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Long-term endoscopic outcomes after the most common bariatric procedures: a multicentre prospective study

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GORD and Barrett's oesophagus after bariatric procedures: multicentre prospective study

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Abstract

Introduction: Gastroesophageal reflux disease (GORD) after bariatric surgery (BS) is a debated topic. This study investigated the prevalence of GORD and related oesophageal complications after bariatric procedures – namely, adjustable gastric banding (AGB), sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB) and one anastomosis gastric bypass (OAGB).

Methods: This was a prospective multicentre study designed to evaluate long-term effects of BS on GORD. Patients were studied at baseline, at >10 years after AGB, SG, RYGB and at >3 years after OAGB (due to its more recent recognition as a standard bariatric procedure). Patients were assessed by endoscopy and GORD symptom evaluation.

Results: A total of 241 patients were enrolled. A minimum follow-up of 10 years was reached by 193 patients after AGB (n=57), SG (n=95), RYGB (n=41) and by 48 subjects >3 years after OAGB. GERD symptoms increased after AGB and SG (from 14.0% to 31.6% and 26.3% to 58.9%; P<0.0001, respectively), improved after RYGB (from 36.6% to 14.6%; P<0.0001) and were unchanged after OAGB. The overall prevalence of erosive oesophagitis was greater after SG (74.7%) than AGB (42.1%), RYGB (22.0%), or OAGB (22.9%), (P<0.0001). Barrett's oesophagus was found only after SG in 16.8%. More biliary-like gastric stagnation was found in SG and OAGB patients (79.7% and 69.4%, respectively) than other groups (P<0.0001). Biliary-type reflux into the oesophagus was worst after SG (74.7%).

Conclusions: Bariatric surgery leads to gastroesophageal consequences of variable extent. Sleeve gastrectomy is particularly troublesome with a large proportion developing Barrett's oesophagus.

Lay summary

Gastroesophageal reflux disease (GORD)-related oesophageal sequelae following bariatric surgery confirm the importance of postoperative endoscopic surveillance for early detection of such conditions. Sleeve gastrectomy demonstrated to be correlated with the highest prevalence of GORD, biliary-type gastric and oesophageal reflux and erosive esophagitis. This in turn seems to be responsible for the elevated number of Barrett's oesophagus cases found in this group of patients. Adjustable gastric banding displayed a scarce effectiveness on weight loss in association with a conspicuous number of reoperations also caused by band-related complications. One anastomosis gastric bypass seems to be associated with an elevated percentage of subjects who develop an often severe inflammation of the gastro-jejunal anastomosis or of the gastric pouch, as a consequence of a chronic biliary-type duodeno-gastric reflux. Finally, Roux-en-Y gastric bypass seems to represent the most 'reliable' bariatric procedure in terms of GORD resolution and the only operation not requiring any re-intervention in our cohort of patients. Each surgical procedure leads to gastroesophageal modifications of variable extent, which need to be taken into consideration when selecting the designated bariatric operation.

Introduction

The prevalence of gastroesophageal reflux disease (GORD) is known to be substantially greater in subjects affected by overweight and obesity compared to the general population [1]. This seems to come as a consequence of the increased intrabdominal pressure caused by excess visceral adiposity, leading in turn to a reduction of the lower oesophageal sphincter competence, often also associated with a weakness of the crura and consequential development of hiatal hernia [2]. Weight loss is generally strongly indicated in conjunction with medical therapy in order to improve GORD symptoms [3].

Although bariatric surgery is capable of inducing considerable weight loss and is deemed to be the most effective treatment modality for the cure of obesity and its related comorbidities [4-5], not all surgical procedures have been shown to lead to improvement or resolution of GORD. On the contrary, there are several bariatric operations amongst the most commonly performed ones, which have been proven to be endowed with a refluxogenic potential, even though conflicting outcomes are still being reported in literature to date [6-7].

Sleeve gastrectomy (SG) is currently the most frequently utilized bariatric procedure globally, representing approximately 46.0% of all operations, followed by Roux-en-Y gastric bypass (RYGB) in 38.2%, one anastomosis gastric bypass (OAGB) in 7.6% and adjustable gastric banding (AGB) in 5.0% [8]. SG has gained widespread popularity due to its technical simplicity in addition to its safety and effectiveness [9-10]. OAGB has been recently introduced and accepted by scientific societies [11-12] as a standard bariatric procedure and is progressively gaining popularity with excellent outcomes and shorter operative times than RYGB [13]. Finally, AGB, initially one of the most long-established bariatric operations, has now become seldom performed due to inferior effectiveness and greater rates of complications and reoperations especially in the long term [8-9].

Several authors have recently shown the de novo appearance or worsening of GORD after SG [14-15], the possible development of gastroesophageal reflux of duodenal derivation after OAGB [16] and the potential progression to Barrett's oesophagus and oesophageal adenocarcinoma (OAC) [17-18]. Conversely, RYGB is well-established as the procedure of choice in the presence of pre-existing GERD thanks to its high rate of symptomatic resolution [19], while AGB has largely shown anti-reflux properties, although de novo GORD and oesophagitis have been reported to eventually increase over longer follow-up periods [20]. The aim of this study was to investigate GORD and related complications after bariatric surgery in the mid- to long-term.

