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ORIGINAL ARTICLE

GH and IGF-I deficiency are associated with reduced loss of fat mass after laparoscopic-adjustable silicone gastric banding

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Summary

Context GH secretion is reduced in obese subjects and increases after body weight loss. It is still unclear if changes in the GH/IGF-I axis after laparoscopic-adjustable silicone gastric banding (LASGB) are associated with changes of body composition.

Objective To analyse the relationships between changes in the GH/IGF-I axis and those of body weight and composition before and after LASGB.

Design Observational, prospective.

Setting University 'Federico II' of Naples (Italy).

Patients Seventy-two severely obese females (BMI: 44·9 ± 4·68; mean age: 33·1 ± 11·34 years) were studied.

Main outcome measures GH peak after GHRH plus arginine test, IGF-I, IGFBP-3 and ALS levels, fat mass (FM) and free fat mass (FFM) (by Bioelectrical Impedance Analysis) at baseline and 6 months after LASGB. The change in percentage of individual variables was calculated as well as that of excess of body weight loss (EBWL%). The FM%, FFM% and EBWL% were correlated with peak GH and IGF-I levels changes.

Results At baseline, GH deficiency (GHD) (GH peak = 4·1 μg/l) was found in 22 patients (31%), 16 of them also had IGF-I deficiency (< –2SDS). IGF-I levels were inversely correlated with waist circumference ($r = -0{\cdot}72$, $P < 0{\cdot}001$) and FM% ($r = -0{\cdot}75$, $P < 0{\cdot}001$). Post-LASGB the patients were classified as follows: group (1) GH and IGF-I sufficient ($n = 44$; 61·1%); group (2) GH and IGF-I deficient ($n = 14$; 19·4%) and group (3) GH sufficient and IGF-I deficient ($n = 14$; 19·4%). The percentage changes of EWBL ($P < 0{\cdot}05$, $P = 0{\cdot}051$, respectively) and FM ($P < 0{\cdot}001$, $P < 0{\cdot}01$, respectively) were lower in groups (2) and (3) than in group (1). At the stepwise linear regression analysis, postoperative IGF-I levels were the strongest determinant of percent changes of FM ($P < 0{\cdot}0001$), of FFM ($P = 0{\cdot}009$) and of EBWL ($P < 0{\cdot}0001$).

Conclusions IGF-I levels is the most sensitive to unfavourable changes in body composition 6 months after LASGB making investigation of the somatotropic axis useful in the evaluation of bariatric surgery outcomes.

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Introduction

Obesity is a lifelong disease which represents a worldwide problem. Bariatric surgery currently provides the only long-term control of obesity, resulting in major weight loss and weight maintenance. Gastric restrictive and malabsorptive procedures are the main surgical options available today.[1] Laparoscopic-adjustable silicone gastric banding (LASGB), the most common bariatric procedure worldwide, is a purely restrictive operation that induces early satiety by a small gastric pouch and does not seem to induce malabsorption.[2,3] Along with a significant weight loss and changes in eating behaviour, LASGB has also been proven as an effective surgical procedure in improving obesity-related comorbidities[4] mostly of the endocrine system.[5]

Among the post-LASGB endocrine changes, those related to the GH and IGF-I system have been poorly studied.

GH and IGF-I have major anabolic and lipolytic actions on muscle, adipose and hepatic tissue.[6] Morbidly obese patients have a reduced GH secretion, both in basal conditions and after pharmacological stimuli, up to levels that are comparable to those found in adult patients with organic GH deficiency (GHD).[7–9] GHD is well known to cause detrimental effects on body composition by increasing fat (FM) and reducing lean body mass (FFM).[10] Therefore, a 'functional' GHD was suggested to occur as one of the multiple maladaptative endocrine changes involved in the pathogenesis of both obesity and metabolic syndrome.[11,12] The GHD in obesity is, however, generally reversible.[13] IGF-I, the mediator of the GH effects, is used as a measure of GH bioactivity as it almost accurately reflects the GH secretory status.[14] Different factors, primarily age, gender, body composition, nutritional driven components, and glucose homeostasis have been reported to affect IGF-I metabolism.[15] Circulating IGF-I levels in obese patients are, thus, widely variable. IGF-I circulates within the intravascular space as part of a ternary complex with IGFBP-3, the predominant plasma binding globulin regulated by GH concentration, and acid-labile subunit (ALS), constituting both a reservoir and a carrier system for IGF-I.[16] Alterations of GH secretion cause changes in IGF-I, IGFBP-3 and ALS.

