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Original article

Predictors of metabolic syndrome persistence 1 year after laparoscopic Roux-en-Y gastric bypass

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Abstract

Background: Laparoscopic Roux-en-Y gastric bypass (LRYGB) is effective in reversing the metabolic syndrome (MS) in up to 90% of patients.
Objectives: The aim of this study was to determine predictors of MS persistence 1 year after LRYGB.
Setting: University Hospital, France.
Methods: Ninety-one patients with a mean age of 44.4 years and a mean body mass index (BMI) of 43.1 kg/m² meeting the criteria for MS were enrolled in this prospective study. Anthropometric, metabolic, and inflammatory biological parameters were assessed before and 1 year after LRYGB. Patients were divided into 2 groups according to the persistence (MS nonresponders) or resolution of MS (MS responders) 1 year after LRYGB and a comparison was performed at baseline and 1 year after surgery.
Results: Sixty-nine patients (75.8%) underwent remission, while 22 (24.2%) showed persistence of MS 1 year after LRYGB. At baseline the MS nonresponders group presented significantly higher values of fasting plasma glucose (7.8 versus 5.3 mmol/L, $P = .004$), glycosylated hemoglobin (HbA_{1c}, 7.3% versus 5.9%, $P = .0004$), triglycerides (TG, 2.37 versus 1.33 mmol/L, $P = .006$), and homeostasis model assessment of insulin resistance (HOMA-IR, 442.5 versus 256, $P = .006$). The rate of diabetes was significantly higher in this group (68.2% versus 36.8%, $P = .0086$), as well as the number of MS components per patient. One year after LRYGB, the MS nonresponders showed a significantly lower excess BMI lost (EBMIL) (56.1% versus 82.4%, $P = .00008$). On multivariate analysis, baseline levels of TG, glucose metabolism markers and EBMIL were associated with the persistence of MS.
Conclusion: Baseline levels of TG, plasma fasting glucose, and HbA_{1c}, as well as history of type 2 diabetes and EBMIL, represent predictors of MS persistence 1 year after LRYGB. (Surg Obes Relat Dis 2015;▮:00–00.)

Keywords: Metabolic syndrome; Roux-en-Y gastric bypass; Triglycerides; Glucose metabolism markers; Excess weight loss; Predictors

Obesity has recently reached epidemic proportions worldwide with a consequent increase in the prevalence of metabolic syndrome (MS) [1–3]. The latter consists of increased waist circumference, hypertriglyceridemia, reduced levels of high-density lipoprotein (HDL) cholesterol,

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hypertension, and increased plasma fasting glucose [1,4]. Although the physiopathology of MS is complex, insulin resistance (IR) plays a pivotal role [1,5]. The visceral adipose tissue behaves as a true endocrine organ producing soluble mediators such as cytokines and adipokines that are in turn responsible for the systemic low-grade inflammation associated with obesity. These molecules are also implicated in the physiopathology of IR through the phosphorylation of the insulin receptor [6]. The association between MS and obesity is particularly important because MS has been found to be a significant risk factor for type 2 diabetes mellitus (T2DM), cardiovascular disease, and premature death [1,7].

Although lifestyle modifications including increased physical activity and a healthy diet can achieve initial weight loss and consequent improvement in MS components, weight regain over time is the rule in most if not all cases [8]. Bariatric surgery is considered the only effective means to achieve an effective and sustained weight loss, maintained in the long term, and associated with a high rate of resolution of obesity-related co-morbidities [8–11]. The Roux-en-Y gastric bypass (RYGB), currently considered by most surgeons as the gold standard of bariatric procedures, is effective at achieving a 60%–70% excess weight loss, which is maintained in the long term [8,9,12]. Furthermore, RYGB has been found to be effective at reversing systemic low-grade inflammation, IR, T2DM, and other obesity-related co-morbidities [10]. In particular, several studies have reported the efficacy of RYGB in reducing the prevalence of MS from 52%–87% at baseline to 2%–29% 1 year or more after RYGB [10,11,13–17]. However, a minority of morbidly obese patients with MS undergoing RYGB experience persistence of MS after surgery [13–15,17–19].

