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Metabolic and Nutritional Status Changes After 10% Weight Loss in Severely Obese Patients Treated with Laparoscopic Surgery vs Integrated Medical Treatment

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Abstract
Background Bariatric surgery is considered the most effective treatment for reducing excess body weight and maintaining weight loss (WL) in severely obese patients. There are limited data evaluating metabolic and body composition changes after different treatments in type III obese (body mass index [BMI]>40 kg/m^2).
Methods Twenty patients (9 males, 11 females; 37.6±8 years; BMI=50.1±8 kg/m^2) treated with dietary therapy and lifestyle correction (group 1) have been compared with 20 matched patients (41.8±6 years; BMI=50.4±6 kg/m^2) treated with laparoscopic gastric bypass (LGBP; group 2). Patients have been evaluated before treatment and after >10% WL obtained on average 6 weeks after LGBP and 30 weeks after integrated medical treatment. Metabolic syndrome (MS) was evaluated using the Adult Treatment Panel III/America Heart Association (ATP III/AHA) criteria. Resting metabolic rate (RMR) and respiratory quotient (RQ) was assessed with indirect calorimetry; body composition with bioimpedance analysis.
Results At entry, RMR/fat-free mass (FFM) was 34.2±7 kcal/24 h·kg in group 1 and 35.1±8 kcal/24 h·kg in group 2 and did not decrease in both groups after 10% WL (31.8±6 vs 34.0±6). Percent FFM and fat mass (FM) was 50.7±7% and 49.3±7% in group 1 and 52.1±6% and 47.9±6% in group 2, respectively (p=n.s.). After WL, body composition significantly changed only in group 1 (% FFM increased to 55.9±6 and % FM decreased to 44.1±6; p=0.002).
Conclusion After >10% WL, MS prevalence decreases precociously in surgically treated patients; some improvements in body composition are observed in nonsurgically treated patients only. Further investigations are needed to evaluate long-term effects of bariatric surgery on body composition and RMR after stable WL.

Keywords Type III obesity · Laparoscopic gastric bypass · Body composition · Resting metabolic rate · Weight loss

Introduction

Severe obesity, corresponding to a body mass index (BMI) ≥40 kg/m^2, is a major health hazard that has not yet been fully recognized by health professionals and health sciences in western societies. A recent US survey shows that severe obesity affects more than 4% of the whole adult population; this prevalence has more than doubled in the last 20 years and is still on the rise [1]. On the other hand, there are epidemiological data confirming that some comorbidities, such as the metabolic syndrome (MS), are present in over 20% of the adult population. A similar figure for nonalcoholic fatty liver disease (NAFLD) has been reported [2, 3]. Both reach a very high prevalence in

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severe obesity: about 60% in men and 55% in women for MS, as reported previously also by our group [4], and 90% in NAFLD [5], respectively.

The best way to significantly decrease the obesity prevalence is prevention. However, whereas this remains the key long-term winning strategy, obesity requires a variety of treatment options based on individual and group intervention. The aims of treatment for obesity are maintaining long-term weight loss (WL), and improving comorbidities and quality of life.

However, severely obese individuals have limited options. Behavioral therapies for reducing energy intake, improving eating behaviors, and increasing physical activity—associated with pharmacotherapy—generally achieve only modest and transient effects [6, 7].

In particular, although it is generally agreed that nonsurgical treatments do not solve the problem of severe obesity, there is little doubt that a well-constructed and supervised medical program can help many people achieve a substantial WL. Nevertheless, bariatric surgery actually represents the most effective therapeutic option for reducing excess weight and maintaining WL in patients with clinically severe obesity.

The ideal goal of any 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) [8]. Maintenance of FFM during WL is considered crucial to preserve skeletal integrity and functional capacities [9]. Moreover, the reduction in resting energy expenditure associated with a loss of FFM may contribute to the difficulty in maintaining body weight often observed in obese subjects after a period of negative energy balance [8, 10].

There are limited data evaluating metabolic and body composition changes comparing medical vs surgical different treatments in type III obese patients (BMI>40 kg/m^2) [11].

The aim of this study was to compare metabolic and nutritional status (body composition and resting energy expenditure) changes in severely obese patients after 10% WL achieved by laparoscopic bariatric surgery or by integrated medical treatment that included hypocaloric diet and lifestyle correction.

Methods

Forty adult patients (18 males [M], 22 females [F]; age range 18–50 years) consecutively attending the outpatient Clinic for Severe Obesity of the Federico II University Hospital in Naples were enrolled in a clinical protocol that had been approved by the local ethical committee.