It is still unclear if changes in GH and IGF-I levels after LASGB may modify postoperative loss in FM and FFM. Therefore, the aim of this observational, prospective study was to explore the effect of LASGB on GH and IGF-I levels and body composition in very severe obese patients. As secondary objective we investigated the usefulness of testing the somatotropic axis before LASGB to predict loss of FM and FFM.

Subjects and methods

Inclusion criteria

The inclusion criteria were: (i) Female gender to exclude the influence of gender on IGF-I levels; (ii) Age between 18 and 50 years to limit the influence of age on GH/IGF-I axis; (iii) Normal glucose tolerance during standard oral (OGTT) to minimize any effects of glucose homeostasis of IGF-I levels variability;[14–16] (iv) Inclusion criteria for bariatric surgery proposed by the 1991 National Institutes of Health Consensus Development Panel Report;[17] and (v) Weight stabilization after surgery without any further band adjustment (< 4 kg of weight lost in the last month) at 6 months.

Exclusion criteria

The exclusion criteria were: (i) Liver or renal failure, cancer, acute or chronic inflammatory diseases were excluded by a complete medical examination and laboratory investigations; (ii) Chronic treatment with any type of medications; (iii) organic pituitary deficiency;[18] (iv) Bulimia Nervosa of the DSM-IV; (v) Ulcers or malignancies excluded by oesophago-gastro-duodenoscopy; and (vi) Soft-tissue over-hydration, preliminary evaluated by BIA Vector by using the BIVA software, as previously reported.[19]

Patients

Out of 212 very severe obese females coming to our Department since 1 January 2003 to 31 December 2005 and undergoing LASGB, 72 patients (34%; body mass index (BMI): 44·7 ± 8·6) with a mean age of 33·1 ± 11·3 years (range 16–55) were enrolled in this study. All premenopausal women were studied during the early follicular phase, 5–7 days after spontaneous menses. All patients gave their written informed consent to the study, which had been approved by the Ethical Committee of the University 'Federico II' of Naples School of Medicine, Italy. The study design was made in accordance with the Helsinki II declaration for study on human experimentations.

Study design

This is an observational, open, prospective study. Main outcome measures were changes in GH peak after GHRH + ARG test and IGF-I levels, and percent changes of FM, FFM and excess of body weight loss (EBWL%).

Study protocol

The OGTT was performed using 75 g dextrose according to the criteria of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus.[20] Homeostatic model of assessment (HOMA) index was calculated according to Matthews *et al.*[21] Blood glucose levels were determined by the glucose oxidase method immediately after the OGTT. Serum insulin was measured by a solid-phase chemiluminescent enzyme immunoassay using commercially available kits (Immunolite Diagnostic Products Co, Los Angeles, CA).

Before and 6 months after LASGB the following parameters were measured:

