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ORIGINAL CONTRIBUTIONS

Efficacy of Bariatric Surgery in Type 2 Diabetes Mellitus Remission: the Role of Mini Gastric Bypass/One Anastomosis Gastric Bypass and Sleeve Gastrectomy at 1 Year of Follow-up. A European survey

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Abstract
Background A retrospective study was undertaken to define the efficacy of both mini gastric bypass or one anastomosis gastric bypass (MGB/OAGB) and sleeve gastrectomy (SG) in type 2 diabetes mellitus (T2DM) remission in morbidly obese patients (pts).
Methods Eight European centers were involved in this survey. T2DM was preoperatively diagnosed in 313/3252 pts (9.62 %). In 175/313 patients, 55.9 % underwent MGB/OAGB, while in 138/313 patients, 44.1 % received SG between January 2006 and December 2014.
Results Two hundred six out of 313 (63.7 %) pts reached 1 year of follow-up. The mean body mass index (BMI) for MGB/OAGB pts was 33.1±6.6, and the mean BMI for SG pts was 35.9±5.9 ($p<0.001$). Eighty-two out of 96 (85.4 %) MGB/OAGB pts vs. 67/110 (60.9 %) SG pts are in remission ($p<0.001$). No correlation was found in the % change vs. baseline values for hemoglobin A1c (HbA1c) and fasting plasma glucose (FPG) in relation to BMI reduction, for both MGB/OAGB or SG (ΔFPG 0.7 and ΔHbA1c 0.4 for MGB/OAGB; ΔFPG 0.7 and ΔHbA1c 0.1 for SG). At multivariate analysis, high baseline HbA1c [odds ratio (OR)=0.623, 95 % confidence interval (CI) 0.419–0.925, $p=0.01$], preoperative consumption of insulin or oral antidiabetic agents (OR=0.256, 95 % CI 0.137–0.478, $p=<0.001$), and T2DM duration >10 years (OR=0.752, 95 % CI 0.512–0.976, $p=0.01$) were negative predictors whereas MGB/OAGB resulted as a positive predictor (OR=3.888, 95 % CI 1.654–9.143, $p=0.002$) of diabetes remission.
Conclusions A significant BMI decrease and T2DM remission unrelated from weight loss were recorded for both procedures if compared to baseline values. At univariate and multivariate analyses, MGB/OAGB seems to outperform significantly SG. Four independent variables able to influence T2DM remission at 12 months have been identified.

Keywords Bariatric surgery · Mini gastric bypass/one anastomosis gastric bypass · MGB/OAGB · Sleeve gastrectomy · SG · T2DM · Type 2 diabetes mellitus · Remission · European multicenter survey

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Introduction

Type 2 diabetes mellitus (T2DM) and morbid obesity are conditions representing increasing public health threats. They are associated with significant morbidity and mortality, and despite lifestyle modifications and medical support, glycemic control remains difficult to achieve in obese diabetic patients [1]. Bariatric surgery has so far shown high efficacy in achieving T2DM long-term remission and durable weight loss [2–4], leading the International Diabetes Federation (IDF) and the American Diabetes Association (ADA) to suggest bariatric surgery as an effective treatment modality in obese patients with T2DM [5, 6].

Different laparoscopic bariatric procedures have been investigated to treat T2DM obese patients, with excellent results in terms of weight loss and glycemic control reported for both the biliopancreatic diversion with or without the duodenal switch (BPD/BPD-DS) and the Roux-en-Y gastric bypass (RYGBP) [2, 7]. Conversely, restrictive procedures such as the sleeve gastrectomy (SG) and the laparoscopic adjustable gastric banding (LAGB), although effective on weight loss, seem to provide different results on T2DM remission. In fact, while the SG presents an outcome that, in some studies, is comparable to RYGBP [8–10], the LAGB seems to determine a lesser impact on glucose homeostasis, achieving controversial results [2, 11, 12]. The mini gastric bypass or one anastomosis gastric bypass (MGB/OAGB) originated by Rutledge in 1997 [13] is an emerging technique consisting in a simplified version of the classic RYGBP. When described, MGB/OAGB raised severe criticism, reprised in a more recent debate [14, 15], but despite such skeptical position, different authors have reported excellent results in terms of weight loss and resolution of obesity-related comorbidities [16], including T2DM [17] and women obesity-related infertility [18]. To date, MGB/OAGB has reached the status of a standard bariatric procedure in Italy (http://www.sicob.org) and many other countries [19], providing excellent results even in the long term [20]. A recent survey endorsed by the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) has reported MGB/OAGB being the most frequently performed procedure following the more established laparoscopic RYGBP, SG, and LAGB in Europe and Asia/Pacific area [21]. Following the Second International Consensus Conference on MGB/OAGB, held in Paris in October 2013, a group of European surgeons especially experienced with both MGB/OAGB and SG agreed to participate in a large-scale multicenter retrospective study to compare and define the efficacy of these two procedures in determining weight loss and T2DM remission.

