

Original

Evolution of nutritional, hematologic and biochemical changes in obese women during 8 weeks after Roux-en-Y gastric bypass

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Abstract

Obesity is a chronic disease of multifactorial origin and currently is a serious public health problem. The treatment of morbid obesity can be effectively done by bariatric surgery. The present study aimed to evaluate the influence of changes in food intake on body composition and some hematologic and biochemical variables in the period of eight weeks after Roux-en-Y gastric bypass (RYGB). The study included 22 women submitted to RYGB. We evaluated anthropometric, nutritional, hematologic and biochemical variables before and 14, 28, 42 and 56 days after surgery. The patients showed a decrease in caloric intake and hence macro- and micronutrients, with significant loss of weight and decrease in body mass index (BMI). Decreases in body weight and BMI were associated with reduced blood levels of total cholesterol, VLDL-C, LDL-C, triglycerides and glucose with time after surgery. The decrease in caloric intake was also associated with decreased intake of protein, iron and calcium, with a decline in hemoglobin, hematocrit and red blood count, and RDW increased after surgery.

(*Nutr Hosp.* 2012;27:1134-1140)

DOI:10.3305/nh.2012.27.4.5812

Key words: *Bariatric surgery. Gastric bypass. Obesity. Weight loss. Nutrition.*

EVOLUCIÓN DE LOS CAMBIOS NUTRICIONALES, HEMATOLÓGICOS Y BIOQUÍMICOS EN MUJERES OBESAS DURANTE 8 SEMANAS DESPUÉS DE BYPASS GÁSTRICO EN Y DE ROUX

Resumen

La obesidad es una enfermedad crónica de origen multifactorial y actualmente es un problema grave de salud pública. El tratamiento de la obesidad mórbida puede hacerse eficazmente por la cirugía bariátrica. El presente estudio tuvo como objetivo evaluar la influencia de los cambios en la ingesta de alimentos sobre la composición corporal y algunas variables hematológicas y bioquímicas en el plazo de ocho semanas después de bypass gástrico en Y de Roux (BGYR). El estudio incluyó a 22 mujeres sometidas a BGYR. Se evaluaron los parámetros antropométricos, nutricionales, bioquímicos antes de la operación y el 14°, 28°, 42° e 56° día después de la cirugía. Los pacientes mostraron cambios significativos en la ingesta de alimentos, con una disminución en la ingesta de calorías y por lo tanto, los macro y micronutrientes, con una pérdida significativa de peso y disminución del índice de masa corporal (IMC). La disminución en el peso corporal y el IMC se asoció con niveles reducidos de colesterol total, VLDL-C, LDL-C, triglicéridos y glucosa con el tiempo después de la cirugía. La disminución de la ingesta calórica también se asoció con disminución de la ingesta de proteínas, hierro y calcio, con una disminución en la hemoglobina, el hematocrito y el recuento de glóbulos rojos, y RDW aumentado después de la cirugía.

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Palabras clave: *Cirugía bariátrica. Bypass gástrico. Obesidad. Pérdida de peso. Nutrición.*

Introduction

Obesity is a chronic, heterogeneous and multifactorial disease, resulting from an imbalance between energy

intake and energy consumed. Currently, it is considered a major public health problem in developed countries due to the increase of its prevalence and the fact that it is associated with several diseases such as hypertension (HBP), diabetes mellitus (DM), arthropathies, dyslipidemia, respiratory insufficiencies and coronary heart disease, among others.¹ Obesity is considered by itself a cardiovascular risk factor, besides being the main risk factor for type 2 diabetes.^{2,3}

Bariatric surgery is considered an effective strategy for weight loss in morbid obesity.⁴ Among the various

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Recibido: 21-II-2012.
Aceptado: 2-III-2012.