1 The GH/IGF-I axis was evaluated by measuring the GH peak after GHRH + ARG and assay of circulating IGF-I, IGFBP-3 and ALS levels. The GHRH (1–29, Geref, Serono, Rome, Italy) + ARG (arginine hydrochloride, Salf, Bergamo, Italy) was performed according to Ghigo *et al.*[22] The GH response after ARG + GHRH was classified as deficient (GHD) when the GH peak was ≤ 4·2 μg/l and sufficient (GHS) when the GH peak was > 4·2 μg/l.[23] Serum GH levels were measured by immunoradiometric assay (IRMA) using commercially available kits (HGH-CTK-IRMA, Sorin, Saluggia, Italy). The sensitivity of the assay was 0·02 μg/l. The intra- and interassay coefficients of variations (C*Vs.*) were 4·5% and 7·9%, respectively. IGF-I levels were classified as deficient (IGFD) when the standard deviation score (SDS) from the mean was < –2 for age and gender and sufficient (IGFS) when the SDS ranged from > –2 to 2.[24] Serum IGF-I levels were measured by IRMA after ethanol extraction (DSL Inc, Webster, TX); assay sensitivity was 0·8 μg/l; the normal ranges in adults aged 20–40 and 41–60 years were 110–494 and 100–300 μg/l, respectively. The intra-assay C*Vs.* were 3·4%, 3·0% and 1·5% for the low, medium and high points of the standard curve, respectively. The interassay CVs. were 8·2%, 1·5% and 3·7% for the low, medium and high points of the standard curve, respectively. IGFBP-3 and ALS levels were measured by ELISA (DSL Inc, Webster, TX). The IGFBP-3 assay had a sensitivity of 0·04 ng/l; the normal range for an adult female population of the same age range of our study population was 2670–5580 ng/ml. The ALS assay had a sensitivity of 0·07 μg/ml; the normal range for an adult female population of the same age range of our study population was 14·2–40·1 μg/ml. The values for the molecular mass of IGF-I and IGFBP-3 used for the calculation were 7.649 kDa and 28.5 kDa, respectively.[25] All blood samples were obtained between 0800 and 0900 h from antecubital vein after an overnight fast, with the patients were in the resting position.

2 Body composition was determined by conventional bioelectrical impedance analysis (BIA) and by impedance vector analysis (BIVA). Resistance (*R*) and reactance (*X*c) were measured by a single investigator with a single-frequency 50 kHz BIA (BIA 101 RJL, Akern Bioresearch, Firenze, Italy) according to the standard tetrapolar technique. Data were calculated by applying the software provided by the manufacturer.[26]

3 Anthropometric measurements were made with the patients wearing only underwear without shoes. Standing height was measured to the nearest centimetres using a wall-mounted stadiometer. Body weight was determined to the nearest 50 g using a calibrated balance beam scale. BMI was calculated as weight (kg) divided by height squared (m^2) and used as an index for obesity. Measurements of the waist circumference were taken at the mid-point between umbilicus and xiphoid. The ideal body weight (IBW) was calculated according to the Lorenz's formula {IBW = [height (cm) – 100] – [height (cm) – 150/2]}.

4 A questionnaire to investigate duration of obesity, eating pattern, smoking habits and physical exercise (no exercise ≤ 2–3 h/week; ≥ 2–3 h/week) was administered to all patients. The duration of obesity was determined as the time interval, since significant obesity had occurred. The estimation of dietary intake was assessed by Winfood (Medimatica software medico 1999, Rome, Italy).

Laparoscopic-adjustable silicone gastric banding (LASGB)

All patients were surgically treated at the Department of Surgery, S-Giovanni Bosco Hospital, Naples. LASGB was performed with the Lap-Band™ System (Inamed Health, Santa Barbara, CA) according to Kuzmak[2] and Angrisani.[3] To minimize postoperative vomiting, the band was left completely unfilled at surgery.[27] 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.[28] The band was tightened in case of weight stabilization (< 4 kg of weight lost in the last month). After LASGB, the diet was arranged to fit an energy intake of 5·7 MJ/day (55% carbohydrate, 25% fat, 20% protein, 30 g fibre). Individual requirements were estimated from resting metabolic rate and physical activity pattern. Resting energy expenditure was indirectly measured. Physical activity was encouraged; it consisted primarily of 60–90 min/day of moderate–intensity activity (e.g. brisk walking).

