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Bioelectrical impedance vector analysis in obese women before and after bariatric surgery: Changes in body composition

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ABSTRACT

Objective: Because of the inefficacy of standard methods for the evaluation of body composition of grade III obese individuals, it is difficult to analyze the quality of weight loss after bariatric surgery in these patients. Electrical bioimpedance vector analysis and the RXc graph uses crude resistance (R) and reactance (Xc) values, like components of the Z vector, to monitor variations in body fluid and the nutritional status of obese individuals. Using bioelectrical impedance vector analysis (BIVA) and the RXc graph, the objective of the present study was to evaluate long-term changes in weight and body composition of obese women after Roux-en-Y bariatric surgery.
Methods: A study was conducted on 43 grade III obese women submitted to bariatric surgery. Anthropometric and bioimpedance (800 mA–50 kHz) data were obtained during the preoperative period and 1, 2, 3, and 4 y after surgery. BIVA was performed by plotting resistance and reactance values corrected for body height (R/H and Xc/H, Ohm/m) as bivariates on the RXc graph. BIVA software was used to plot the vectors of the RXc plane.
Results: Surgery promoted changes in body composition, with a reduction of fat mass and of fat-free mass. During the postoperative period, the vectors demonstrated migration to the right lower quadrant of the graph, corresponding to the classification of cachexia and water retention.
Conclusion: Weight loss due to surgery results in an important reduction of fat-free mass characterized by the position of most individuals in the cachexia quadrant throughout the postoperative period.

Introduction

The prevalence of obesity in recent (defined by body mass index [BMI] $\geq$ 30 kg/m^2) has markedly increased over the past decades, representing a worldwide epidemic [1]. Clinical treatment, including behavioral changes with a reduction of energy intake and increased practice of physical activity, at times associated with drug treatment, results in modest and transitory effects, without resolving the problem of severe obesity [2]. The indication of surgical treatment currently is increasing and today is accepted as the only efficient tool for the treatment of grade III obesity, inducing the loss of excess weight and its later maintenance, as well as positive results regarding comorbidity conditions such as type 2 diabetes mellitus (T2 DM), hyperlipidemia, and arterial hypertension [2]. Roux-en-Y gastric bypass is currently the procedure most accepted by surgeons [3].

Ideally, weight loss should primarily occur due to reduction of fat mass (FM), thus minimizing the loss of fat-free mass (FFM) [4]. The assessment of body composition plays an important role in clinical evaluation and in monitoring FM and FFM changes during specific therapeutic regimens in obese individuals as a way to determine the efficacy of the interventions regarding weight loss [5]. However, the validation of body composition measurements in obese individuals is still scarce [6]. Some

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traditional methods used for individuals of normal weight or overweight are ineffective for the evaluation of grade III obese individuals due to practical reasons such as patient size and design and capacity of the equipment [6].

Bioelectrical impedance (BIA) is a simple, low-cost, and noninvasive procedure used for the evaluation of body composition in clinical routine and in weight reduction programs [7]. The method is based on the principle that electric flow is facilitated through hydrated tissue and extracellular water compared with adipose tissue, providing reproducible and rapidly obtained results [8]. Although BIA is widely employed for the evaluation of grade III obese individuals, its use is still controversial [5]. Studies have demonstrated that obese patients present variations of soft tissue hydration, which may generate errors in the evaluation of body composition by standard methods such as predictive equations [6,9,10]. It has been demonstrated that changes in body composition occur in obese individuals, characterized by an increased quantity of FM and a reduction of total body water [10].

Bioelectrical impedance vector analysis (BIVA) and the RXc graph are useful methods for the determination of changes in tissue hydration and nutritional status [11]. BIVA uses resistance (R) and reactance (Xc) values as components of the Z vector in the RXc graph, with R and Xc being normalized for height (R/H and Xc/H) and plotted as bivariates in the RXc graph [12]. Thus, the length of the vector indicates the state of hydration and the migration of the vector correlates with the quantity of soft tissue regardless of the measurements of body weight or predictive equations [12].

The postoperative period of bariatric surgery is accompanied by rapid weight loss. Due to the inefficacy of standard methods for the evaluation of the body composition of grade III obese individuals, however, it is difficult to analyze the quality of weight loss after surgery. Thus, the objective of the present study was to evaluate the long-term changes in weight and in body composition after Roux-en-Y bariatric surgery by BIVA and the RXc graph in obese women.