Patients and Methods

Under the coordination of the pilot center located at the University of Naples Federico II, Italy, seven hospital bariatric units, three from Italy and four from Germany, Netherlands, Portugal, and Czech Republic respectively, participated in this multicenter audit. Only the clinical records of 3252 bariatric patients operated by MGB/OAGB or SG between January 2006 and December 2014 were retrospectively reviewed. Criteria of inclusion in the study, according to the widely accepted criteria from IFSO and ADA [22], were obese patients with at least 1 year of follow-up, who underwent MGB/OAGB or SG with a body mass index (BMI) >35 kg/m^2, with an age ranging from 18 to 60 and presenting a glycosylated hemoglobin A1c (HbA1c) level ≥6.5 % or a fasting plasma glucose (FPG) level ≥126 mg/dL (fasting was defined as no caloric intake for at least 8 h) or a 2-h plasma glucose level ≥200 mg/dL during an oral glucose tolerance test (OGTT) or a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, with a random plasma glucose level ≥200 mg/dL.

Exclusion criteria included revision, reversal, or conversion bariatric surgery for any reason; perioperative complications including operated patients who developed a malignancy during follow-up; or patients lost to follow-up.

Starting from January 2014, data from all patients fulfilling inclusion criteria were included in an electronic sheet and returned to pilot center. Two independent reviewers collected all charts from each center in a prospectively built database.

Data Extraction

The following data were considered:

- At baseline: patient age and sex, preoperative BMI (kg/m^2), preoperative FPG (mg/dL), preoperative HbA1c (%), diabetes duration in years, assumption of insulin or oral antidiabetic agents, antihypertensive drugs, preoperative total and fractionated cholesterol (mg/dL), preoperative triglycerides (mg/dL), lipid-lowering agent assumption, preoperative blood pressure (mmHg), and type of surgical procedure (MGB/OAGB or SG)
- Within the first 30 postoperative days: perioperative mortality and morbidity
- At follow-up (1 year for all centers): BMI, ΔBMI, excess weight loss rate (EWL%), FPG, HbA1c, use of insulin or glucose-lowering agents, blood pressure (BP), antihypertensive drug assumption, total and fractionated cholesterol, triglycerides, and lipid-lowering agent assumption

Surgical Technique

The SG standard technique, performed in all centers, followed previously described procedures [23–25]. Vertical gastrectomy started from 5.5±1.5 cm proximal the pylorus with a bougie size ranging from 36 to 40 French (Fr) size in all patients. The MGB/OAGB surgery was performed by preparing a gastric pouch sizing 15±2.5 cm in length and tailoring a mechanical linear wide gastrojejunal anastomosis at 195±25.5 cm from the ligament of Treitz in all patients [13, 25]. No single-incision laparoscopic surgery (SILS) procedures were performed in these patients.

Outcomes

The following endpoints have been investigated:

- Primary endpoint: to define and compare the efficacy of MGB/OAGB and SG in determining type 2 diabetes remission according to the 2009 consensus group criteria endorsed by the American Diabetes Association [26]. FPG levels <126 mg/dL or HbA1c <6.5 % of at least 1-year duration in the absence of insulin or glucose-lowering agent administration were considered as remission criteria.
- Secondary endpoint: to define the efficacy and the eventual risks of both MGB/OAGB and SG in determining BMI and EWL% changes in this specific subset of diabetic patients. The following were considered as perioperative complications: pulmonary embolism (PE), acute myocardial infarction (AMI), stroke, intra-abdominal bleeding, gastrointestinal bleeding, and gastrointestinal leak.
- Tertiary endpoint: to evaluate the impact of diabetes duration on the efficacy of surgical procedures.