Table I
Evolution of body weight, weight loss, excess weight loss (EWL) and BMI (mean \pm standard deviation) of patients (n = 22) before and after RYGB surgery

	Pre-operative	Post-operative			
		14 th day	28 th day	42 th day	56 th day
Body weight (kg)	115.26 \pm 15.19 ^a	106.87 \pm 14.63	104.15 \pm 14.29	101.61 \pm 13.91 ^a	99.56 \pm 13.53 ^a
Weight loss (%)	–	7.31 \pm 1.51 ^a	9.71 \pm 1.50 ^{ab}	11.87 \pm 1.90 ^{abc}	13.65 \pm 2.10 ^{abc}
Excess weight loss (%)	–	17.72 \pm 5.66 ^a	23.46 \pm 6.80 ^b	28.65 \pm 7.95 ^a	32.98 \pm 9.14 ^{ab}
BMI (kg/m ²)	44.28 \pm 5.45 ^a	41.05 \pm 5.20	40.00 \pm 5.06 ^a	39.02 \pm 4.87 ^a	38.23 \pm 4.78 ^a

^{a,b,c}Each pair of the same letter indicates a statistically significant difference (p < 0.05) between the different moments of the study (ANOVA, Tukey's test).

types of bariatric surgery there is the technique of Roux-en-Y gastric bypass (RYGB), which has been considered the most effective procedure^{5,6} and therefore is the most widely used in Brazil. This type of surgery provides a satisfactory loss of weight excess, in addition to the concomitant improvement of comorbidities and quality of life.^{7,8,9}

RYGB surgery also results in changes in nutritional status of the patient. Limiting the intake of food due to restriction of stomach capacity, along with the direct passage of food to the jejunum, results in decreased intake and absorption of some nutrients. However, there are still few studies that address the changes in food intake of macro- and micronutrients and their relationship to hematologic and biochemical changes to which are subject patients undergoing RYGB, particularly in the short term. Within this context, this study aims to evaluate the influence of these changes at different times after surgery to RYGB.

Material and methods

This study followed the ethical standards of the Declaration of Helsinki and was approved by the Ethics Committee in Research of the Federal University of Uberlândia, Brazil. Each participant signed a consent form.

We conducted a prospective observational study with 22 women candidates for bariatric surgery in the Obesity Center of Uberlândia (CENTROBESO), of which 15 had morbid obesity and 7 had class II obesity. All patients underwent RYGB surgery, in line with inclusion and exclusion criteria for surgery as the consensus of surgery for morbid obesity.¹⁰

Anthropometric parameters (weight, BMI), clinical history (comorbidities, medication use), and hematologic and biochemical variables (total cholesterol and fractions, triglycerides and fasting glucose) of the patients were evaluated before and 14, 28, 42 and 56 days after surgery. Blood samples for hematologic and biochemical tests were collected after an overnight fast of 12 hours.

The patients were instructed regarding the changes in eating habits after surgery, especially regarding the

quantity and nutritional quality of food eaten. The post-operative diet consisted of four phases according with the nutritional protocol of CENTROBESO: 1) liquid diet (21 days), 2) soft diet (7 days), 3) semi-solid diet (15 days) and 4) solid diet (final). All patients were advised to make use of multivitamin-mineral supplementation and iron (50 mg of elemental iron daily) after 15 days of surgery.

Dietary intake was assessed using three food records made in two midweek days and in one weekend day, at different times (before surgery and in the four phases of the diet after surgery). For the nutritional analysis of food records and macronutrients (carbohydrates, proteins and lipids) and micronutrients (iron and calcium), we used the software Virtual Nutri Plus^a (VirtualNutri +, São Paulo, SP, Brazil). Statistical analysis was performed using the application OriginPro 8.0 (Microcal Inc., Northampton Massachusetts, USA).

The numerical results were evaluated for distribution through the Kolmogorov-Smirnov test. The results were expressed as mean and standard deviation (SD). The correlations between changes in variables were tested using Pearson's correlation, with P < 0.05 indicating statistically significant relationships.