Twenty patients (9 M, 11 F; age 37.6±8.5 years; BMI=50.1±8.5 kg/m^2) successful treated with dietary and lifestyle correction (group 1) were retrospectively compared with 20 age-, sex-, and BMI-matched patients (9 M, 11 F; 41.8±6.3 years; BMI=50.4±6.5 kg/m^2) treated with laparoscopic bariatric surgery (group 2). All patients were selected among those regularly attending the clinic and evaluated before treatment and after achieving about 10% WL, on average 6 weeks after bariatric surgery and at 30 weeks after integrated medical treatment.

At entry, all patients underwent a clinical examination to determine the presence and severity of associated medical conditions. Dietary history, food habits, and previous WL efforts were accurately evaluated by means of an interview.

Anthropometry

Initial assessment included anthropometric measurements by means of standard procedures: height was measured to the nearest 0.1 cm with a stadiometer and body weight was measured to the nearest 0.1 kg on a balance beam scale with the subject barefoot and wearing only light undergarment; height and weight were recorded and BMI (kg/m^2) calculated; waist circumference was assessed with a tape measure at the iliac crests.

Hematobiochemical Examination

All patients underwent a routine hematobiochemical examination including: total and high-density lipoprotein cholesterol (HDL-C), triglyceride (TG), glucose and insulin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyltrasferase (GGT), alkaline phosfatase (AP), total bilirubin (T-Bil), hemoglobin (Hb), and total red blood cell count. All analytes were detected using current hematochemical kits.

Metabolic Syndrome

Blood pressure was measured on the right arm after the patient had sit for at least 5 min; a standard sphygmomanometer and adequately sized cuff were used. The diagnosis of high blood pressure was made when values were >130/85 mmHg. Hypercholesterolemia, hypertriglyceridemia, and low HDL-cholesterolemia were diagnosed when values were over 200 mg/dl, 150 mg/dl, and below 40 mg/dl in men and <50 mg/dl in women, respectively. These cutoff points were chosen according to the Adult Treatment Panel III (ATP III) and the American Heart Association (AHA) criteria to identify MS. The cutoff points for waist circumference were 102 cm in men and 88 cm in women according to the ATP III and 94 cm in men and 82 cm in women according to the AHA.

The cutoff points for glycemia were ≥110 mg/dl according to the ATP III and ≥100 mg/dl according to the AHA. The prevalence of MS was determined considering the combination of three out of five risk factors as described elsewhere [12].

Homeostasis model assessment (HOMA), based on serum fasting glucose (mmol/l)×insulin levels (μU/l)/22.5, was also used as an index of insulin resistance. MS was evaluated using both ATP III and AHA criteria.

Fatty Liver Index

The risk to have hepatic steatosis was evaluated with the Fatty Liver Index (FLI), an algorithm based on BMI, waist circumference, triglycerides, and GGT, as previously described by other authors [13].

Single-frequency Bioimpedance Analysis

Body composition was assessed by bioimpedance analysis (BIA). Single-frequency BIA was carried out by the same operator using a BIA 101 device (injection of an alternating current at 800 μA and 50 kHz) (RJL/Akern System, Florence, Italy). Measurements were performed on the nondominant side of the body at an ambient temperature of 22–24°C after voiding and after being in the supine position for 20 min. A standard tetrapolar technique was used, placing the measuring electrodes on the anterior surface of the wrist and ankle, and the injecting electrodes on the dorsal surface of the hand and foot. The BIA variables considered were resistance (R), reactance (Xc), and phase angle (PhA). The bioimpedance index (BI) was calculated as the ratio height^2/resistance (cm^2 Ω^{-1}). The instrument was routinely checked with resistors and capacitors of known values.

Indirect Calorimetry

Resting metabolic rate (RMR) was measured by indirect calorimetry using a canopy system (V max 29 N, Sensor Medics, Anaheim, USA) in a quiet environment and with patients in the supine position for 30 min before measurement. After a 15- to 20-min adaptation period to the instrument, oxygen consumption and carbon dioxide production were determined for 45 min. Energy expenditure was derived from CO_2 production and O_2 consumption with the appropriate Weir's formula neglecting protein oxidation. The apparatus was calibrated with gas mixtures of known composition before each test and regularly checked by burning ethanol.

Integrated Medical Treatment: Group 1

Twenty patients (9 M, 11 F; age 37.6±8.5 years; BMI=50.1±8.5 kg/m^2) underwent psychiatric consultation followed by diet therapy and lifestyle correction (group 1).