As a complementary endpoint, the control of hypertension and dyslipidemia, according to ADA criteria [3, 27], was also investigated. Hypertension control is defined as systolic BP lower than 130 mmHg and diastolic BP lower than 80 mmHg. Definitions of dyslipidemia control include low-density lipoprotein (LDL) lower than 100 mg/dL, high-density lipoprotein (HDL) higher than 40 mg/dL (or 50 mg/dL in men), and triglycerides lower than 150 mg/dL. Data were reported only for patients previously in treatment, free at control visit from antihypertensive or lipid-lowering agent drug therapy.

Statistical Analysis

Statistical analysis was performed using the SPSS 17 system (SPSS Inc., Chicago, IL, USA). Continuous data were expressed as the means±SD, and categorical variables were expressed as the % changes. To compare continuous variables, an independent and/or paired sample *t* test was performed and correlation was assessed using Pearson's linear correlation coefficients (*r*). Changes in BMI (ΔBMI) were expressed as the % changes vs. baseline values as well. The chi-square test was used to analyze categorical data. When the minimum expected value was <5, Fisher's exact test was used. To adjust for major covariates and to generate predictions, a logistic regression (stepwise) model was applied, with diabetes remission at 1 year, as the dependent variable, and age, gender, baseline BMI, hypertension, hypercholesterolemia, diabetes duration, T2DM treatment, FPG, HbA1c, surgical treatment, BMI, and EWL% at 1 year, as independent variables. All of the results are presented as two-tailed values with statistical significance defined as p values <0.05.

Results

Baseline Conditions

According to the above mentioned criteria, 313/3252 T2DM patients (9.62 %) were screened for inclusion in the study. They were split into two groups according to the surgical intervention performed (SG or MGB/OAGB). Baseline data for those 206/313 patients (65.8 %) reaching 1 year of follow-up were considered in the analysis. Table 1 defines the preoperative conditions for all patients. No significant differences were observed between patients who underwent MGB/OAGB or SG on any parameter at baseline.

Perioperative Complications

No perioperative deaths were recorded for both interventions. Table 2 reports the morbidity rate in the two groups. All 313 patients were evaluated during the perioperative period. No significant differences were reported between patients who underwent MGB/OAGB or SG at this stage.

Follow-up

Of 175 patients who underwent MGB/OAGB, 112 were eligible for follow-up at 1 year. Among these, 96 (85.7 %) came for control visit. SG patients eligible for follow-up at 1 year were 128, and among these, 110 (85.9 %) came for control visit. The dropout rate at 1 year was of 34 patients (14.1 %) (see Table 3). The BMI decreased significantly for both procedures if compared to baseline values (MGB from 48.3±9.2 to 33.1±6.6, $p<0.001$; SG from 48.1±7.8 to 35.9±5.9, $p<0.001$). Noteworthy, the MGB/OAGB provided significant BMI decrease when compared to SG at 1 year (33.1±6.6 vs. 35.9±5.9, $p<0.001$). This was confirmed by the observation that MGB/OAGB compared to SG at 1 year provided both a higher % BMI reduction vs. baseline levels (−30.9±8.93 vs. −24.8±8.07, $p<0.001$) and a larger EWL% increase (64.7±22.9 vs. 52.4±18.3, $p<0.001$).

Both surgical procedures achieved T2DM remission if compared to baseline values (MGB from 182.5±69.7 to 104.0±19.6, $p<0.001$; SG from 189.9±66.4 to 122.2±38.6, $p<0.001$, for FPG; MGB from 7.6±1.5 to 5.9±1.1, $p<0.001$; SG from 7.3±1.3 to 6.2±0.9, $p<0.001$, for HbA1c). However, it should be noticed that MGB/OAGB provided a better performance than SG at 1 year (see Table 4). If we, in fact, consider patients who underwent MGB/OAGB, we have a

Table 1 Baseline conditions in patients with 12 months of follow-up according to surgical procedure