Statistical analysis

Data were stored and analysed using the Statistical Package for Social Science program (SPSS, release 13·0; SPSS Chicago, IL). Data distribution was analysed by the Kolmogorov–Smirnov test. Values are given as mean ± SD unless otherwise specified. To compare data for continuous variables, ANOVA followed by Bonferroni test as *post hoc* test were used. The Pearson's bivariate correlation analysis was used to compute the correlation between variables. Comparison were analysed in the patients before and after LASGB, in patients with GHD *vs.* those GHS, and among patients GHS and IGFS [group (1)], GHD and IGFD [group (2)] and GHS and IGFD [group (3)]. *P*-values less than 0·05 were considered statistically significant. The stepwise multiple linear regression was performed to assess the relative importance of GH peak after GHRH + ARG, IGF-I, IGFBP-3, ALS and IGF-I : IGFBP-3 molar ratio on anthropometric variables, pre- and postoperatively. In this analysis, we entered only those variables that had a *P*-value less than 0·01 in the univariate analysis.

Table 1. Results of anthropometry, body composition by BIA, metabolic and hormonal parameters, at baseline and 6 months after laparoscopic-adjustable silicone gastric banding (LASGB)

	Baseline	After LASGB	*P*
N	72	72	
BMI (kg/m²)	44·9 ± 4·68	36·4 ± 4·66	< 0·001
Waist circumference (cm)	119·5 ± 7·19	105·7 ± 9·36	< 0·001
Excess body weight (kg)	60·7 ± 11·20	38·9 ± 11·34	< 0·001
Fat mass (kg)	58·9 ± 5·82	47·7 ± 12·84	< 0·001
Fat mass (%)	49·5 ± 5·31	44·1 ± 8·92	< 0·001
Free fat mass (kg)	58·4 ± 6·41	52·2 ± 7·29	< 0·001
Free fat mass (%)	50·5 ± 5·31	55·9 ± 8·92	< 0·001
Fasting glucose (mmol/l)	4·7 ± 0·48	4·8 ± 0·51	0·308
Insulin (mU/l)	19·8 ± 5·41	15·1 ± 3·63	< 0·001
HOMA index	4·2 ± 1·22	3·2 ± 1·04	< 0·001
Peak GH response (μg/l)	9·8 ± 7·23	14·3 ± 9·35	< 0·001
GH deficiency (%)	31	19·4	0·120
IGF-I (μg/l)	158·8 ± 64·31	144·2 ± 75·96	0·003
IGF-I deficiency (%)	22·2	38·9	0·04
IGFBP-3 (ng/ml)	3667·3 ± 661·07	3541·8 ± 814·47	0·126
IGF-I : IGFBP-3 molar ratio	0·02 ± 0·004	0·01 ± 0·004	< 0·001
ALS (μg/ml)	13·9 ± 5·74	12·9 ± 7·43	0·183

At study entry, mean age was 33·1 ± 11·34 years (range: 18–50 years). According to the GH response after ARG + GHRH, GH deficiency was diagnosed when the GH peak is ≤ 4·2 μg/l. IGF-I deficiency was diagnosed when the IGF-I concentrations were SD score < –2 for age and gender.

Results

Baseline characteristics

Patients' profile at study entry is reported in Table 1. GHD was found in 22 (31%) patients, and IGFD was found in 16 patients (22%). IGFBP-3 and ALS levels were below normal in 5 (5·6%) and 22 patients (31%), respectively. All IGFD patients were GHD and also had low-IGFBP-3 and ALS levels. IGF-I levels were normally distributed, though highly variable because of the presence of both IGF-I deficient and sufficient patients.

Table 2 shows anthropometric variables, body composition and metabolic parameters in GHD and GHS patients. Age, BMI, EBW, duration of obesity, eating pattern, smoking habits, physical exercise or glucose metabolism did not significantly differ in the two groups. The only exceptions were higher waist circumference and FM% and lower FFM% in GHD than in GHS.

Six months after LASGB

All the patients completed the study and no postoperative complications occurred. The composition of the diet corresponded to dietary prescriptions in all cases but none of the patients reported to exercise regularly. As reported in the inclusion criteria, patients' evaluation was performed without any further band adjustment.