The aim of this study was to determine the predictors of MS persistence 1 year after laparoscopic (L) RYGB in a prospective series of 91 patients.

Materials and Methods

Study protocol

The study was performed according to French legislation regarding Ethics and Human Research and was approved by the local Ethics Committee (Huriet-Serusclat law, DGS 2003/0395). Written, informed consent was obtained from all patients. All patients met the 1991 National Institutes of Health (NIH) Consensus Conference guidelines [18]. Data were collected prospectively in a database.

All patients had negative hepatitis B and C viral markers, absence of auto-antibodies indicative of autoimmune hepatitis, and negligible alcohol consumption (<20 g/d). Alcohol abuse was also excluded by interviewing the patients' relatives. Patients with a history of inflammatory disease, current infections, recent (<5 yr) history of cancer, or severe pulmonary or cardiac disease were not enrolled in the study.

Preoperative workup included medical history and physical examination; endocrine and biochemical evaluation to detect glucose intolerance, dysthyroidism, and hypo- and hypercortisolism; psychiatric and nutritional evaluation; blood pressure determination; anthropometric investigations; chest radiography; electrocardiogram; abdominal ultrasound; upper gastrointestinal endoscopy; determination of fat and lean mass by indirect impedancemetry [20]; and assessment of resting energy expenditure (REE) by indirect calorimetry.

Before surgery and after overnight fasting, blood samples were obtained and used for the determination of glucose, glycosylated hemoglobin (HbA_{1c}), insulin, C-peptide, alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma glutamyl transferase (GGT), triglycerides (TG), HDL cholesterol, low-density lipoprotein (LDL) cholesterol, and C-reactive protein (CRP). High-sensitivity CRP was measured by nephelometry [21]. To assess IR, the homeostasis model assessment of IR (HOMA-IR) by Wallace et al. was used, which is the product of fasting plasma C-peptide concentration (pmol/L) and glucose concentration (mmol/L) divided by 22.5 [4]. The same workup was done 12 months after surgery.

Patients were scheduled for postoperative follow-up at our bariatric center, including the outpatient visit by a bariatric surgeon and a dietician at 1, 3, 6, and 12 months after surgery. Extensive counseling was routinely provided about the importance of physical activity and adherence to diet and vitamin supplementation.

MS was diagnosed according to the definition by Alberti et al. [22], which consists of 3 parameters among the following 5: (1) central obesity, defined as a waist circumference ≥ 80 cm in women and ≥ 94 cm in men; (2) TG ≥ 1.7 mmol/L or treatment for this; (3) HDL cholesterol <1.30 mmol/L in women and <1 mmol/L in men; (4) systolic blood pressure ≥ 130 mm Hg, or diastolic blood pressure ≥ 85 mm Hg, or treatment for hypertension; and (5) fasting plasma glucose ≥ 5.6 mmol/L or previously diagnosed T2DM.

Remission of T2DM was defined as fasting glucose levels ≤ 5.6 mmol/L in addition to an HbA_{1c} value $<6.5\%$ without the use of oral hypoglycemics or insulin.

Surgical technique

All procedures were attempted and completed laparoscopically. LRYGB consisted of a 30–45 mL gastric pouch with an antecolic antegastric 150-cm Roux limb, 50 cm from the ligament of Treitz, and an 11-mm hand-sewn gastrojejunostomy.

Patient selection

Two hundred forty-five patients undergoing LRYGB for morbid obesity at our center from January 2003 to December 2008 signed a written informed consent and accepted to enter this prospective study. These patients

represent about 20% of the entire bariatric population undergoing surgery during the same period. Two hundred twenty-one patients (90.2% of the initial population) completed the 1-year follow-up. Those fulfilling diagnostic criteria for MS according to the definition by Alberti et al. [22] were selected and represent the study population of the present report. For the purpose of this study patients were subsequently divided into 2 groups according to the persistence or resolution of MS 1 year after LRYGB.