At the first visit, all patients were instructed by the dietician on how to fill in their food and activity diaries. After a week, they were given a low calorie diet, which was tailored to each patient's resting energy expenditure, food and activity diary, and metabolic data.

The patients were instructed to gradually increase their physical activity by walking outdoors up to 30 min a day. Each patient was seen on a biweekly basis. All patients were studied at entry and after achieving >10% WL, as a mean 30 weeks after starting the integrated medical treatment.

Bariatric Surgery: Group 2

Twenty patients, gender-, age-, and BMI-matched with group 1 (41.8±6.3 years; BMI=50.4±6.5 kg/m^2), were selected for Roux-en-Y gastric bypass (RYGBP) (group 2).

All patients were reviewed weekly by the doctor and the dietician for evaluation of symptoms and careful dietary monitoring and supplementation. Patients were encouraged to start physical activity sessions, particularly walking 30 min a day.

All patients underwent a comprehensive preoperative and postoperative psychiatric evaluation conducted by a behaviorist with expertise in bariatric patient management. This assessment included personal and social history, history of psychiatric problems, current living situation, and support system. None of the participants had any evidence of psychiatric diseases.

All patients were studied at entry and after achieving >10% WL, on average 6 weeks after laparoscopic RYGBP.

Operative technique The patient was placed in the lithotomic position with legs abducted, under intermittent pneumatic compression; two monitors were located on the right side, at the level of shoulder and hip, and the endoscope at the left shoulder. The procedure began with the hemiomentectomy to facilitate the antecolic transposition of the Roux limb. The aspirator was inserted in the epigastric trocar to retract the left liver. The height of the gastroesophageal junction was localized by the transillumination of the endoscope and the gastric pouch was transacted 6 cm caudally toward the angle of His alongside a 38 French bougie. The gastrojejunostomy was fashioned manually by antecolic transposition of the entire biliopancreatic limb about 50 cm caudally to the ligament of Treitz without sectioning it. Along the Roux limb, a distance of 150 cm from the gastrojejunostomy was then measured and a side-to-side jejunojejunostomy was performed. The biliopancreatic limb was than divided from the gastrojejunostomy. Water-soluble contrast, such as gastrograffin, was checked by Rx through the anastomosis before starting oral feeding on postoperative day 5.

Statistical Analysis

A statistical analysis was performed using the Statistical Package Social Sciences (SPSS), 14.0 program. Results are expressed as the mean±standard deviation. Comparisons were performed using unpaired t test. Linear correlation analysis was performed. The null hypothesis was rejected at a two-tailed $p \leq 0.05$.

Results

Both treatments were effective in reducing excess body weight. The 10% WL was achieved more rapidly with bariatric surgery than with integrated medical treatment (6 vs 30 weeks).

Serum cholesterol levels were unchanged in group 1 (202±41 vs 202±43 mg/dl, p=n.s.) and significantly decreased in group 2 (200±27 vs 168±36 mg/dl, $p<0.01$); serum HDL-C did not change in group 1 (43.1±12 vs 43.4±14 mg/dl, p=n.s.) but decreased significantly in group 2 (51.5±16 vs 43.5±13 mg/dl, $p<0.005$), whereas triglycerides decreased in both groups (group 1=134±48 vs 114±48 mg/dl, p=n.s.; group 2=156±70 vs 124±53 mg/dl, $p<0.02$).

Blood glucose decreased significantly in both groups (group 1=96.2±19 vs 89.4±9 mg/dl, $p<0.05$; group 2=98.9±15.1 vs 90.8±9.9 mg/dl, $p<0.01$), as did insulin serum concentration (group 1=25.1±12 vs 14.9±10 μg/U, $p<0.001$; group 2=25.1±13.9 vs 10.6±5.6 μg/U, $p<0.001$); the HOMA index significantly decreased accordingly (from 5.8±2.7 at baseline to 3.3±2.1 at 10% WL $p<0.001$ in group 1 and from 6.1±3.3 to 2.4±1.3 in group 2, $p<0.001$).

All the MS risk factors improved with WL, but there was a more marked reduction of the HOMA index after surgery ($p=0.001$) (Table 1).

At entry, the prevalence of MS was 75% or 80% (n=15 or 16) according to the ATP III or AHA, respectively, in group 1 and 65% or 70% (n=13 or 14) in group 2 (p=n.s.) accordingly. After treatment, MS prevalence decreased in both groups to 65% or 65% (n=13) in group 1 vs 40% or 40% (n=8) in group 2 ($p<0.05$).