Postoperative patients' profile is reported in Table 1. As expected, in all patients BMI, waist circumference, EBW, FM, FFM, insulin levels and HOMA index were significantly reduced when compared with

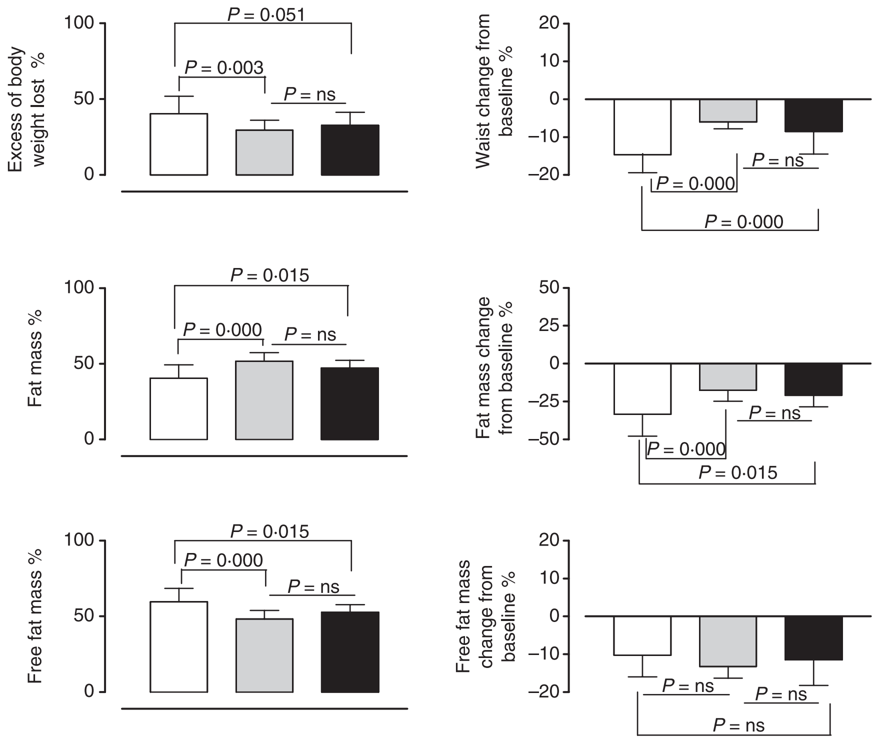

Fig. 1 Postoperative patients' profile. The patients were classified according to their GH and IGF-I status as follows: group (1) patients with normal GH and IGF-I levels (□; $N = 44$; 61·1%); group (2) patients with GH and IGF-I deficiency (▨; $N = 14$; 19·4%) and group (3) patients with normal GH but IGF-I deficiency (■; $N = 14$; 19·4%).

Table 2. Results of anthropometry, body composition by BIA, and metabolic parameters at baseline grouping the obese patients according to their GH status

	GHD	GHS	*P*
N	22	50	
Age	33·8 ± 12·91	32·8 ± 10·72	0·72
BMI (kg/m^2)	45·2 ± 4·84	44·7 ± 4·64	0·68
Waist circumference (cm)	123·0 ± 6·66	117·7 ± 6·70	0·003
Excess body weight (kg)	61·8 ± 11·80	60·2 ± 11·01	0·543
Fat mass (%)	52·1 ± 4·58	48·4 ± 5·26	0·006
Free fat mass (%)	47·9 ± 4·59	51·3 ± 5·26	0·011
Fasting glucose (mmol/l)	4·6 ± 0·42	4·8 ± 0·44	0·139
Insulin (mU/l)	20·3 ± 4·94	19·6 ± 5·62	0·644
HOMA index	4·2 ± 1·24	4·2 ± 1·23	0·992

GHD, patients with GH deficiency; GHS, patients without GH deficiency.

baseline values. Mean EBWL% was 36·6 ± 11·08% (range 16·3%–64·4%). GHD was found in 14 (19·4%) patients, while IGFD was found in 28 (38·9%). In particular, eight of the 22 GHD patients restored their GH response (36·4%), but 12 patients IGFS at baseline became IGFD (21·4%). Serum IGFBP-3 and ALS levels were similar before and after LASGB but the IGF-I : IGFBP-3 molar ratio was significantly reduced. Serum IGFBP-3 and ALS levels remained below normal in 5 (5·6%) and 18 (25%) patients, respectively.