Statistical analysis

Continuous data are presented using median and [25th–75th] interquartile range.

Statistical analysis was performed in 2 steps: (i) univariate analysis of biological parameters was carried out for patients with persistence or resolution of MS 1 year after surgery. Comparisons were made using the χ^2 test for nominal data or Mann-Whitney test for continuous data; (ii) multivariate analyses were performed using binary logistic regression with estimation of odds ratios (OR) and 95% confidence intervals (95% CI). Because of the limited number of patients, and to avoid redundancy, 4 models of logistic regression were constructed taking into account significant baseline parameters; glucose metabolism parameters (plasma fasting glucose, HbA_{1c}, HOMA-IR, history of T2DM) were introduced separately.

A second multivariate analysis was performed by using the significant baseline parameters resulting from the 4 previously mentioned models and by introducing the forced variable excess BMI lost (EBMIL) because of its high value as predictor of MS resolution in the literature [15,17].

All statistical analyses were performed using NCSS 2007 software (NCSS, Kaysville, Utah, USA).

Results

Patients' characteristics at baseline

Among the 221 patients (90.2% of the initial population) having completed the 1-year follow-up, 91 (41.2%) fulfilled the criteria for MS before bariatric surgery and represent the study population. A clinical comparison between patients with and without MS at baseline is shown in Table 1. Patients with MS were older and presented a higher waist circumference. There were 11 men and 80 women, with a median age of 44.4 years and a median body mass index (BMI) of 43.1 kg/m². Concerning ethnicity, 89 patients were Caucasian and 2 were African.

Sixty-nine patients (75.8% of the total) underwent remission of MS (MS responders group), whereas 22 (24.2%) showed persistence of MS (MS nonresponders group) 1 year after LRYGB. Consequently the overall prevalence of MS of the study population passed from 41.2% (91/221 patients) at baseline to 10% (22/221 patients) 1 year after surgery.

A comparison of MS responders versus MS nonresponders at baseline is shown in Table 2. At baseline the MS nonresponders group presented significantly higher values of plasma glucose (7.8 versus 5.3 mmol/L, $P = .004$), HbA_{1c} (7.3% versus 5.9%, $P = .0004$), HOMA-IR (442.5 versus 256, $P = .006$), and TG (2.37 versus 1.33 mmol/L, $P = .006$). The rate of diabetes was significantly higher in this group (68.2% versus 36.8%, $P = .0086$), as well as the number of MS components per patient. Cholesterol levels were comparable, as well as liver transaminases and GGT, reflecting liver abnormalities such as liver steatosis or steatohepatitis.

The white blood cell counts and the CRP serum levels, reflecting low-grade systemic inflammation, were also comparable between the 2 groups, as well as the anthropometric characteristics, REE, and duration of the obesity.

Patients' characteristics 1 year after LRYGB

A comparison of MS responders versus MS nonresponders at 1 year after LRYGB is shown in Table 3.

One year after surgery all the investigated parameters had significantly improved in the whole study cohort. Nevertheless, the MS nonresponders group showed significantly higher values of BMI and waist circumference, reflecting a lower EBMIL (56.1% versus 82.4%, $P = .00008$), and significantly higher fat mass at impedancemetry. Although

Table 1
Characteristics of patients with and without MS at baseline

	Without MS at baseline (n = 130)	With MS at baseline (n = 91)	*P*
Gender (M/F)	9/121	11/80	.188
Age (yr)	37 [29.8–44]	44.4 [39–52]	.000002
Weight (kg)	111.5 [103–129]	115 [106–124]	.683
BMI (kg/m²)	42 [40–44.3]	43.1 [40–46]	.301
Waist circumference (cm)	114 [107–125]	122 [113.5–129.5]	.0003
Fat-free mass (kg)	55 [49–62]	56.2 [50.5–68.7]	.196
Fat mass (kg)	56 [50–61.5]	54.5 [49.1–61.2]	.577
EBMIL at 1 yr after LRYGB (%)	89.2 [71.5–99.6]	77.5 [59.8–93.1]	.001

BMI = body mass index; EBMIL = excess BMI lost; LRYGB = laparoscopic Roux-en-Y gastric bypass; MS = metabolic syndrome.
All values shown are median and [25th–75th] interquartile range unless stated otherwise.

