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Laparoscopic gastric banding and body composition in morbid obesity

Bruna Guida [a,*], Anna Belfiore [a], Luigi Angrisani [c], Fausta Micanti [b], Concetta Mauriello [a], Rossella Trio [a], Pierluigi Pecoraro [a], Claudio Falconi [a]

[a] *Physiology Nutrition Unit, Department of Neuroscience, University Federico II, Naples, Italy*
[b] *Psychotherapy Unit, Department of Neuroscience, University Federico II, Naples, Italy*
[c] *S-Giovanni Bosco Hospital, Department of Surgery, Naples, Italy*

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Summary *Background and aim:* Gastric banding induced considerable and rapid weight loss in morbid obesity. Nevertheless data on changes in body composition following gastric banding are scanty. In this study, we evaluated the 2-year changes in body composition in a small group of morbidly obese women treated by laparoscopic adjustable gastric banding (LAGB) associated with a well balanced low-calorie diet.

Methods and results: We studied 20 premenopausal morbid obese women with BMI ranging from 35 to 57 (kg/m^2) before, and 6, 12 and 24 months after laparoscopic adjustable gastric banding (LAGB). A well balanced 5.4 MJ/day hypocaloric diet was prescribed after surgery. Total body water (TBW), fat-free mass (FFM) and fat mass (FM) were investigated using conventional bioelectrical impedance analysis (BIA). Tissue hydration was also assessed by impedance vector analysis and the RXc graph method.

The subjects showed a total weight loss of 28% of baseline body weight. In the first 6 months after surgery, patients lost 18.5±5.9 kg of body weight (17.6±6.2 kg of FM and 0.7±1.4 kg of FFM). From 6 to 12 months, a further 12.5±7.5 kg of body weight was lost (10.5±8.2 kg of FM and 2.2±3.8 kg of FFM). During the last 12 months, weight loss was 3.0±2.3 kg (1.9±3.7 kg of FM and 1.1±2.9 kg of FFM). The weight loss observed after LAGB was mainly due to a decrease in FM, whereas TBW, FFM and BCM were only slightly and non-significantly reduced. No changes in body hydration status were observed after surgery.

* Corresponding author. Dept of Physiology, Faculty of Medicine, University "Federico II" of Naples, Via Tasso 91/B 80100 Napoli, Italy. Tel.: +39 81 7463216; fax: +39 81 7463639.
E-mail address: bguida@unina.it (B. Guida).

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Conclusions: LAGB associated with a well balanced low-calorie diet achieved a satisfactory 2-year weight loss, while sparing FFM and not causing body fluid alterations.

Introduction

The ideal goal of weight reduction therapy in obesity is to obtain and maintain a reduction of fat mass (FM), without inducing a significant loss of fat free mass (FFM) [1]. Maintenance of FFM during weight loss is considered to have a crucial role in preservation of skeletal integrity and functional capacity [2]. Moreover, the reduction in resting energy expenditure associated with a loss of FFM may contribute to the difficulty in the maintenance of body weight often observed in obese subjects after a period of negative energy balance [1,3].

Maintenance of FFM is of particular concern in obesity surgery, when large amounts of body weight are lost in morbidly obese patients. At the beginning of the bariatric surgery experience, an undesirable loss of body cell mass with a relative expansion of extracellular component, a pattern characteristic of malnutrition, was observed after jejunolieal bypass [4]. More recently, significant, although less severe, reductions of FFM have been reported after biliopancreatic diversion [5,6] and gastric bypass [7]. Gastric restrictive procedures, in which no malabsorptive mechanisms were active and a less severe weight loss was produced, were considered to have only minor effects on FFM, particularly if associated with a well balanced low-calorie diet. However, the long-term changes in body composition after gastric restrictive procedures have not been analyzed recently.

In this study, we evaluated the 2-year changes in body composition in a small group of morbidly obese women treated by laparoscopic adjustable gastric banding (LAGB) associated with a well balanced low-calorie diet.

Methods

To reduce the hormonal interference on body composition, 20 premenopausal morbidly obese women aged 36±6 years were studied. The patients were consecutively recruited among over 100 severely obese women referred to the Nutritional Unit of the Department of Neuroscience from 2000 to 2002. Patients were selected for LAGB according to the inclusion criteria standardized by the National Institutes of Health [8]. Patients were considered to be premenopausal if they had at least 10 menstrual periods in the previous year, the last one less than 60 days before the baseline examination. All the subjects gave their informed consent to the study, which had been approved by the Ethical Committee of the Medical School of the University Federico II of Naples. All patients underwent a comprehensive pre- and postoperative psychiatric evaluation conducted by a behaviorist who has expertise in bariatric patient management. This assessment included personal and social history, history of psychiatric problems, current living situation, and support system. None had any evidence of psychiatric diseases.