Results

The average age of the population was 37.91 \pm 9.13 years. The mean body weight of patients before surgery was 115.25 \pm 15.59 kg and mean BMI was 44.28 \pm 5.45 kg/m². The evolution of body weight, weight loss, excess weight loss (EWL) and BMI of patients undergoing the RYGB at different times is shown in table I.

Of the 22 volunteers, six (27.3%) had impaired fasting glucose (100-125 mg/dL), one (4.5%) was classified as diabetic (\geq 126 mg/dL) and 15 (68.2%) had normal preoperative glucose (70-99 mg/dL).¹¹ After 56 days of surgery, only one patient had impaired fasting glucose (4.5%) and the remaining 21 patients (95.5%) had normal fasting glucose.

In relation to blood cholesterol, 22 volunteers from 11 (50%) had elevated cholesterol (\geq 240 mg/dL), 9 (40.9%) had borderline cholesterol (200-239 mg/dL)

Table II
Analysis of simple correlations of anthropometric, hematologic and biochemical variables with time before and after surgery (0-56 days)

<i>Variables</i>	<i>n*</i>	<i>r²</i>	<i>p</i>
Body weight	110	(-) 0.1180	0.0001 [§]
Body Mass Index	110	(-) 0.1382	0.0000 [§]
Triglycerides	110	(-) 0.0717	0.0027 [§]
Total cholesterol	110	(-) 0.0515	0.0098 [§]
VLDL-cholesterol	110	(-) 0.0717	0.0027 [§]
LDL-cholesterol	110	(-) 0.0319	0.0344 [§]
HDL-cholesterol	110	(+) 0.0090	0.8695
Blood glucose	107	(-) 0.0612	0.0059 [§]
Mean corpuscular hemoglobin concentration	110	(-) 0.0031	0.2499
Mean corpuscular hemoglobin	110	(-) 0.0005	0.3344
Mean corpuscular volume	110	(-) 0.0054	0.5227
Red cell distribution width	110	(+) 0.0409	0.0193 [§]
Hemoglobin	110	(-) 0.1032	0.0004 [§]
Hematocrit	110	(-) 0.0862	0.0011 [§]
RBC count	110	(-) 0.0719	0.0027 [§]

*n = number of volunteers (22) x number of moments considered in the study (5).

[§]p < 0.05 indicating statistically significant correlations.

and 2 (9.1%) had cholesterol levels within desirable levels before surgery (< 200 mg/dL).¹² On 56 day after surgery, only one volunteer (4.5%) had high cholesterol, 3 (13.6%) had borderline cholesterol and 18 (81.8%) had normal cholesterol. The levels of HDL-C were lower than recommended (< 40 mg/dL) before the procedure in 6 (27.3%) and desirable in 16 (72.7%) of the volunteers (\geq 40 mg/dL).¹² After 14 days of surgery, the HDL-C levels were low in 19 (86.4%) and desirable in 3 (13.6%) of the volunteers. But 56 days after surgery the levels of HDL-C remained below the recommended in 9 (40.9%) and within the recommended values in 13 (59.1%) of the volunteers.

Before surgery, triglyceride levels were high (201-499 mg/dL) in four (18.2%), borderline (150-200 mg/dL) in 8 patients (36.4%) and optimum (<150 mg/dL) in 10 (45.5%) of the volunteers.¹² At 56 days after surgery, levels of triglycerides were borderline in 5 (22.7%) and optimum in 17 (77.3%) of the volunteers.

The simple correlation analysis between anthropometric, hematologic and biochemical variables with time of surgery were statistically significant, except for HDL-C, MCHC, MCH and MCV, as shown in table II.

After bariatric surgery, patients showed significant changes in food intake, with decreased caloric intake and, therefore, of macronutrients (fig. 1) and micronutrients (fig. 2).

Discussion

With the increase in the incidence of obesity and the failure of noninvasive methods for promoting weight

loss and its maintenance, bariatric surgery has become an effective strategy for the treatment of morbid obesity, and consequently for the improvement of comorbidities and quality of life of the patient.