	MGB/OAGB (*n*=96)	SG (*n*=110)	*p*
Patients number	96/175	110/138	
Age	48.5±8.7	49.2±9.1	0.5
Male gender	58/96 (60.4 %)	80/110 (72.7 %)	0.07
BMI	48.3±9.2	48.1±7.8	0.8
FPG	182.5±69.7	189.9±66.4	0.4
HbA1c	7.6±1.5	7.3±1.3	0.1
Diabetes duration >10 years	14/96 (14.5 %)	14/110 (12.7 %)	0.8
Oral antidiabetic	49/96 (51 %) +	46/110 (41.8 %) +	
Insulin	31/96 (32.3 %)	39/110 (35.4 %)	
	80/96 (83.3 %)	85/110 (77.2 %)	0.3
No medication	16/96 (16.6 %)	25/110 (22.7 %)	0.3
Total cholesterol	184.9±41.2	183.1±36.9	0.7
HDL cholesterol	44.7±13.9	43.0±12.6	0.3
LDL cholesterol	119.3±40.4	120.8±38.8	0.7
Triglycerides	207.9±123.4	200.4±100.5	0.6
Blood pressure			
Max (range)	136.6±16.9	140.1±18.2	0.1
Min (range)	82.4±10.8	82.5±11.0	0.9

The *p* value reports the eventual statistical difference in patients assuming oral antidiabetic agents and/or insulin

remission rate from T2DM of 82/96 patients (85.4 %) for those controlled at 1 year, while patients who underwent SG have a remission rate of 67/110 (60.9 %) ($p<0.001$, see Fig. 1). Finally, comparing for each intervention, MGB/OAGB or SG, the % change vs. baseline values for HbA1c and FPG in relation to BMI reduction, no significant correlation was found (ΔFPG 0.7 and ΔHbA1c 0.4 for MGB/OAGB; ΔFPG 0.7 and ΔHbA1c 0.1 for SG; see Figs. 2 and 3).

Both the lipid profile and the blood pressure change, following the two surgical procedures, have been evaluated. Table 4 shows an improvement in lipid profile at 1 year in patients who underwent MGB/OAGB or SG. The differences were not significant between the two procedures. The same table shows a significant decrease in both systolic and diastolic blood pressure levels at 1 year in patients who underwent MGB/OAGB vs. patients who received SG ($p<0.003$ and $p<0.003$, respectively). After adjusting for various clinical and demographic characteristics in a multivariate logistic regression analysis, high baseline HbA1c [odds ratio (OR)=0.623, 95 % confidence interval (CI) 0.419–0.925, $p=0.01$], preoperative consumption of insulin (OR=0.256, 95 % CI 0.137–0.478, $p<0.001$), and diabetes duration longer than 10 years (OR=0.752, 95 % CI 0.512–0.976, $p=0.01$) were found to be negative predictors of diabetes remission at 1 year. Conversely, the use of MGB/OAGB resulted as a positive predictor of diabetes remission (OR=3.888, 95 % CI 1.654–9.143, $p=0.002$).

Table 2 Morbidity for both procedures

	MGB (*n*=175)	SG (*n*=138)	*p*
Preoperative complications			
Pulmonary embolism, *n* (%)	2 (1.1)	1 (0.7)	1.0
Myocardial infarction	0	0	–
Stroke	0	0	–
Intra-abdominal bleeding, *n* (%)	5[a] (3.6)	3 (2.1)	1.0
Gastrointestinal bleeding	0	0	–
Gastrointestinal leak	0	1 (0.7)	1.0
Others, *n* (%)	1 (0.5)	0	1.0
Total, *n* (%)	8 (4.5)	5 (3.6)	0.7

[a] Two patients who underwent MGB/OAGB needed surgical revision for postoperative intra-abdominal bleeding

Discussion

The primary risk factor for type 2 diabetes is obesity, and 90 % of all patients with type 2 diabetes are either overweight or obese. The National Health and Nutrition Examination Survey III (1988–1994) data demonstrated that the risk for chemical diabetes is approximately 50 % with a BMI greater than or equal to 30 kg/m^2 and over 90 % with a BMI of 40 kg/m^2 or more

Table 3 Patients in follow-up at 1 year

Follow-up	1 year	
Surgery	MGB	SG
Total patients	175	138
Eligible patients	112	128
Controlled patients, *n* (%)	96 (85.7)	110 (85.9)

