Center of Bariatric Surgery of the University Hospital (Rasol Hospital) in Tehran during the period 2014-2015.

According to National Institutes of Health criteria, patients with a BMI > 40 kg/m^2 or a BMI > 35 kg/m^2 with obesity-related morbidity were candidates for RYGB surgery.

Exclusion criteria were having any diagnosed diseases, including thyroid disorders, liver and kidney dysfunction, binge eating, polycystic ovary syndrome, and psychiatric disorder.

Furthermore, patients who used drugs, including hormonal agents and sibutramine in current or 6 months before the surgery was excluded from the study.

After an explanation of the objective and procedure of the study, written informed consent was taken from each participant. The study protocol was approved by the Medical Ethics Committee of Tehran University of Medical Sciences.

Study assessments such as anthropometric, biochemical parameters, physical activity, and dietary intake of all participants were measured at the time of entry to the study, that is, 7 days before surgery and 3 months after the RYGB surgery.

All patients were discharged within 1 day after surgery. After complete resolution of nausea and vomiting, patients followed the only clear liquid diet, such as water and fruit juice in the first 2 weeks post-surgery. Concentration of foods gradually increased, and patients were allowed to consume liquids with small particles and softened foods during the next 4 weeks.

Three 24-hour recall questionnaires were completed for each participant. These questionnaires were completed by a trained nutritionist in a face-to-face interview. Dietary intakes (energy, macro- and micro-nutrients) were determined using Nutritionist 4 (N4) software (First Databank Inc., Hearst Corp., San Bruno, CA).

Weight and height were measured using a Seca scale (Seca725 GmbH & Co. Hamburg, Germany) while subjects wear 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 24-recall questionnaire for 3 days, which filled by the same trained dietitian.

Nutritionist 4 (N4) software was used to analyze the dietary intake and calculating energy, protein, carbohydrate, and fat intake.

Statistical Package for Sciences Software (version 16; SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. Continuous data were presented as a mean ± standard deviation. Pair t-test was used for the comparison between variables, including weight, BMI, and dietary intake components.

For comparison of estimated resting energy expenditure (REE) by Harris Benedict formula and total energy intake, a two-tailed Student's t-test was used.

Results

All of the participants were women aged from 40.5 ± 11.8 years. The mean weight of morbidly obese patients before the surgery was 121.9 ± 19.4 kg with the mean BMI of 41.45 ± 5.68 kg/m^2.

3 months after the RYGB surgery, the mean of weight and BMI reached to 94.8 ± 18.0 kg and 35.80 ± 5.47 kg/m^2, respectively. Mean total weight loss and change in BMI in 3 months follow-up were statistically significant ($p < 0.001$ for both) (Table 1).

Table 2 shows the mean of daily dietary intake, including total energy and macronutrients of patients at baseline and 3 months after the surgery. Mean total energy intake decreased from 2105.10 ± 697.14 kcal at baseline to 739.81 ± 376.39 kcal at 3 months after surgery. The results showed that the estimated REE (by Harris Benedict formula) was statistically significant higher at baseline (2307.91 ± 183.75 kcal) and 3 months after the surgery (2048.26 ± 166.23 kcal) than total energy intake ($p < 0.001$). Furthermore, the total intake of macronutrients including carbohydrate, protein and saturated fatty acids (SFA), poly un-SFAs, and mono un-SFAs decreased between baseline and 3 months post-surgery that was statistically significant for all of the macro-nutrients.

The energy intake from carbohydrate (54.81% ± 20.03% to 44.34% ± 14.59%, $p = 0.059$) decreased, while the energy intake from protein (18.57% ± 5.73% to 26.24% ± 9.83%, $p = 0.001$) and fat (31.06% ± 8.64% to 35.18% ± 25.41%, $p = 0.460$) increased during the prospective follow-up period compared to baseline values.

The absolute and relative intake of all micronutrients with regards to the recommended dietary allowances (RDA) and estimated average requirements (EAR) are depicted in tables 3-5. As expected, the mean intake of all micronutrients had decreased during follow-up that was statistically significant for B group vitamins (B1, B2, B3, and B6), folate, iron, zinc, and copper ($p < 0.017$ for vitamin B2, $p < 0.001$ for others).