LAGB was performed with the Lap-Band™ System (Inamed Health, Santa Barbara, CA) according to Kuzmak [9] and Angrisani [10]. To minimize postoperative vomiting, the band was left completely unfilled at surgery [11]. At discharge, patients were instructed to follow a solid diet containing an inventory of the foods permitted and a list of rules specifically developed for patients with gastric restriction [11,12]. The diet was arranged to fit an energy intake of 5.4 MJ/day (55% carbohydrate, 25% fat, 20% protein, 30 g fiber). Physical activity was encouraged; it consisted primarily of 60–90 min/day of moderate–intensity activity (e.g., brisk walking). The band was tightened in case of weight stabilization (<4 kg of weight lost in the last month), providing that a solid food item per meal was ingested and a low vomiting frequency was observed [12]. No more than one adjustment per month was performed and no more than 1.5 ml of sterile saline was added in each step. Band competence was always controlled with a barium swallow before and after the adjustment.

Anthropometry, body composition and dietary intake were evaluated at the same time of the day with the subjects in a non-fasting state, before and 6, 12 and 24 months after LAGB. Body weight was measured to the nearest 0.1 kg and height to the nearest 0.1 cm with the subjects wearing swimming costumes. BMI was calculated from weight and height (kg/m^2). Daily caloric intake and diet composition were calculated during a personal interview using a detailed food-frequency questionnaire of 130 foods and beverages [13].

Body composition was determined by conventional bioelectrical impedance analysis (BIA) and by impedance vector analysis (BIVA). BIA is a widely used, non-invasive, simple and cheap technique for estimating body composition in humans. Resistance (R) and reactance (Xc) were measured by a single investigator with a single-frequency 50 kHz bioelectrical impedance analyzer (BIA 101 RJL, Akern Bioresearch, Firenze, Italy) according to the standard tetrapolar technique, with the subject in supine position and the electrodes placed on the dorsal surface of the right foot and ankle, and the right wrist and hand. Body composition was calculated from bioelectrical measurements and anthropometric data by applying the software provided by the manufacturer, which incorporated validated predictive equations for total body water (TBW), FM and FFM [14,15]. Soft tissue hydration of individual subjects was evaluated by BIA Vector using the BIVA software (Piccoli A, Pastori G. BIVA software, Department of Medical and Surgical Sciences, University of Padova, Italy, 2002; available from apiccoli@unipd.it). R and Xc were normalized by the height of subjects (R/H and Xc/H) and the resulting vectors were plotted on a graph reporting the gender-specific 50th, 75th, and 95th tolerance ellipses of similar vectors calculated from a reference healthy population [16,17]. According to the RXc graph method, vectors falling within the reference gender-specific 75th tolerance ellipse indicated normal hydration, short vectors (below the lower pole of the 75th tolerance ellipse) indicated overhydration and long vectors (above the upper pole of the 75th tolerance ellipse) indicated underhydration [16,18,19]. Vector position was also compared with the fat-fluid linear threshold discriminating between short vectors from either edematous or obese subjects falling out of the lower pole of the reference 75% tolerance ellipse, with vectors from obese subjects without edema expected to fall above the fat-fluid threshold and vectors from edematous patients that expected to fall below the fat-fluid threshold [20]. Vector's length was calculated as $|Z| = \sqrt{[(R/H)^2 + (Xc/H)^2]}$ and the vector's phase angle as the arctan of Xc/R.

Values are given as mean ± SD. Analysis of variance and Bonferroni post-hoc test were used for the comparison among groups. A $p < 0.05$ was considered significant.

Results

Anthropometry and body composition of the patients before and after surgery are reported in Table 1. At baseline, BMI ranged from 35 to 57 kg/m^2. No postoperative complications occurred in these patients. In the first 6 months after surgery, patients lost 18.5 ± 5.9 kg of body weight (17.6 ± 6.2 kg of FM and 0.7 ± 1.4 kg of FFM). From 6 to 12 months, a further 12.5 ± 7.5 kg of body weight was lost (10.5 ± 8.2 kg of FM and 2.2 ± 3.8 kg of FFM). During the last 12 months, weight loss of 3.0 ± 2.3 kg (1.9 ± 3.7 kg of FM and 1.1 ± 2.9 kg of FFM) occurred. The weight loss observed after LAGB was mainly due to a decrease in FM, whereas TBW and FFM were only slightly and non-significantly reduced.