Table 4 Clinical and biochemical conditions in patients at 12 months of follow-up according to surgical procedure

	MGB/OAGB (*n*=96)	SG (*n*=110)	*p*
BMI	33.1±6.6	35.9±5.9	<0.001
% BMI	−30.9±8.93	−24.8±8.07	<0.001
EWL%	64.7±22.9	52.4±18.3	<0.001
FPG	104.0±19.6	122.2±38.6	<0.001
HbA1c	5.9±1.1	6.2±0.9	<0.001
Oral antidiabetic	7/96 +	23/110 +	
Insulin	7/96	20/110	
	14/96 (14.6 %)	43/110 (39.1 %)	<0.001
Remission	82/96 (85.4 %)	67/110 (60.9 %)	<0.001
Total cholesterol	168.7±29.4	178.7±29.1	0.9
HDL cholesterol	52.4±17.3	51.6±10.5	0.7
LDL cholesterol	104.2±31.2	107.2±29.9	0.4
Triglycerides	141.6±56.7	140.9±51.4	0.9
Blood pressure			
Max (range)	129.0±12.3	134.8±14.8	0.003
Min (range)	77.0±11.4	81.5±10.4	0.003

The *p* value reports the eventual statistical difference in patients assuming oral antidiabetic agents and/or insulin

[17]. Since Pories' first report in 1995 [28], a powerful body of published evidence has shown the efficacy of bariatric surgery in determining T2DM remission. The superiority of surgery even in comparison to conservative treatment [29, 30] has led many authors to investigate different procedures able to improve or heal T2DM in both morbidly obese and mildly obese patients. However, the mechanism by which bariatric surgery causes T2DM remission is yet to be defined. In 2009, Cummings reviewed the existing conjectures regarding the mechanisms underlying diabetes remission. Based on this study, three main hypotheses were postulated. The ghrelin hypothesis, which affirms that hormone release may be disturbed following RYGBP or SG. Diminished ghrelin secretion can, in fact, decrease appetite and food intake, also increasing glucose tolerance, given that ghrelin can stimulate counter-regulatory hormones [31]. This hypothesis remains, however, controversial. If some studies

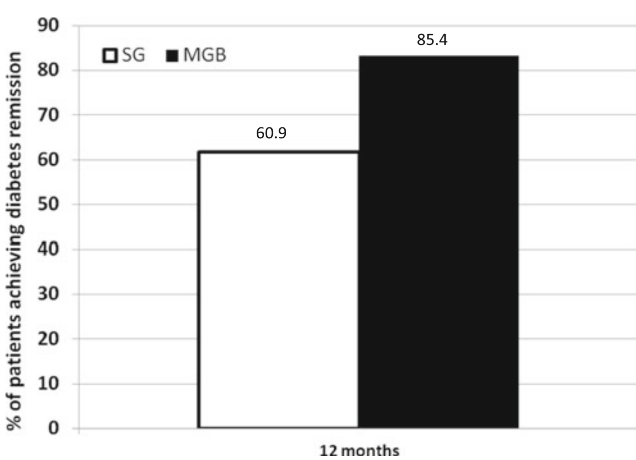

Fig. 1 Remission rate from T2DM of patients who underwent MGB/OAGB or SG

have, in fact, shown ghrelin levels being very low following RYGBP or SG, conversely, more recent papers have shown hormone levels to remain unchanged following RYGBP [32]. The upper intestinal hypothesis, which states that avoiding nutrient contact with the duodenum is somehow a key in the process through which diabetes is improved. The basis for this hypothesis is that unknown factors or processes from the duodenum influence glucose homeostasis [33]. Finally, the lower intestinal hypothesis, which claims that the intestinal shortcuts created by bariatric surgery, expedite delivery of ingested nutrients and increase glucagon-like peptide-1 (GLP-1) release.

It is therefore interesting to observe how, starting from Buchwald meta-analysis [2] to a more recent study from Denmark [34], it seems confirmed that only bariatric procedures as SG, RYGBP, or BPD-DS, recalling at least one among the three hypotheses, are able to provide an acceptable and enduring T2DM remission. However, conversely, it remains unclear how much diabetes remission, regardless of hypothesized mechanism, can be achieved independently from weight loss.