The RYGB promotes a reduction in body weight due to decreased energy intake. The weight loss supports the biochemical changes associated with structural and functional homeostasis of the organism, such as the improvement in glycemic control. The reduction in body weight also leads to biochemical and hematologic changes that affect the supply and demand of O₂ in the tissues (fig. 3).

In this prospective study conducted with 22 women submitted to RYGB, patients experienced a significant loss of body weight and, therefore, of BMI, during the period evaluated.

The prevalence of type 2 diabetes is attributable to overweight and obesity in more than 95% of cases.¹³ Several studies show that the risk of developing this disease increases with increasing body weight. Indeed, in a population of 46 subjects with morbid obesity, Ocón and colleagues¹⁴ found 67.3% of patients with insulin resistance before RYGB, but no patients with this clinical condition after surgery.

The results of this study showed a prevalence of 27.3% of patients with impaired fasting glucose (100-125 mg/dL) and 4.5% of diabetic patients (\geq 126 mg/dL) in the population studied. It is worth mentioning that the size of this population was lower when compared to other studies in the literature.^{15,16,17}

The results also showed that half of the patients had higher than desirable cholesterol (\geq 240 mg/dL), 27.3% had HDL-C levels below recommended levels (< 40 mg/dL) and 18.2% had triglycerides above the