Table 2
Characteristics of patients at baseline according to the remission or persistence of MS 1 year after LRYGB

Baseline characteristics	MS responders (n = 69)	MS nonresponders (n = 22)	*P*
Age (yr)	44 [39–51]	45.5 [35–53.3]	.735
Gender (M/F)	7/62	4/18	.314
BMI (kg/m²)	43 [40.4–46.6]	43.5 [39.9–51.2]	.556
Duration of obesity (yr)	20 [12.3–30]	18 [10–26]	.38
Waist circumference (cm)	121 [112.5–128.5]	126.5 [116.3–130.8]	.134
Fat-free mass (kg)	56.5 [50.3–68.0]	55.6 [51.7–69.3]	.976
Fat mass (kg)	54.4 [49–60.3]	57.4 [47.8–65.0]	.652
Resting energy expenditure (kcal/24 hr)	1760 [1645–2210]	2050 [1830–2280]	.079
White blood cells (10^9/L)	7.9 [6.8–9.2]	8 [6.9–9.8]	.650
Neutrophil polynuclear cells (10^9/L)	5[4–5.7]	4.7[4.2–6.3]	.706
AST (IU/L)	27 [20.8–35.3]	24.5 [17–33.8]	.412
ALT (IU/L)	36 [21–48]	27.5 [18–51]	.754
GGT (IU/L)	36.5 [21–54.3]	39 [29–119]	.071
Glucose (mmol/L)	5.3 [4.6–6.3]	7.8[5.1–12.3]	**.004**
HOMA-IR	256 [202.7–423.8]	442.5 [263–587.7]	**.006**
C peptide (pmol/L)	1083 [875–1373]	1095 [1023–1501]	.374
HbA_{1c} (%)	5.9 [5.4–6.6]	7.3 [6.1–9.0]	**.0004**
Type 2 diabetes	25 (36.8%)	15 (68.2%)	**.0086**
Total cholesterol (mmol/L)	5 [4.9–6]	5.6 [4–8]	.323
HDL cholesterol (mmol/L)	1.2 [1.1–1.4]	1.3 [1.1–1.5]	.426
LDL cholesterol (mmol/L)	3.3 [2.8–3.9]	3.0 [2.5–4.0]	.488
Triglycerides (mmol/L)	1.97 [1.4–2.4]	2.33 [1.9–4.2]	**.006**
CRP (mg/L)	10 [7.1–17]	8.5 [5.5–12.9]	.134
MS components = 3	39 (56.5%)	10 (45.5%)	**.025**
MS components = 4	24 (34.8%)	5 (22.7%)	
MS components = 5	6 (8.7%)	7 (31.2%)	

ALT = alanine aminotransferase; AST = aspartate aminotransferase; BMI = body mass index; CRP = C-reactive protein; GGT = gamma glutamyl transpeptidase; HbA_{1c} = glycosylated hemoglobin; HDL = high-density lipoprotein; HOMA-IR = homeostasis model assessment of insulin resistance; LDL = low-density lipoprotein; LRYGB = laparoscopic Roux-en-Y gastric bypass; MS = metabolic syndrome.

All values shown are median and [25th–75th] interquartile range unless stated otherwise.