Despite previous reports [9, 35–37], the metabolic efficacy of SG remains an interesting issue. While several studies have reported the efficacy of this technique, conversely, Panunzi, in a recent meta-analysis [11], considering 4944 diabetic patients, has reduced the metabolic role of SG, reporting a T2DM remission rate of 60 %, very similar to LAGB remission rate of 62 % and significantly lower than the remission offered by both BPD (89 %) and RYGBP (77 %). This is confirmed by another large-scale meta-analysis from China on 7883 diabetic patients [12]. If we, in fact, consider the data, available for 6373 patients, about the efficacy of different surgical procedures, LRYGBP, SG, and LAGB provided a T2DM remission rate of 74.4, 61.3, and 33 %, respectively.

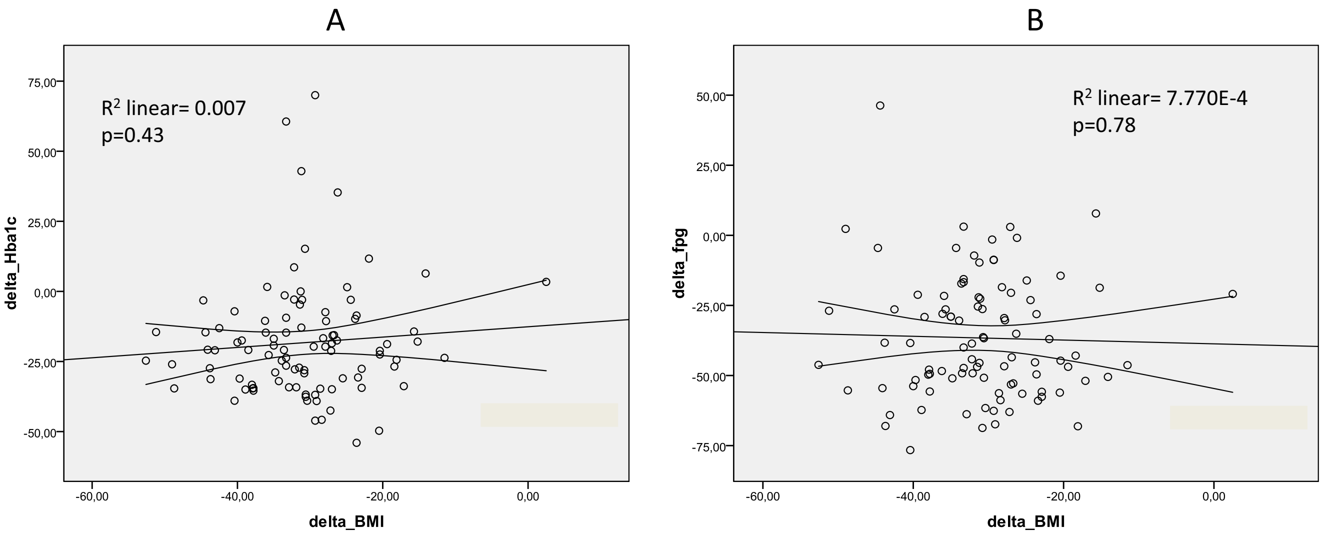

Fig. 2 Scatter plot of Pearson's correlations between BMI and HbA1c (**a**) and BMI and FPG changes (**b**) following MGB/OAGB. *Delta:* mean± SD at 12 months—baseline at time of surgery; *HbA1c* hemoglobin A1c, *BMI* body mass index, *FPG* fasting plasma glucose, *MGB/OAGB* mini gastric bypass/one anastomosis gastric bypass