Material and methods

Study design and participants

The sample consisted of women with grade III obesity submitted to bariatric surgery by Roux-en-Y gastric bypass and followed up at the National Reference Center of Bariatric Surgery of the University Hospital, Faculty of Medicine of Ribeirão Preto, University of São Paulo (HC-FMRP/USP). Data were collected retrospectively by analysis of medical/nutritional records. Among all the patients followed up at the service, those who attended all return visits and for whom complete information was available regarding anthropometry and body composition were included. The study was approved by the Research Ethics Committee of HC-FMRP/USP and all patients gave written informed consent to participate.

Data collection

Body composition analysis of two compartments was obtained by standard BIA (R, Xc, FFM [kg], FM [kg], and total body water [kg]) during the preoperative period and 1, 2, 3, and 4 y after surgery, as well as weight (kg), height (m), and BMI (kg/m^2). As part of the protocol of the service, body weight was measured with a Filizola scale with 100 g precision (Filizola, Sao Paulo, Brazil), with the participant standing erect, barefoot, and wearing minimal light clothing. Height was measured with a graded metal rod with a maximum length of 2 m and 0.5 cm precision. BMI was calculated as weight divided by height squared.

A monofrequency Quantum BIA 101 q-RJL Systems analyzer (Clinton Township, MI, USA) was used to evaluate body composition. The analyzer provides values of resistance and reactance to the passage of an electrical current of 800 μA and 50 kHz by means of electrodes positioned on the dorsum of the hand and of the ipsilateral foot of individuals lying in dorsal decubitus. Patients were previously instructed to avoid alcohol intake and exhausting physical activity on the day before the exam and to limit food or fluid intake to 4 h before the test.

FFM and FM were determined by means of linear regression equations validated for adults [13] using the RJL Systems Weight Manager 2.05 a software. The phase-angle (PA) was calculated from R and Xc values according to this equation [14]: $\Phi = Xc/R \times 180/\pi$.

Based on the RXc graph method, R and Xc values were standardized for patient height (H), with R/H and Xc/H values being obtained as Ohm/m. BIVA software was used to plot the vectors of the RXc plane [15]. The 50%, 75%, and 95% tolerance ellipses of a reference population determined in a previous study [16] were used to evaluate the evolution of the individual vectors of the patients. As previously reported [15], the ellipses were divided into four quadrants named obese, athletic, lean, and cachectic.

Statistical analysis

Mixed-effects regression models were used for the analysis of the anthropometric and body composition variables during the postoperative period. For group comparison, ellipses of 95% confidence were calculated for the mean impedance vectors and the Hotelling T^2 test and univariate analysis (F test) were used. The absence of overlap of the 95% tolerance ellipses indicated a significant difference ($P < 0.05$) between the mean values of the vectors positioned on the RXc plane.

Results

Longitudinal evaluation

To date, the Reference Center of Bariatric Surgery has conducted 550 bariatric surgeries. Of all patients undergoing the surgery, 370 completed 4 y of postoperative period; 124 patients had BIA data, and only 54 had complete BIA data for every 4-y period; however, 11 of these were men. Thus, the study was conducted on 43 women with a mean age of 43.2 ± 9.3 y and a mean height of 1.62 ± 0.1 cm during the preoperative period. The anthropometric and body composition data of the patients are reported in Table 1. During the preoperative period 27.9% patients had T2 DM, 58.1% had hypertension, 25.6% had dyslipidemia, 14% had hypothyroidism, and 4.6% had hyperuricemia.

A reduction of 47.4 ± 15.7 kg (35%) of initial weight, 8.9 ± 4 kg (14.2%) of FFM, and 38.5 ± 12 kg (52.6%) of FM was observed during the postoperative year 1, with 81.2% of the weight loss involving FM and 18.8% involving FFM. PA, total body water, and Xc also resulted in a significant reduction ($P < 0.001$) during the first year.

By postoperative year 4, there was a 15.5% reduction of FFM in parallel to a 9.6% reduction of total body water, suggesting loss of muscle and bone tissue. The significant reduction of R and PA values is emphasized ($P < 0.001$).

Evolution of individual vectors

The distribution of vectors in the tolerance ellipses during the preoperative period and at the different postoperative times is illustrated in Figure 1. It can be seen that during the preoperative period, 88.4% of the vectors were outside the 95% ellipse and only 11.6% demonstrated adequate tissue hydration.

Short vectors tending to be located on the lower right side of the graph were observed at all-time points and, after bariatric surgery, the vectors indicated a rightward shift characterizing migration of the vectors parallel to the major axis of the graph. At the end of the study, the patients were predominantly located in the quadrant denoted as cachexia and water retention, according to a previous report [15].

Group comparison

Figure 2 shows the 95% tolerance ellipses for the groups. There was a significant difference between the preoperative and