MS responders: patients with MS remission 1 year after LRYGB. MS nonresponders: patients with MS persistence 1 year after LRYGB.

glucose and lipid metabolism parameters improved in both groups, the significant difference in HbA_{1c}, plasma glucose, and TG found at baseline was still present 1 year after surgery. Moreover, 1 year after surgery, MS nonresponders had higher levels of total cholesterol, lower HDL cholesterol, and higher HOMA-IR. The rate of diabetes persisted significantly higher in this group.

Table 4 shows the evolution of the prevalence of each component of MS in the 2 groups. Although at baseline no difference in prevalence was found between MS responders and nonresponders, 1 year after LRYGB all 5 components were significantly more common in the MS nonresponders.

On multivariate analysis, when only baseline parameters were considered, serum levels of TG, plasma fasting glucose, and HbA_{1c} as well as history of T2DM, were associated with the persistence of MS 1 year after LRYGB (Table 5A).

A second logistic regression analysis (Table 5B) was constructed by taking into account TG and HbA_{1c}, which was the most significant glucose metabolism marker, and by adding the forced variable EBMIL in reason of its high value as predictor of MS resolution in the literature [15,17]. The result of this model confirmed the high value of EBMIL in predicting MS persistence, but at the same time baseline TG level remained significant.

Discussion

This study indicates that baseline levels of TG and glucose metabolism markers (plasma fasting glucose, HbA_{1c}, history of T2DM) as well as EBMIL are significant independent predictors of MS persistence 1 year after LRYGB.

In light of these data, we can consider the severity of metabolic disease as one of the key points for the resistance of MS to RYGB. According to our findings, both TG levels and glucose metabolism markers can reflect the refractoriness to surgery. However, the type and the quality of surgery are likely to play a central role, in consideration of their association with weight loss.

LRYGB is considered to be the bariatric procedure of choice by most bariatric surgeons [8,9,12,23]. Several studies have reported the efficacy of RYGB in reducing the prevalence of MS after 1 year or more of follow-up, with resolution rates of 80%–98.4% at 1 year [13–16]. In a previous report we found 100% MS remission in a small group of patients [11]. The results of this study confirm the

Table 3
Characteristics of patients 1 year after LRYGB according to the remission or persistence of MS

Characteristics 1 yr after LRYGB	MS responders (n = 69)	MS nonresponders (n = 22)	*P*
BMI (kg/m²)	28.2 [25.3–31.0]	33.1 [28.9–36.9]	**.0003**
Waist circumference (cm)	89 [81–98]	97 [93.3–110.3]	**.005**
Fat-free mass (kg)	47.3 [43.2–54.5]	51.2 [44.8–59.2]	.190
Fat mass (kg)	23.9 [19.7–31.6]	34.6 [26.4–48.1]	**.008**
Resting energy expenditure (kcal/24 h)	1355 [1202–1532]	1550 [1317–1777]	.057
White blood cells (10^9/L)	6.5 [5.6–7.6]	7.2 [5.9–9.5]	.107
Neutrophil polynuclear cells (10^9/L)	3.6 [3.1–4.7]	4.2 [3.3–5.9]	.089
AST (IU/L)	21 [18–28]	23 [21–29]	.285
ALT (IU/L)	19 [15–27]	25 [15–34]	.252
GGT (IU/L)	13 [10–18]	22.5 [17.3–51.3]	**.0001**
Glucose (mmol/L)	4.7 [4.2–5.1]	5.3 [4.7–6.5]	**.003**
HOMA-IR	95.6 [72–138.4]	135.8 [106.7–191.3]	**.04**
C peptide (pmol/L)	469 [380.5–626]	628 [438–657.5]	.202
HbA_{1c} (%)	5.2 [5–5.6]	5.8 [5.3–6.4]	**.002**
Type 2 diabetes	1 (1.4%)	12 (54.5%)	**<.0000001**
Total cholesterol (mmol/L)	4.7 [4–5]	5.3 [4–7]	**.003**
HDL cholesterol (mmol/L)	1.5 [1.4–1.8]	1.2 [1.0–1.6]	**.006**
LDL cholesterol (mmol/L)	2.76 [2.3–3.2]	3.18 [2.5–4.5]	.069
Triglycerides (mmol/L)	1.1 [.8–1.4]	2 [1.3–2.6]	**.000012**
CRP (mg/L)	2.5 [1.1–3.7]	2.9 [1–4.8]	.995
EBMIL (%)	82.4 [70.7–98.2]	56.1 [44.9–76.7]	**.00008**