The soft tissue hydration was evaluated according to the RXc graph method in Fig. 1. Before surgery none of the patients' vectors were below the boundary line threshold discriminating between the obese and the edematous, indicating normal hydration. All vectors fell in the lower left quadrant, out of the boundary line of the 75th tolerance ellipse, as expected in morbidly obese patients with normal hydration. The bioelectrical measurements (R, Xc, phase angle and length of the vectors) before and after surgery are reported in Table 2. Phase angle and Xc were significantly reduced after surgery. However, no significant differences in R and in the vector length were observed, indicating no significant changes in the hydration status of the patients.

Dietary intake based on interviewer administered questionnaire is reported in Table 3. After surgery, a significant reduction in food intake was observed and the composition of the diet fit quite

Table 1 Anthropometry and body composition estimated by BIA in 20 morbidly obese women before and 6, 12 and 24 months after laparoscopic adjustable gastric banding

	BW (kg)	BMI (kg/m^2)	WL %	FM (kg)	FFM (kg)	TBW (l)
T_0	120.2 ± 16.4	46.1 ± 6.8	–	61.3 ± 12.8	59.1 ± 5.0	43.2 ± 3.7
T_6	102.1 ± 13.0*	39.0 ± 5.1*	15.2	43.7 ± 9.9*	58.3 ± 4.5	42.7 ± 3.3
T_{12}	89.3 ± 6.9*°	34.2 ± 3.4*†	25.1	33.2 ± 4.7*†	56.1 ± 4.8	41.1 ± 3.5
T_{24}	86.1 ± 5.7*°	32.6 ± 2.8*†	28.2	30.7 ± 3.2*†	55.3 ± 4.3	40.5 ± 3.1

T_0, baseline; T_6, after 6 months; T_{12}, after 12 months; T_{24}, after 24 months. BW, body weight; WL %, percent weight loss; FM, fat mass; FFM, fat free mass; TBW, total body water. *$p < 0.05$ vs T_0; †$p < 0.05$ vs T_6.

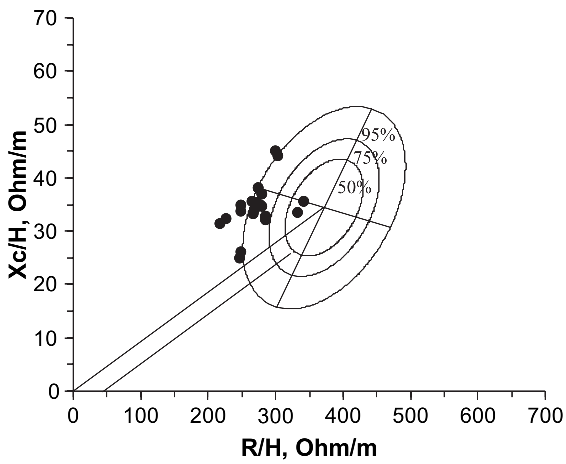

Figure 1 Individual impedance vectors in 20 morbidly obese women before laparoscopic adjustable gastric banding were plotted on the reference 50th, 75th, and 95th tolerance ellipses of a reference healthy population. The mean impedance vector of the reference population is shown (arrow) [17]. The fat—fluid threshold is drawn below the mean reference vector [20].

well with dietary prescriptions. None of the treated subjects dropped out of the study.

Discussion

In this study, we present the 2-year postoperative modifications in body composition of a small group of morbidly obese patients treated by LAGB associated with a 5.4 MJ/day hypocaloric diet. We observed a highly significant 28.2% reduction of body weight, without significant loss of FFM or body fluid alterations.

Body composition was determined by BIA. BIA is an attractive method for repeated measurements of body composition in vivo, because it is non-invasive, simple and cheap. Although the accuracy of the method in the determination of the changes in body composition in obese patients losing weight has been criticized; body geometry and body water distribution can modify the body resistance affecting the validity of the BIA method in the severely obese state. Nevertheless, Van der Kooy et al. showed that the changes in FFM estimated by body mass index, skinfold thicknesses and BIA in a group of obese patients losing weight were almost similar, but significantly higher than the decrease in FFM measured by densitometry [21]. In addition, recent data showed that the estimates of changes in body composition obtained by BIA in a group of obese subjects losing 18% of baseline body weight agreed well with tritiated water dilution and neutron activation measurements [22]. Therefore, in the present study the limitation of the BIA method to evaluate body composition in obese patients can be overcome by the length of follow-up.