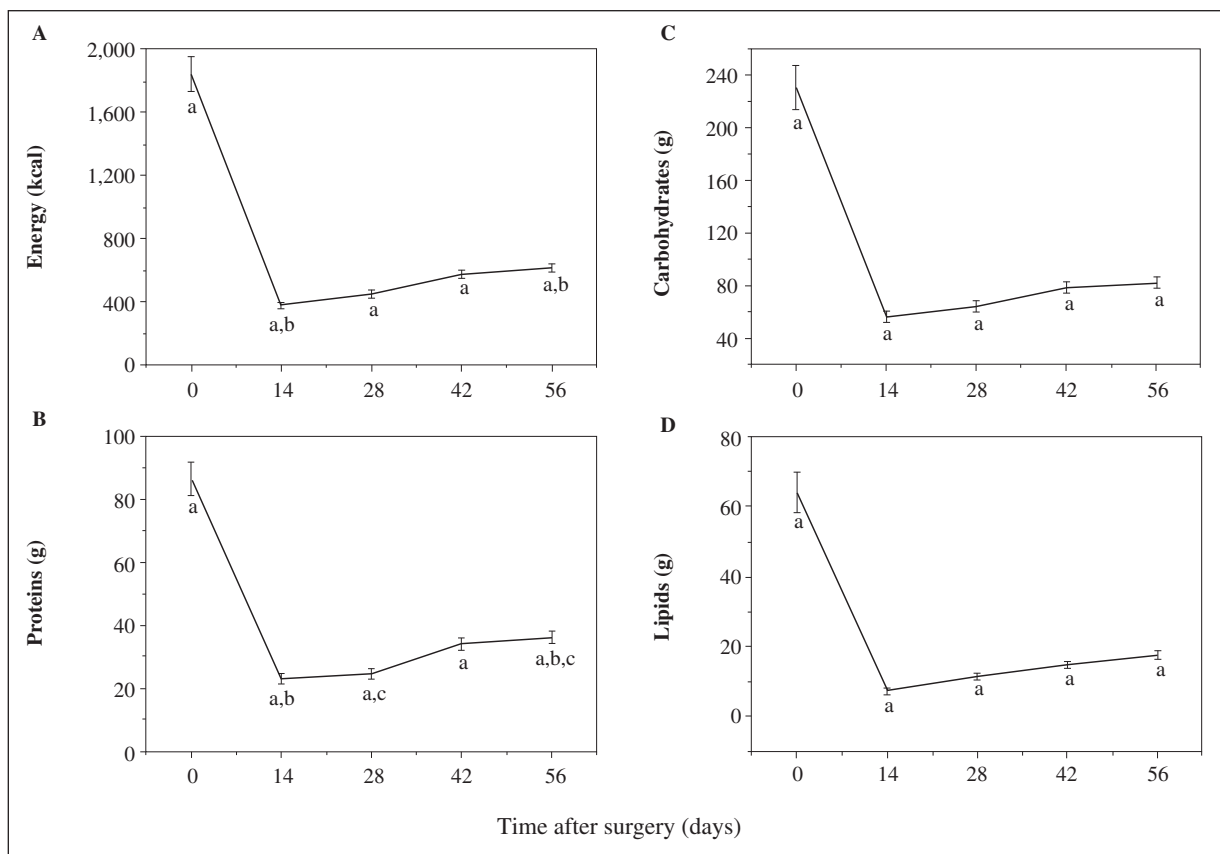


Fig. 1.—Relation of the ingestion (mean \pm standard deviation, $n = 22$) of energy. A) proteins, B) carbohydrates; c) and lipids D) with time before and after RYGB. ^{a,b,c}Each pair of the same letter indicates a statistically significant difference ($p < 0.05$) between the periods (ANOVA, Tukey's test).

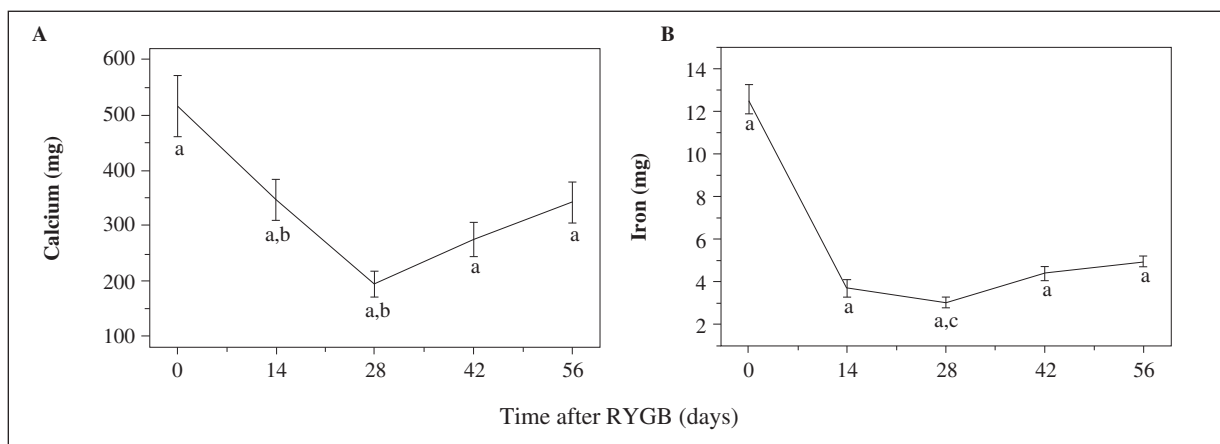


Fig. 2.—Relation of ingestion (mean \pm standard deviation, $n = 22$) of iron. A) and calcium B) with time before after RYGB surgery. ^{a,b,c}Each pair of the same letter indicates a statistically significant difference ($p < 0.05$) between the periods (ANOVA, Tukey's test).

value of reference (201-499 mg/dL). These values were close to the frequencies of 53 of hypercholesterolemia and 18.6% of hypertriglyceridemia reported by Cercato and colleagues¹⁸ in a population of 412 obese women with 42.9 ± 13.4 years in São Paulo.

In the preoperative period was observed average intakes of $1,845.47 \pm 526.33$ kcal/day, 231.06 ± 80.01

g/day (50.1%) of carbohydrates, 86.45 ± 24.94 g/day (18.7%) of proteins and 64.15 ± 26.33 g/day (31.3%) of lipids. These data are similar to values of $1,608 \pm 752$ kcal/day, 219.3 ± 111.6 g/day (54.5%) of carbohydrates, 69.1 ± 27.4 g/day (17.7%) of proteins and 48.8 ± 30.0 g/day (26.8%) of lipids, reported by Carrasco and colegas¹⁹ for a population of 23 women with BMI of 44.5 ± 3.7 prior to the RYGB.