FLI decreased in both groups (group 1=99.0±1.4 vs 91.9±9.1; $p=0.001$ and group 2=99.3±1.1 vs 96.4±5.4; $p=0.009$) (Table 1).

Blood pressure values were similar at baseline (126/79±13/10 mmHg in group 1 vs 128/83±10/7 in group 2, p=n.s.), a significant reduction was observed only in group 1 patients at 10% WL (118/74±11/7 vs 128/83±17/7 in group 2, $p<0.002$).

Heart rate showed a significant decrease only in surgical patients compared to baseline (77.2±9.3 vs 75.9±9.3 beats/min, p=n.s. in group 1 and 81.2±9 vs 73.0±12 beats/min, $p<0.001$ in group 2).

At entry, FFM and FM was 50.7±6.7% and 49.3±6.7% in group 1 and 52.1±6.1% and 47.9±6.1% in group 2, respectively (p=n.s.). After approximately 10% WL, body composition distribution (FFM 50.7±6.7% and FM 49.3±6.7%) significantly changed in group 1 (FFM increased to 55.9±6.5% and FM decreased to 44.1±6.5%; $p=0.002$), but remained unchanged in surgical patients, as reported in Table 1. RMR as absolute values decreased in both groups but significantly ($p<0.05$) in surgically treated patients, whereas corrected for FFM (RMR/FFM kg). RMR did not significantly decrease in either group. Respiratory quotient (RQ) decreased significantly ($p=0.007$) only in the surgical group (Table 2).

Discussion

In evaluating the role of surgery in the treatment of clinically severe obesity, a National Institutes of Health-sponsored Consensus Conference panel concluded that "the surgical procedures in use [gastric bypass and vertical banded gastroplasty] can induce substantial weight loss [in severely obese patients], and this, in turn, may ameliorate

Table 1 MS prevalence and FLI before and after medical and bariatric treatments

	Medical treatment		Bariatric surgery	
	Group 1		Group 2	
	Before	After (6 months)	Before	After (6 weeks)
MS-ATP III (%)	15/20 (75)	13/20 (65)	13/20 (65)	8/20 (40)
MS-AHA (%)	16/20 (80)	13/20 (65)	14/20 (70)	8/20 (40)
FLI (%)	99.0±1.4	91.9±9.1*	99.3±1.1	96.4±5.4*

MS-ATP: Metabolic Syndrome according to Adult Treatment Panel III, *MS-AHA*: Metabolic Syndrome according to American Heart Association, *FLI*: Fatty Liver Index.
*$p<0.05$ vs baseline

Table 2 Anthropometric characteristics and body composition changes before and after medical and bariatric treatments

	Medical treatment		Bariatric surgery	
	Group 1		Group 2	
	Before	After (6 months)	Before	After (6 weeks)
WEIGHT (kg)	139±17	117±19*	138±27	124±24*
BMI (kg/m^2)	50.1±8.5	42.1±7.8*	50.4±6.5	45.3±6.6*
WC (cm)	139.0±12.6	124.6±.9*	144.3±16.4	136.6±15.3*
FFM (%)	50.7±6.7	55.9±6.5*	52.1±6.1	51.9±6.2
FM (%)	49.3±6.7	44.1±6.5*	47.9±6.1	48.1±6.2
RMR (kcal/24 h)	2338±421	2051±382	2434±348	2135±376*
RMR/FFM (kcal/24 h·kg)	34.2±7.1	31.8±5.9	35.1±8.3	34.0±5.9
RQ	0.88±0.05	0.86±0.05	0.86±0.07	0.78±0.07**

BMI: body mass index, *WC*: waist circumference, *FFM*: fat-free mass, *FM*: fat mass, *RMR*: resting metabolic rate, *RMR/FFM*: resting metabolic rate corrected for fat-free mass, *RQ*: respiratory quotient.
*$p<0.05$ vs baseline
**$p<0.01$ vs baseline and medical treatment

comorbid conditions” [14]. This has been clearly demonstrated by the Swedish Obesity Surgery (SOS) Study Group that showed amelioration of all cardiovascular risk factors, except for hypercholesterolemia, after surgery compared with conventional therapy [15].

In a recent systematic review, O’Brien et al. asserted that bariatric surgery can achieve a major weight reduction that is sustained for at least 10 years. Each of the principal groups of procedures shows a stable, at least 50%, excess WL. No other therapy for severe obesity in use today could achieve and sustain this degree of weight reduction over such a period of time [16]. Laparoscopic Roux-en-Y gastric bypass has gained greatest acceptance among bariatric surgeons in the USA [17] and represents the first choice intervention also by our group.