According to their GH and IGF-I status, were found 44 patients GHS and IGFS [61·2%; group (1)]; 14 patients GHD and IGFD [19·4%; group (2)] and 14 patients GHS but IGFD [19·4%; group (3)]. The percent changes of EBWL, waist circumference, FM and FFM in these groups are given in Fig. 1. Compared to group (1), weight loss, percent EBWL and percent of waist circumference changes were significantly reduced in groups (2) and (3). In addition, in groups (2) and (3) the FM% was higher than in group (1), and consensually also its percent changes from baseline were lower in groups (2) and (3) than in group (1) (Fig. 1).

Study correlation

Both pre- and postoperatively, the GH peak ($r = -0·40$ and $r = -0·69$, $P < 0·001$; $r = -0·29$, $P = 0·014$ and $r = -0·65$, $P < 0·001$) and IGF-I levels ($r = -0·38$ and $r = -0·72$, $P < 0·001$; $r = -0·48$ and $r = -0·75$, $P < 0·001$) were inversely correlated with waist circumference and FM%. Only postoperatively, GH peak ($r = -0·29$, $P = 0·013$) and IGF-I levels ($r = -0·29$, $P = 0·015$) were also inversely correlated with BMI. Both the GH peak and IGF-I levels were also directly correlated with percent changes of waist circumference ($r = 0·62$ and $r = 0·81$, $P < 0·001$), FM ($r = 0·64$ and $r = 0·70$, $P < 0·001$) and EBWL ($r = 0·52$ and $r = 0·81$, $P < 0·001$).

At the multiple regression analysis, postoperative IGF-I levels were the most important predictor of EBWL% ($\beta = 0·53$, $t = 5·20$, $P < 0·0001$), percentage of FM ($\beta = 0·70$, $t = 8·20$, $P < 0·0001$) and FFM changes from baseline ($\beta = -0·31$, $t = 2·70$, $P = 0·009$).

Discussion

To efficiently lose FM and to sufficiently spare FFM is of particular concern in obese patients after bariatric surgery because of the serious complications associated with rapid and sustained weight loss.[4,29] Therefore, it is of general interest to understand the complex relationships between endocrine and metabolic changes induced by significant weight loss after surgical procedures which do not induce malabsorption, such as gastric restrictive procedures. In this context, we previously reported in a limited series of very severe obese patients that subtle changes in the adrenal axis, with a decrease in cortisol : DHEA-S molar ratio, were associated with favourable body composition changes 6 months after LASGB.[19] We also reported that at baseline obese GHD patients showed higher FM and lower FFM than GHS patients[30] as confirmed in the current study. These results were obtained in spite of any difference in nutrition-driven components, physical exercise, age, gender, BMI, EBW or glucose metabolism between obese GHD and obese GHS groups.

The most relevant finding of the current study is that 6 months after LASGB, a purely restrictive bariatric procedure, both GH peak and IGF-I levels were inversely correlated with waist circumference and FM% in very obese females. Of all parameters of the GH/IGF-I axis, postoperative IGF-I levels were demonstrated by a stepwise linear regression analysis to represent the most important predictor of percent changes of EBWL, FM and FFM from baseline. In addition, a subset of patients presented with a dissociation between GH and IGF-I levels after LASGB. In fact, the prevalence of IGF-I deficient patients increased from 22% before LASGB to about 40% after LASGB, in spite of partial restoration of the GH response after GHRH + ARG. Thus, while at baseline all patients with IGF-I deficiency also had GHD, postoperatively about 20% of patients were IGF-I deficient but had a normal GH peak response. This is particularly relevant since the most unfavourable body composition changes were observed in IGF-I deficient patients. In particular, all the patients with IGF-I deficiency showed lower FFM, and lower percent of changes of EBWL and FM than patients with normal GH peak and IGF-I levels.