Less is known about the metabolic efficacy of MGB/OAGB. Lee, in 2011, investigated the metabolic role of this procedure in a randomized controlled trial (RCT) involving 60 moderately obese diabetic patients [38]. The results showed a higher efficacy of MGB/OAGB vs. SG both in terms of weight loss and T2DM remission. These results are confirmed in another multicenter Asian report in 2012 on 200 moderately obese patients [39]. Individuals who underwent gastric bypass procedures (LRYGBP or MGB/OAGB) lost more weight and reached a higher T2DM remission rate at 1 year, compared to patients treated by restrictive procedures (SG or LAGB). The efficacy of MGB/OAGB in providing diabetes remission is confirmed in long-term studies as well. Lee reports a significantly lower level of HbA1c at 5 years in patients who underwent MGB/OAGB vs. SG in a RCT [40], while Guenzi reported 82.5 % of diabetes control with HbA1c lower than 6.5 %, after a mean follow-up of 26 months, following MGB/OAGB [41]. This is also confirmed in our Italian multicenter experience, reporting a T2DM remission rate of 84.4 % at 5 years of follow-up [42]. Published evidence on large numbers seems, therefore, to allow some conclusions. The first one is the higher efficacy of bypass procedures, when compared to SG or LAGB, in inducing T2DM remission [3, 11, 12, 40], the second being the significant positive effect on remission provided by short diabetes duration [11, 12, 43]. Again, it has to be observed that the T2DM remission rate is negatively influenced by both high preoperative HbA1c levels and insulin use [10–12, 34, 35, 43]. The results provided by our study confirm

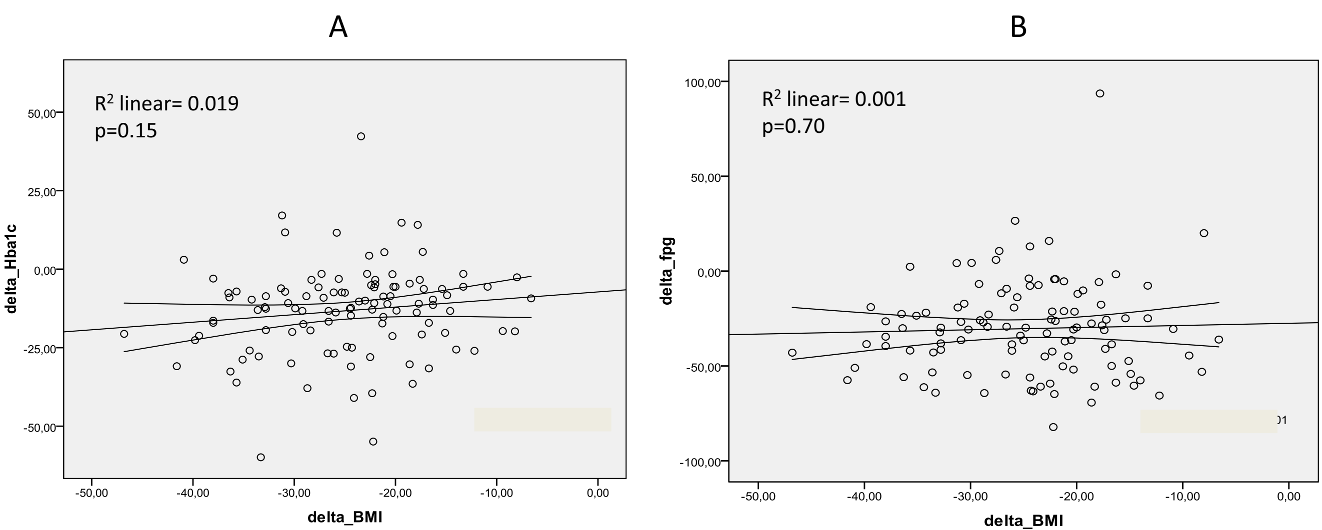

Fig. 3 Scatter plot of Pearson's correlations between BMI and HbA1c (**a**) and BMI and FPG changes (**b**) following SG. *Delta:* mean±SD at 12 months—baseline at time of surgery; *HbA1c* hemoglobin A1c, *BMI* body mass index, *FPG* fasting plasma glucose, *SG* sleeve gastrectomy

these conclusions. Both FPG and HbA1c at 1 year are significantly lower in diabetic patients treated by MGB/OAGB when compared to SG patients. Furthermore, the postoperative consumption of insulin or oral antidiabetic agents resulted to be significantly higher in this latter group as shown in Table 4. At the same time, while diabetes duration longer than 10 years, high HbA1c levels, and consumption of insulin at preoperative stage represented negative predictors; conversely, the use of MGB/OAGB resulted as a positive predictor of T2DM remission in a multivariate analysis.