ALT = alanine aminotransferase; AST = aspartate aminotransferase; BMI = body mass index; CRP = C-reactive protein; GGT = gamma glutamyl transpeptidase; HbA_{1c} = glycosylated hemoglobin; HDL = high-density lipoprotein; HOMA-IR = homeostasis model assessment of insulin resistance; LDL = low-density lipoprotein; LRYGB = laparoscopic Roux-en-Y gastric bypass; MS = metabolic syndrome.

All values shown are median and [25th–75th] interquartile range unless stated otherwise.

MS responders: patients with MS remission 1 year after LRYGB. MS nonresponders: patients with MS persistence 1 year after LRYGB.

efficacy of the procedure with 75.8% of patients experiencing remission of MS at 1 year.

Nevertheless there is a small subgroup of patients who are metabolically refractory to LRYGB with persistence of MS after surgery. To date a few studies have attempted to identify these patients [15,17].

Batsis et al. in their retrospective study analyzed a subgroup of 143 patients with MS at baseline undergoing LRYGB and compared the 98 MS responders to the 45 nonresponders at a follow-up of at least 1 year to determine the risk factors for MS persistence. They found that MS nonresponders were older and had a higher baseline BMI, lower excess weight loss (EWL), higher serum levels of TG, higher fasting blood glucose, a greater prevalence of baseline T2DM, and increased usage of angiotensin-converting enzyme inhibitors. EWL was a highly significant predictor of MS resolution [17]. The results of this paper are in accord with our study, with the only exceptions of the predictive value of male gender and baseline BMI.

Other studies have identified longstanding T2DM, insulin usage, and lower EWL as the most important predictors for nonremission of T2DM [24–26].

MS resolution at 1 year is strongly associated with EWL in several studies [15,17]. These results were confirmed in our study, as MS nonresponders presented at 1 year lower EBMIL compared with MS responders.

RYGBP is followed by a profound weight loss mainly because of decreased fat stores. Weight loss accompanies

Table 4
Comparison of the prevalence of each component of MS at baseline and 1 year after LRYGB according to the remission or persistence of MS

Parameters of the MS according to Alberti et al. [21] definition	MS responders (n = 69)		MS nonresponders (n = 22)		Comparison between data at baseline for MS responders and MS nonresponders *(P)*	Comparison between data at 1 yr after LRYGB for MS responders and MS nonresponders *(P)*
	Baseline	1 yr post-LRYGB	Baseline	1 yr post-LRYGB		
High waist circumference n (%)	69 (100)	51 (74)	22 (100)	22 (100)	—	.007
High blood pressure n (%)	49 (71)	17 (25)	20 (90)	17 (77)	.06	.000009
High fasting blood glucose n (%)	38 (55)	4 (6)	15 (68)	13 (59)	.278	< .0000001
High triglycerides level n (%)	48 (70)	4 (6)	19 (86)	16 (73)	.119	< .0000001
Low HDL cholesterol level n (%)	39 (57)	9 (13)	9 (41)	12 (55)	.202	.00006

HDL = high-density lipoprotein; LRYGB = laparoscopic Roux-en-Y gastric bypass; MS = metabolic syndrome.

MS responders: patients with MS remission 1 year after LRYGB. MS nonresponders: patients with MS persistence 1 year after LRYGB.