The dissociation between GH and IGF-I after bariatric surgery had already been reported after biliopancreatic diversion.[31] In this case, the catabolic state induced by this malabsorptive surgical procedure was likely to have produced reduced IGF-I levels, as it happens in other different catabolic conditions.[32] On the contrary, Eden *et al.*[33] reported that plasma IGF-I values increased after Roux-en-Y gastric by-pass, a mixed restrictive and malabsorptive intervention. In the Eden *et al.* series, however, both female and male subjects were included, and about one third of the patients had impaired fasting glucose or diabetes before surgery. In our series, the dissociation between GH and IGF-I indicated the persistence of abnormalities in this axis and let us to hypothesize that IGF-I deficiency could be related to a persistent mild state of underlying catabolism. In other terms, in spite of a nonmalabsorptive surgical procedure and a moderate calorie restriction, nutritional status might have likely affected plasma IGF-I concentrations more than weight loss *per se* and/or restoration of GH response.

Several confounding variables have been reported to affect IGF-I levels[14–16] that are nonlinear related to BMI. Mean IGF-I concentration increases up to 28 kg/m^2, but reduce as BMI increases further[34] and in very obese individuals total IGF-I is often significantly decreased compared with individuals of normal weight. In order to try to limit all variables influencing IGF-I secretion, in the current study we included only premenopausal very severe obese women treated with a nonmalabsorptive surgical procedure, within a strict age range, and with a normal glucose metabolism, followed after surgery with a careful monitoring of their calorie intake and physical activity. To adopt a careful strategy, we also decided to re-evaluate all patients 6 months post-LASGB, when weight tends to stabilize after the initial acute negative energy balance.[35] In our conditions, we could clearly demonstrate that alterations in GH and IGF-I secretion after LASGB are associated with a reduced loss of body weight and in particular of FM. The levels of IGFBP-3 and ALS were less associated with body composition changes after LASGB. It is well-known that serum levels of ALS and IGFBP-3 are GH dependent.[14,16,36] However, ALS and IGFBP-3 are also subject to nutritional regulation. Several studies have demonstrated that ALS and IGFBP-3 levels decreased in catabolic conditions, such as calorie-restricted animals and critically ill patients[32] but their changes were variable during the follow-up.[14] In the present study, IGFBP-3 and ALS did not change significantly after LASGB despite IGF-I levels decreased significantly. Accordingly, the IGF-I : IGFBP-3 molar ratio, estimated in order to get the relative concentration changes of IGF-I and IGFBP-3 levels, significantly decreased after surgery. This dissociated behaviour between IGF-I, ALS and/or IGFBP-3 further supports the efficacy of a well-balanced diet in our obese patients, whereas IGF-I more likely reflects, and more accurately, the underlying catabolic state.

Conclusion

This is the first evidence of an inverse correlation between IGF-I levels and waist circumference and fat mass (FM%) along with a persistent deficiency in the GH/IGF-I axis in obese females after a nonmalabsorptive surgical procedure. Postoperative low IGF-I levels are associated to a less effective surgical outcome, and were found to be the most sensitive to changes in body composition among all parameters of GH/IGF-I axis at the stepwise linear regression analysis. Thus, the data of the present study confirm and extend our previous findings on the possible role of the GH/IGF-I in the phenotypic expression of obesity.[30] Moreover the current study suggests that the GH/IGF-I status might contribute to individual postoperative body composition changes. In this context, the usefulness to testing the GH/IGF-I axis both at baseline and in the follow-up of very obese patients after bariatric surgery could be indicated. Finally, as low-IGF-I levels might represent a possible marker of an underlying persistent catabolic state, postoperative IGF-I levels might be proposed as one of the predictive factors for the evaluation of bariatric surgery outcomes. This evidence is particularly relevant in severe obese patients considering the protective effect of IGF-I against cardiovascular disease, atherosclerosis[37,38] and diabetes.[39] Therefore, follow-up after laparoscopic-adjustable silicone gastric banding should include not only nutritional interventions but also specific endocrine and metabolic expertise.

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