The last question coming from published evidence is more controversial. It is represented by the role played by BMI changes in diabetes remission. In our study, we actually found a bypass procedure as MGB/OAGB being more effective than the SG in providing diabetes remission but, conversely, the significantly higher BMI decrease offered by MGB/OAGB does not allow us to define in which terms T2DM remission is related to weight loss at 1 year. While some authoritative series claims, in fact, the importance of BMI decrease in reaching a significant and long-lasting T2DM remission [2, 3, 10, 29, 40], on the other hand, if we observe large numbers of meta-analysis, this issue seems to lose relevance [8, 11, 12] especially when moderately obese diabetic patients are considered [44]. This debatable issue has been validated by Mingrone as well, who recorded T2DM remission occurring before significant weight loss [30]. Our finding seems to confirm those hypotheses that diabetes remission may be independent from weight loss and reinforces the concept that the type of surgery may play a more relevant role. If we, in fact, consider, for both MGB/OAGB and SG, the changes of FPG and HbA1c in relation to BMI decrease, we did not find any significant correlation at Pearson's analysis as shown in Figs. 2 and 3.

Cardiovascular events are also reduced following bariatric surgery. In this light, our review seems to confirm high-volume long-term studies [45, 46]. If we, in fact, consider lipid profile and blood pressure in our patients, we observe changes in HDL, LDL, triglycerides, and systolic and diastolic pressure, which are significant if we compare surgery to baseline condition. Furthermore, MGB/OAGB provided a significant improvement in blood pressure values, at univariate analysis, when compared to SG. Interestingly, confirming a previous smaller series from our group [47], no significant differences were observed in the lipid profile by comparing MGB/OAGB to SG at 1 year (Table 4).

To our knowledge this is the wider series reporting MGB/OAGB outcome on T2DM patients; nevertheless, our study presents some limitations. The first one is the retrospective design of the study accompanied by a follow-up limited at 12 months. Secondly, given that some useful T2DM parameters as HOMA and C-peptide levels in the past were not routinely evaluated in some participating centers, they were not available for this study. Again, the variation in lipid profile and blood pressure was considered only for patients known in treatment with antihypertensive drugs or lipid-lowering agents. Finally, a dropout rate approaching 15 % of patients eligible for follow-up has been recorded.

In conclusion, according to our results at 1 year, both MGB/OAGB and SG, in patients presenting a BMI >35 kg/m^2, provide significant weight loss and T2DM remission, although, interestingly, this last result is unrelated to weight loss for both techniques. In particular, MGB/OAGB, while offering a very acceptable surgical risk rate, outperforms significantly SG in terms of BMI reduction, T2DM remission, and reduction in blood pressure values. Following a multivariate analysis, a long history of diabetes, accompanied by high HbA1c levels and consumption of antidiabetic drugs, remains to be a negative predictor of T2DM remission following surgery; conversely, MGB/OAGB may be regarded as an independent factor able to favor T2DM remission.

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Conflict of Interest Authors Mario Musella, Jan Apers, Karl Rheinwalt, Rui Ribeiro, Emilio Manno, Francesco Greco, Michal Čierny, Marco Milone, Carla Di Stefano, Sahin Guler, Isa Mareike Van Lessen, Anabela Guerra, Mauro Natale Maglio, Riccardo Bonfanti, Radoslava Novotna, Guido Coretti, and Luigi Piazza (1), in the past 5 years, have not received reimbursements, fees, funding, or salary from an organization that may in any way gain or lose financially from the publication of this manuscript, either now or in the future; (2) do not hold any stocks or shares in an organization that may in any way gain or lose financially from the publication of this manuscript, either now or in the future; (3) do not hold or are not currently applying for any patents relating to the content of the manuscript; (4) have not received reimbursements, fees, funding, or salary from an organization that holds or has applied for patents relating to the content of the manuscript; (5) do not have any other financial competing interests or financial ties to disclose; and (6) do not have non-financial competing interests (political, personal, religious, ideological, academic, intellectual, commercial, or any other) to declare in relation to this manuscript.

Ethical Approval This is a retrospective study. For this type of study, ethical formal consent is not required.

Informed Consent No identifying information of any patient included in the study is available in the article.

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