Notwithstanding the possible overestimation suffered by the BIA method in the measurement of FFM loss, we predominantly observed a loss of FM without a significantly considerable loss of FFM in patients treated by LAGB. Wadstrom et al. previously showed a significant decrease in lean body mass and muscle protein concentration in the phase of rapid weight loss following gastroplasty [23]. We suggest that our different findings were due to differences in postoperative nutritional management. In vertical banded gastroplasty, neostoma circumferences <5.0 cm required patients to avoid fibrous food and to use highly processed high-calorie snacks, liquids, and ''junk'' foods [24]. In LAGB, a more conservative band management (band left unfilled at surgery and very prudent postoperative band inflation) resulted in a reduction in vomiting frequency and easier ingestion of solid foods [11,12], facilitating the patient to comply with a well balanced hypocaloric diet. Previous investigations showed that the nitrogen balance in obese patients was not maintained when energy intake was restricted to less than 4.6 MJ/day [25,26]. In our study, a balanced energy intake of 5.4 MJ/day was prescribed and repeated dietary assessments demonstrated a good nutritional compliance.

In obese patients, subtle variations of the hydration of soft tissues can propagate errors in the prediction of body composition from the reference

Table 2 BIA measurements in 20 morbidly obese women before and 6, 12 and 24 months after laparoscopic adjustable gastric banding

	R (ohms)	R/H (ohms/m)	Xc (ohms)	Xc/H (ohms/m)	Phase angle (°)	Vector length (ohms/m)
T_0	442 ± 53	272 ± 30	56 ± 8.2	34 ± 4	6.9 ± 0.9	270 ± 30
T_6	438 ± 52	270 ± 28	48 ± 7.6*	30 ± 4*	6.3 ± 0.7*	270 ± 30
T_{12}	451 ± 66	278 ± 37	47 ± 6.4*	29 ± 3*	6.1 ± 0.9*	280 ± 40
T_{24}	457 ± 43	282 ± 27	49 ± 4.8*	30 ± 3*	6.2 ± 0.4*	280 ± 30

T_0, baseline; T_6, after 6 months; T_{12}, after 12 months; T_{24}, after 24 months. R, resistance; Xc, reactance. $*p<0.05$ vs T_0.

Table 3 Dietary intake based on interviewer-administered questionnaire in 20 morbidly obese patients before and 6, 12 and 24 months after laparoscopic adjustable gastric banding

	Before	6 months	12 months	24 months
Energy intake, MJ/day	12.05±1.77	5.67±1.05*	5.96±0.96*	6.49±0.75*
Total carbohydrate, % energy	46.9±11.4	53.1±8.7	54.6±10.3	54.2±9.8
Total fat, % energy	35.4±9.7	27.4±4.5*	25.4±7.9*	25.6±5.2*
Total protein, % energy	17.7±4.9	19.5±6.9	20.0±5.6	20.2±7.4

$*p<0.05$ vs before.

methods to the predictive equations used in conventional BIA [27—30]. In this study, we used impedance vector analysis and the RXc graph method to check for changes in tissue hydration. A recent study documented the invariability of the impedance vector length after an energy restricted diet leading to pure FM loss [20] and a lengthening of the impedance vector predicted FFM loss in obese subjects losing weight [31,32]. Based on this new method, we demonstrated a normohydration status at baseline and no changes in body hydration after surgery, as indicated by the unchanged length of the impedance vector. Short term maintenance of FFM with only very mild body fluids alterations after LAGB was confirmed in a recent study with absorptiometry and dilution methods [33].

In conclusion, our experience demonstrated that in patients treated with LAGB a 2-year satisfactory weight loss can be achieved without significant decrease in FFM. We suggest that the conservation of FFM was the result of a well balanced mildly hypocaloric diet with healthy food choices and behavioral changes of dietary and activity habits coupled with a conservative postoperative band management. Therefore, primary requisites to achieve optimal results after LAGB should include, along with refined surgical technique, a comprehensive long-term nutritional management program.

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