Table 5A
Multivariate analysis (logistic regression) of most significant parameters at baseline associated with the persistence of MS 1 year after LRYGB

First model, $r^2 = .23$			
	OR	95% CI	*P*
HbA_{1c}	1.73	1.14–2.62	**.01**
Number of MS components	1.14	.49–2.66	.76
TG	1.55	1.02–2.35	**.04**
Second model, $r^2 = .21$			
	OR	95% CI	P
Fasting plasma glucose	1.28	1.06–1.54	**.01**
Number of MS components	.92	.39–2.17	.85
TG	1.78	1.11–2.85	**.02**
Third model, $r^2 = .20$			
	OR	95% CI	P
HOMA-IR	1.01	.99–1.02	.200
Number of MS components	1.51	.54–4.20	.430
TG	1.55	1.01–2.38	**.046**
Fourth model, $r^2 = .19$			
	OR	95% CI	P
Type 2 diabetes	3.76	1.08–13.15	**.038**
Number of MS components	1.10	.49–2.46	.823
TG	1.83	1.13–2.97	**.014**

CI = confidence interval; HbA_{1c}, glycosylated hemoglobin; HOMA-IR = homeostasis model assessment of insulin resistance; LRYGB = laparoscopic Roux-en-Y gastric bypass; MS = metabolic syndrome; OR = odds ratio; TG = triglycerides.

with several changes that participate in the remission of MS. These include reduced plasma leptin and ghrelin levels, increased adiponectin levels, improved insulin sensitivity, reduced fatty acid turnover, decreased systemic inflammation, and improved endothelial function [27]. However, how much excess weight has to be lost to achieve the remission of metabolic disorders is still a matter of debate.

Identifying nonresponder patients before RYGB may be of mainstay importance because a procedure more effective either on excess weight or metabolic disorders, such as the biliopancreatic diversion/duodenal switch (BPD/DS), may be preferred. Indeed, the BPD/DS has been reported to result in a greater EWL than the LRYGB [9,28–31]. Furthermore, in a meta-analysis Buchwald recently found that the BPD/DS is also associated with the greatest rate of remission of T2DM [9]. Similarly, Hedberg et al. confirmed in their meta-analysis the superiority of BPD/DS compared with RYGB in term of T2DM remission [31]. Although these meta-analyses did not take into account the evolution of MS, it may be speculated that the rate of MS remission is significantly higher after the BPD/DS because the IR remission plays a pivotal role in the evolution of the MS components [1,5].

We acknowledge that the present study has several flaws linked to the limited number of patients and to the duration of follow-up of only 1 year. However, its strength relies on the exhaustive prospective investigational workup, including anthropometrics, lipid and glucose metabolism, and inflammation markers in the entire cohort of morbidly obese patients.

Table 5B
Multivariate analysis (logistic regression) of most significant parameters at baseline associated with the persistence of MS and EBMIL as a forced variable ($r^2 = .37$)

	OR	95% CI	*P*
EBMIL at 1 yr after LRYGB	.94	.91–.98	**.002**
HbA_{1c} at baseline	1.51	.98–2.32	.064
TG at baseline	1.83	1.02–3.30	**.04**

CI = confidence interval; EBMIL = excess BMI lost; HbA_{1c}, glycosylated hemoglobin; HOMA-IR = homeostasis model assessment of insulin resistance; LRYGB = laparoscopic Roux-en-Y gastric bypass; MS = metabolic syndrome; OR = odds ratio; TG = triglycerides.

Conclusion

Several studies have reported that RYGB is effective in reversing MS in up to 90% of patients. The results of this study confirm the efficacy of the procedure with 75.8% remission rate at 1 year. Nevertheless a small subgroup of patients have proven metabolically refractory to LRYGB with persistence of MS after surgery. In this study we found that baseline levels of TG, glucose metabolism markers (plasma fasting glucose, HbA_{1c}, history of T2DM), and

EBMIL are significant independent predictors of MS persistence 1 year after LRYGB. Studies with a longer follow-up are necessary to confirm these data in the long term.

Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article.

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