Table 1. Demographic characteristics of participants at baseline and 3 months after the surgery

Variables	Baseline	3 months after surgery
Age (year)	8.11 ± 5.40	8.11 ± 5.40
Kg (weight)	4.190 ± 9.121	0.18 ± 8.94
Height (cm)	31.600 ± 1.164	31.600 ± 1.164
Body mass index (kg/m^2)	4.60 ± 1.46	7.5 ± 8.35

Table 2. Daily intake of total of daily dietary intake of patients at the baseline (before the surgery) and at 3 months after surgery (n = 21)

Variables	Baseline	3 months after surgery	p value
Energy (kcal)	2105.80 ± 697.14	739.81 ± 376.39	< 0.001
Carbohydrate (g)	295.04 ± 187.69	83.64 ± 54.96	< 0.001
Protein (g)	95.99 ± 41.05	46.44 ± 24.51	< 0.001
Fat (g)	74.69 ± 36.29	27.68 ± 22.57	< 0.001
Saturated fat (g)	19.03 ± 12.74	7.99 ± 5.18	0.003
Poly unsaturated fat (g)	9.15 ± 8.08	2.98 ± 1.59	0.004
MUFA (g)	12.55 ± 11.94	4.5 ± 2.5	0.041
Omega 3 (g)	0.49 ± 0.46	0.20 ± 0.11	0.020
Omega 6	7.14 ± 7.41	2.24 ±1.26	0.013
Dietary fiber (g)	10.99 ± 5.35	6.98 ± 6.36	0.051
Energy from fat (%)	31.06 ± 8.64	35.18 ± 25.42	0.460
Energy from CHO (%)	54.81 ± 20.03	44.34 ± 14.59	0.056
Energy from protein (%)	18.57 ± 5.72	26.24 ± 9.83	< 0.001

Data are expressed as mean ± SD. $p < 0.050$ is statistically significant. MUFA = Mono unsaturated fatty acids; SD = Standard deviation

Table 3. Daily intake of micro-nutrient in patients at the baseline (before the surgery) and at 3 months after the surgery (n = 21)

Variables	Baseline	3 months after surgery	p value
Vitamin A (RE)	274.49 ± 147.40	203.87 ± 87.11	0.060
Vitamin E (mg)	2.28 ± 1.06	1.89 ± 2.69	0.540
Vitamin D (µg)	0.46 ± 0.94	0.29 ± 0.77	0.500
Vitamin C (mg)	68.16 ± 53.06	48.5 ± 56.43	0.190
Thiamin (B_1) (mg)	1.62 ± 0.46	0.74 ± 0.54	< 0.001
Riboflavin (B_2) (mg)	1.32 ± 0.56	0.93 ± 0.65	0.017
Niacin (B_3) (NE)	25.05 ± 7.76	11.5 ± 7.17	< 0.001
Vitamin B_6 (mg)	1.26 ± 0.50	0.78 ± 0.38	< 0.001
Vitamin B_{12} (µg)	2.03 ± 1.25	1.51 ± 0.95	0.060
Folic acid (µg)	111.53 ± 63.40	73.82 ± 53.86	< 0.001
Calcium (mg)	660.30 ± 285.91	538.31 ± 246.30	0.160
Mg (mg)	148.25 ± 63.74	122.21 ± 84.94	0.170
Iron (mg)	19.71 ± 13.70	6.10 ± 4.55	< 0.001
Zinc (mg)	8.96 ± 4.05	3.95 ± 2.47	< 0.001
Copper (mg)	1.11 ± 0.71	0.45 ± 0.32	< 0.001
Sodium (mg)	1862.9 ± 800.7	1046.3 ± 754.5	< 0.001
Potassium (mg)	1561.00 ± 619.27	1102.20 ± 574.85	0.001

Data are expressed as mean ± SD. p < 0.050 is statistically significant. SD = Standard deviation

Table 4. Daily intake of the micro-nutrients compared to the RDA in patients at the baseline (before the surgery) and at 3 months after the gastric bypass surgery (n = 21)