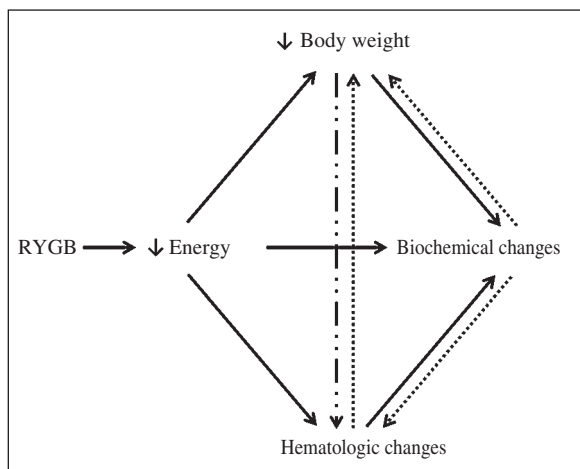


Fig. 3.—Possible interrelations between RYGB, energy intake and anthropometric, hematologic and biochemical variables.

The reduced caloric intake found before surgery can be partly explained by subnotification of food consumption by patients or even because they were following nutritional guidelines they had before the study.

The change in diet after the surgery leads to a drastic reduction in the ingestion of calories and hence also of macro- and micronutrients. As might be expected due to the surgical procedure, in the present study there was a reduction in caloric intake and thus lower intake of proteins, lipids, carbohydrates and micronutrients. 14 days after surgery, the liquid diet provided to patients an average intake of 375.92 ± 103.03 kcal/day, 56.2 ± 17.52 g/day of carbohydrates, 23.12 ± 7.50 g/day protein and 7.16 ± 3.84 g/day of lipids.

In the present study there was a progressive increase in caloric intake with the time of surgery. About two months after surgery, the patients took an average of 617.82 ± 116.17 kcal/day of energy, 82.21 ± 19.24 g/day of carbohydrates, 36.26 ± 9.30 g/day of proteins and 17.46 ± 5.93 g/day of lipids. Dias and colleagues,²⁰ assessing the food intake of 40 women with three months of surgery, found an average intake of 529.4 ± 47.5 kcal/day of energy.

The results presented in figures 1 and 2 show that the mean energy intake was significantly larger before than at all times after surgery. However, there was a significant increase in the average caloric intake between the 14th and 56th days after surgery. Although the average intake of macronutrients (carbohydrates, proteins and lipids) after surgery was significantly lower than in the preoperative period, there was a significant increase in the average intake of proteins in the 56th postoperative day when compared with the 14th and 28th days after surgery. The average intake of iron and calcium decreased significantly postoperatively. However, the average intake of iron showed a significant increase between the 28th and 56th days postoperatively.

Several studies show that there is a progressive increase in food intake after surgery.^{19,20,21} The diet in the immediate postoperative period has a very low caloric content that increases slowly over the months. But even after a year of surgery, most patients remain with intakes of calories and proteins much smaller than those recommended.

Dietary proteins are important for promoting satiety and maintenance of lean body mass in weight loss,²² although it is questionable the role of protein-rich diet to prevent weight regain in patients undergoing RYGB.²³

The intake of 60-120 g of protein daily is recommended for the maintenance of lean body mass during the loss of weight.²² Protein intakes in the assessed periods were below the recommended levels in the current study, as well as in other published studies,^{19,21} which makes necessary the supplementation of this nutrient. The low protein intake, especially in the first month after surgery is due to intolerance for foods, especially meat, and to the small amount of food ingested.^{21,24}

There was a gradual increase in energy intake with the time of surgery, as well as the intake of lipids, as previously described. After 56 days of surgery, there was an average intake of 17.5 g of lipids, which corresponds to 25.4% of the caloric intake. Brolin and colleagues²⁵ found 31% and 34% of caloric intake in lipids 6 and 12 months after surgery, respectively. The lower intake of lipids found in the present study can be due to the period analyzed, when patients still have a more restrictive diet.