The large WL achieved with surgery may depend on ongoing dietary/lifestyle interventions and should be assessed against a 0.5–1% postoperative mortality risk and an increased risk of wound dehiscence, venous thromboembolism, and cardiorespiratory failure [18]. Newer laparoscopic techniques, however, are associated with fewer postoperative complications [18, 19].

Clinically important WL, defined by obesity experts as 5–10% loss of baseline weight [20, 21], may improve lipid, glucose, and blood pressure levels [22, 23] with potential reductions in cardiovascular risk [24]. However, it is unclear if WL improves risk factors in all obese individuals or in high-risk groups only. Few dietary/lifestyle and surgical therapy studies have a ‘usual care’ control group, which limits the assessment of WL efficacy that might occur in clinical practice [25].

In our study, blood glucose, insulin, and HOMA index significantly decreased in both groups; in particular, insulin resistance improved 6 weeks after surgery, as also demonstrated by other authors who have reported very early changes in hormonal gastric pattern [26]. Blood triglycerides also decreased in both groups according to other studies [27]. MS prevalence was significantly reduced at 10% WL after surgery—a clearer improvement in result compared to medical treatment. This improvement is probably because of the drastic restriction of food absorption and possible gastrointestinal hormone adaptation. In fact, the slightly greater reduction in HOMA index—because of a drop in insulin serum concentration and resistance—indicates that this type of bariatric surgery can modify gastrointestinal endocrine pattern in a more favorable way than conventional medical treatment [28].

This is also mirrored by the reduction of RQ observed in surgical patients. The reduction in RQ reflects the increased fat oxidation that accompanies the faster WL because of the reduction in food intake in the few weeks after surgery.

Maintenance of FFM is of particular concern in obesity surgery when large amounts of body weight are lost in a short length of time [29]. At the beginning of the bariatric surgery experience, an undesirable marked loss of body cell mass with a relative expansion of extracellular component, typical of protein-energy malnutrition, has been observed especially after jejunoileal bypass [30].

More recently, significant, although less severe, reductions of FFM have been reported after biliopancreatic diversion [31, 32] and gastric bypass [33]. Gastric restrictive procedures in which no malabsorptive mechanisms were active and a less marked WL was produced were considered to have only minor effects on FFM, particularly when associated with a well-balanced low-calorie diet. Nonetheless, Wadstrom et al. showed a significant decrease in lean body mass (LBM) and muscle protein content in the rapid WL phase after gastroplasty [34].

Nevertheless, in patients treated with laparoscopic adjustable gastric banding (LAGB), a 2-year satisfactory WL can be achieved without significant decrease in FFM [29].

In our study, % FFM appeared unchanged in surgically treated patients, suggesting that, at least within the initial phase of WL, there is a similar loss of FM and FFM also related to the higher fluid loss in the short-term. In medical patients, instead, the percentage increase in FFM might be related to the physical activity program undertaken during the 6 months of the study but specifically suggests that WL obtained with the integrated medical treatment preferentially involves fat mass more than FFM.

As well known, RMR accounts for a large percentage of daily calorie expenditure. Obese individuals generally have elevated RMR and experience a significant drop in RMR with WL [31, 35]. Changes in body weight by 10% or more obtained by dietary interventions are associated with compensatory reduced changes in energy expenditure that tend to oppose the weight change, and this may at least partially account for the poor long-term results of obesity treatment [36]. Gastroplasty has been associated with a sustained fall in measured resting metabolic expenditure (MRME) related to the metabolic compensation for prolonged induced dietary restriction [37]. Very low calorie diets are associated with a 15% to 30% reduction in MRME, which tends to normalize during the refeeding phase [38].

That WL may produce a disproportionate reduction in RMR [39], even when adjusted for changes in LBM and FM, has been disputed by some other authors [40, 41]. Carey et al. described a significant RMR reduction only in the first month after surgery; this result is linear with LBM changes. They found significant relationships between decreases in LBM and RMR, 6 and 12 months after surgery [11]. A study of RYGBP patients showed that the loss of FFM accounted for 40% of the weight lost [27].

Our study shows a mild and nonsignificant reduction of RMR in patients treated with an integrated dietetic plus physical exercise program and a significant reduction of RMR in surgically treated patients; however, RMR/FFM remained unchanged in surgically and medically treated patients. It will be necessary to have a larger number of patients to confirm these findings.

In conclusion, our preliminary results confirm the safety and efficacy of surgical treatment in improving metabolic pattern and nutritional status of severe obesity provided that a careful selection and clinical follow-up of patients is performed by well-qualified surgical and medical teams.

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