Variables	Baseline %	3 months after % surgery	p value
Vitamin A (RE)	43.44 ± 18.42	25.48 ± 10.88	0.066
Vitamin E (mg)	15.24 ± 7.08	12.63 ± 17.97	0.540
Vitamin D (µg)	0.92 ± 1.88	0.58 ± 1.55	0.520
Vitamin C (mg)	100.99 ± 78.60	71.86 ± 83.61	0.190
Thiamin (B_1) (mg)	202.56 ± 57.60	93.71 ± 0.68	< 0.001
Riboflavin (B_2) (mg)	139.76 ± 59.38	98.33 ± 69.14	0.017
Niacin (B_3) (NE)	250.53 ± 77.69	115.04 ± 71.17	<0.001
Vitamin B_6 (mg)	120.90 ± 48.01	74.860 ± 37.005	< 0.001
Vitamin B_{12} (µg)	126.94 ± 72.48	94.56 ± 59.00	0.060
Folic acid (µg)	33.54 ± 19.07	22.20 ± 16.19	< 0.001
Calcium (mg)	66.03 ± 28.59	53.83 ± 24.63	0.160
Mg (mg)	47.06 ± 20.23	38.77 ± 26.96	0.170
Iron (mg)	109.54 ± 76.15	33.92 ± 25.29	< 0.001
Zinc (mg)	112.07 ± 50.74	49.37 ± 30.92	< 0.001
Copper (mg)	124.07 ± 79.61	50.04 ± 36.58	< 0.001

Data are expressed as mean ± SD. p < 0.050 is statistically significant. SD = Standard deviation; RDA = Recommended dietary allowances

Table 5. Daily intake of the micro-nutrients compared to the EAR in patients at the baseline (before the surgery) and at 3 months after the gastric bypass surgery (n = 21)

Variables	Baseline %	3 months after % surgery	p value
Vitamin A (RE)	43.91 ± 22.58	32.61 ± 13.93	0.066
Vitamin E (mg)	19.05 ± 8.85	15.79 ± 22.47	0.540
Vitamin D (µg)	0.92 ± 1.88	0.58 ± 1.55	0.520
Vitamin C (mg)	113.61 ± 88.43	80.84 ± 94.06	0.190
Thiamin (B_1) (mg)	162.05 ± 46.08	74.97 ± 54.68	< 0.001
Riboflavin (B_2) (mg)	120.65 ± 51.28	84.92 ± 59.71	0.017
Niacin (B_3) (NE)	208.77 ± 64.74	95.88 ± 59.31	< 0.001
Vitamin B_6 (mg)	115.41 ± 45.82	71.45 ± 35.32	< 0.001
Vitamin B_{12} (µg)	101.55 ± 57.98	75.65 ± 47.62	0.060
Folic acid (µg)	34.85 ± 19.81	23.07 ± 16.83	< 0.001
Calcium (mg)	82.54 ± 35.73	67.28 ± 30.78	0.160
Mg (mg)	44.92 ± 19.31	37.01 ± 25.74	0.170
Iron (mg)	328.63 ± 22.84	101.77 ± 75.88	< 0.001
Zinc (mg)	95.37 ± 43.18	42.02 ± 26.31	< 0.001
Copper (mg)	159.76 ± 102.43	64.34 ± 47.03	< 0.001

Data are expressed as mean ± SD. p < 0.050 is statistically significant. EAR = Estimated average requirements

Discussion

In the present study, the average intake of energy and macronutrients in patients undergoing RYGB surgery was significantly reduced after surgery compared to baseline (prior to surgery).

Miller et al. evaluated dietary intake in 17 patients undergoing RYGB surgery by completing 24-hour recall questionnaire at 5 times, including at baseline (prior to surgery), 3 weeks, 3 months, 6 months, and 12 months after the surgery. They reported that the mean energy intake have decreased from 2150 ± 165 kcal at baseline to 649 ± 40 kcal at 3 weeks and then 1307 ± 129 kcal at 12 months after the RYGB surgery [9].

Data from our study showed that the percentage of total daily calories from carbohydrate decreased (54.81% vs. 44.34%), whereas from protein (18.57% vs. 26.24%) and fat (31.06% vs. 35.18%) increased post-surgery compared to baseline. Although the percentage of daily energy intake from macronutrients were in the recommended range after the RYGB surgery. Another study that conducted on 69 patients 4 years after RYGB surgery, 52% Caucasian, 25% African-American, 23% Hispanic, reported that the total daily energy intake was 1733 ± 930 kcal/day, with 44%, 22%, and 33% of calories from carbohydrates, protein and fat, respectively [10].