Recent guidelines for nutritional support for patients undergoing bariatric surgery do not recommend a specific ratio of carbohydrates in the diet. Observational studies show an intake of approximately 45% of carbohydrates.^{26,27} The higher average consumption of carbohydrates (50,1%) observed in this study can be explained by period of time considered, as in the first months after surgery carbohydrates predominate in the diets.

In this study, we also evaluated the intake of the micronutrients calcium and iron. Calcium intake was far below the recommendation for the age group of volunteers, which is 1 g/day,²⁸ both before (517.4 mg/day) and 56 days after surgery (343.2 mg/day).

A study by Campos²⁹ found an average calcium intake of 525.5 mg/day in a population consisting of 40 women after more than eight years of RYGB. These data show that low calcium intake continues in the long term.

With respect to iron, there was an ingestion of this mineral below the 18 mg/day recommended³⁰ for the age range of the volunteers, especially in the first month after surgery. In this study, all patients were advised to make use of complex of vitamins and minerals, prescribed at hospital discharge.

Regarding hematologic variables considered in this study, there was a decrease in hemoglobin, hematocrit and red blood count, but increase in RDW, with time after surgery.

Several studies show a significant improvement in lipid profile after bariatric surgery, including lowering triglycerides and LDL-C and increased HDL-C.¹³ The relations of the biochemical variables with time after surgery showed the occurrence of decline in triglycerides, total cholesterol, VLDL-C and LDL-C and also in the blood levels of glucose.

In the preoperative stage of the study, one patient was classified as diabetic and six patients had impaired fasting glucose, but 56 days after surgery there was significant decline in blood glucose and only one patient, one previously diagnosed as diabetic, had impaired fasting glucose.

Observational studies show an improvement in glycemic control in a few days after surgery.³¹ According to Cummings,³² this acute improvement could not be attributed to weight loss and nor to the improvement in insulin resistance.

A study by Lim and colleagues,³³ in which 11 volunteers with diabetes underwent a severe dietary restriction, reported normalization of fasting glucose and sensitivity to insulin after eight weeks of energy restriction.

The negative energy balance that occurs immediately after surgery may explain the normalization of blood glucose due to the reduction of glucotoxicity on pancreatic cells.³⁴ The glucotoxicity, characterized by chronic effects of hyperglycemia on the pancreatic beta cell function, leads to decreased glucose tolerance due to exhaustion of these cells and reduction of its mass by apoptosis.³⁵

After surgery, patients gradually increase the ingestion of calories. However, concomitant weight loss occurs, which leads to improved glucose tolerance. This improvement is due to increased sensitivity to insulin, with decreasing glucotoxicity, lipotoxicity on pancreatic beta cells.³² The lipotoxicity, resulting from high levels of fatty acids for prolonged periods, results in a reduction of beta cell responsiveness to blood levels of glucose.^{35,36}

Another mechanism that may act in the reversal of hyperglycemia in association with low energy intake involves a set of changes in the release of gastrointestinal hormones, such as reduced production of ghrelin and elevation of serum GLP1.³⁷

In summary, the remission of hyperglycemia after RYGB surgery should be the result of a combination of factors such as low-calorie diet associated with weight loss, and changes in production and/or sensitivity to the action of gastrointestinal hormones and own insulin.³⁸

Conclusions

Data from this study show that patients undergoing RYGB presented declines in body weight and BMI in the study period. These results were associated with a reduction in calorie intake, with decreased blood levels of total

cholesterol, VLDL-C, LDL-C, triglycerides and glucose after surgery. Although the decrease in energy intake has meant an improvement in obesity-related comorbidities, it was also associated with decreased intake of proteins and iron, with a reduction in hemoglobin, hematocrit and red blood count, and RDW increased after the RYGB procedure, even with supplementation of vitamins and minerals after 15 days of surgery.

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