It appears that RYGB is the successful Bariatric operation to achieve significant and long-term reduction in daily energy intake. The long-term follow-up studies in patients after RYGB surgery showed that despite a graduated increase in dietary energy intake, it did not return to baseline values in patients [11]. The mean intake of dietary energy has been reported in a range of 1000-1800 kcal at the 1st year after surgery [12].

Miller et al. reported that patients had an imbalance dietary intake at baseline and throughout the 12 months after RYGB surgery, as the intake of protein and percent energy from carbohydrate increased and intake of fat and specific fatty acids decreased [9]. Previous investigations have been indicated that high-level intake of proteins after the gastric bypass surgery may improve the reduction in free fat mass, ameliorate the basal metabolic rate and help to glycemic control [12-14].

Due to the high absorption of proteins in the middle ileum, the intake of dietary protein is lower in patients after restrictive Bariatric surgeries compared to gastric bypass operations [15]. The micronutrient deficiency following the Bariatric surgeries is an important concern, particularly in patients undergoing bypass surgery, which combines two methods of restriction and malabsorption. It was noticeable that in our study, the intake of micronutrients except for vitamins B1, B2, B3, B6, B12, iron, zink, and copper were lower than the RDA. In addition, the values of all micronutrients were lower than EAR except for B1, B2, B3, B6, B12, C, iron, and copper.

The absolute and relative intake of all micronutrients with regards to the RAD and EAR were lower in 3 months post-surgery compared to baseline (pre-surgery). However, the decrease intake of micronutrients was statistically significant for vitamin B1, B2, B3, B6, folate, iron, zinc, and copper. Therefore, the intake of niacin (vitamin B3) was in the defined range of RDA and the intake of iron was in the defined range of EAR after the surgery.

Our observation indicated that gastric bypass surgery could cause to micronutrient deficiency or even intensify it via both two mechanisms of restriction and malabsorption. In the previous studies, the most frequent mineral and vitamin deficiency after Bariatric surgeries included vitamin A, vitamin D, folate, vitamin B1, B2, B3, B6, zinc, calcium, and copper [16].

Iron is one of the most important elements that play a significant role in many vital functions of the body such as electron chain transport system.

Several factors contributed in iron deficiency after bypass Bariatric surgeries, including decrease intake of red meat as the main dietary source of iron, bypass the stomach and reduce the acidity of the stomach which is necessary for bioavailability and absorption of iron. In addition to iron, other micronutrients such as zinc and copper need to low pH stomach environment for solution and absorption in gastrointestinal system. Therefore, reduce the acidity of the stomach after gastric bypass surgery may be the cause of Zn and Cu deficiencies after surgery [17].

In our study, we showed that dietary intakes of vitamin B1, B2, B3, B6, and folate were decreased 202.56% versus 93.71%, 139.76% versus 98.33%, 250.3% versus 115.04%, 120.9% versus 74.86% and 33.54% versus 22.20% of RDA recommendation, respectively at 3 months post-compared to pre-surgery.

Deficiencies of B vitamins are common after RYGB operations due the high incidence of nausea/vomiting and decreased consumption of the dietary sources of vitamins B following surgery. In the other hand, reduced gastric acid and eliminated the upper small intestine may be other causes of vitamin B-complex deficiency post-surgery [18, 19].

Folic acid deficiency is less common after RYGB surgery compared to iron and vitamin B12 deficiencies that may be due to decreased acid secretion after gastric bypass in RYGB surgery [13].

In addition to the observational nature of this study, the current study has several limitations including small sample size, short duration of follow-up and lack of the control group. Lacked the completion of the food frequency questionnaires and food records for participants were another limitation of our study.

Future studies should include long-term follow-up duration after surgeries and larger sample size to determine dietary intake and eating behavior after Bariatric surgeries.

Although, there are differences in the eating patterns in each population, more research are needed to evaluate the quality and quantity of dietary intakes according to each patient dietary pattern prior and post-surgery.

Conclusions our data demonstrate that low dietary intake of energy, micro- and macro-nutrients (absolute values and relative to the RDA), are highly prevalent after RYGB surgery.

Therefore dietary counseling, clinical assessments, and the recommendation of supplements if needed in pre- and post-operatively, might be considered for health promotion after RYGB surgeries.

Acknowledgments

This study was supported by Vice-chancellor for Research of Tehran University of Medical Sciences (TUMS) (grant no: EC_00299).

Conflict of interest

None of the authors had any personal or financial conflicts of interest.

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