Methods

Study design

This was a prospective multicentre study designed to evaluate the long-term effects of BS on GORD. The study flow chart is reported in Figure 1. Between October 2006 and December 2010, a total of 373 patients affected by morbid obesity underwent bariatric surgery at Sapienza University Hospital in Rome, Italy. One hundred fifteen patients received AGB, 162 SG and 96 RYGB. Endoscopic follow up is routinely performed 2 years after bariatric surgery and surveillance is continued every 2-3 years thereafter. In patients with Barrett's oesophagus, endoscopy and biopsies are performed yearly. A clinical-endoscopic assessment was proposed to all patients, who were informed about the follow-up benefits, in terms of prevention and early treatment of any detected condition. Participants were followed-up > 10 years to assess the long-term effect of different surgical procedures on GORD. Patient inclusion criteria comprised those enlisted by international guidelines [21]. Patients were included in the study regardless of pre-existing GORD symptoms or antacid/PPI medication use. Subjects who underwent revisional bariatric surgery were excluded from the study. All patients who underwent OAGB had a follow-up greater than 3 years postoperatively.

All patients underwent a standard preoperative multidisciplinary workup following institutional, national and international guidelines, involving complete history and physical examination, routine laboratory tests, chest X-ray, abdominal ultrasonography, oesophagogastroduodenoscopy (OGD) and nutritional and psychiatric assessment. Additional examinations or specialist consultations were performed when clinically required. Furthermore, patients underwent preoperative GORD symptom evaluation (i.e. acid reflux, regurgitation, heartburn, belching and cough) by means of a Visual Analogue Scale (VAS) score. Reported use of proton pump inhibitors (PPIs) or other antacid medications was also recorded. The study was approved by the Ethical Committee of this University hospital. All participants provided written informed consent to participate in the study.

Sample size calculation

A superiority of SG causing oesophagitis in the mid-long term versus AGB, RYGB and OAGB was hypothesised. The primary endpoint was the difference in the incidence of GORD and related modifications among patients undergoing AGB, RYGB or OAGB compared with SG. The study was powered to detect an absolute difference of 20 percentage points in the incidence of oesophagitis between the AGB and SG (on the basis of an incidence of 30% for SG and of 10% for AGB) and a difference of 24 percentage points in the incidence between the RYGB and the SG group (on the basis of an incidence of oesophagitis of 6% for RYGB), a difference of 16 percentage points in the incidence between the OAGB and the SG group (on the basis of an incidence of oesophagitis of 14% for OAGB), with a statistical power of 80% at a one-sided P value of 0.05. Because the study was not powered to assess differences among treatments on all the analysed variables, results that are not related to the primary outcome should be considered as merely indicative. Analysis of the primary endpoints was performed on an intention-to-treat basis.

Postoperative follow-up

After all surgical procedures, an upper gastrointestinal series with a water-soluble iodinated contrast was routinely performed 1 to 2 days postoperatively. Patients were discharged on a semiliquid diet for 1 month along with 30 mg daily of PPIs for the first 3 months, followed by 15 mg for the next 2 months and discontinued if the patient was asymptomatic for GORD. Follow-up schedule entailed medical examination at 1, 3, 6 and 12 months after surgery and once a year thereafter.

Follow-up was fully completed at least 10 years after surgery (mean follow-up, 11.4±1.2 years) by 193 patients and at least 3 years after OAGB (mean follow-up, 3.9 ±0.8 years) by 48 patients. Study follow-up also comprised physical examination, OGD and GORD symptom evaluation by means of a VAS score questionnaire.

Endoscopy

OGD was performed by using a high-definition standard gastroscope (Evis ExeraII; Olympus Corporation, Shinjuku, Tokyo, Japan) under conscious sedation (intravenous midazolam).

Macroscopic examination of the upper digestive tract was performed in all patients. The distance from the upper dental arch to the Z-line (squamous-columnar junction) and to the diaphragmatic oesophageal hiatus were measured. An upward migration of the Z-line >2 cm was considered noteworthy and recorded.

Oesophageal inflammatory lesions were classified according to the Los Angeles Classification [22]. Biliary-like reflux into the oesophagus or stomach was also carefully evaluated and documented. Cardial incontinence was evaluated during retroflexion manoeuvre and was defined by a wide-open cardia allowing the passage of gastric fluid content into the oesophagus.

When Barrett's Oesophagus was macroscopically suspected, Prague Endoscopic Classification was applied as the evaluation criteria. This classification considers circumferential and proximal maximum extension of metaplastic mucosal tongues. Biopsy samples were performed according to the Seattle Protocol which recommends 4 biopsy samples, one for each quadrant of BE segment, every 2 cm starting 1 cm above the gastroesophageal junction.

Gastric contents and mucosal characteristics of the stomach were evaluated; biopsy samples were always performed in the antrum and fundus (when present), searching for H. Pylori, to determine gastritis histopathology, classified according to 3 degrees of severity (mild, moderate and severe).

The presence and placement level of any gastric band in patients who underwent AGB was noted. The characteristics of the mucosa at the gastrojejunal anastomosis site in patients who previously received RYGB or OAGB were recorded, evaluating the existence of any inflammatory process and any mucosal lesions, including erosions and ulcerations.

Surgical technique

Adjustable Gastric Banding

For this procedure the LAP-BAND System and pars flaccida technique [23] are used. Dissection is performed in proximity to the angle of His by opening the gastro-phrenic ligament. Then, the lesser omentum is opened at the level of the pars flaccida. The right crus is exposed and a retrogastric tunnel is performed with a blunt grasper which is then utilized to pull through the gastric band from left to right. The band is closed and secured with two gastro-gastric sero-muscular non-absorbable stitches. Finally, the port is fixed to the anterior sheath of the rectus muscle in the left subcostal region with non-absorbable sutures.

Sleeve Gastrectomy

The standard surgical procedure for SG has been previously described [24]. Full mobilization of the gastric fundus with complete dissection of the posterior gastric wall from the left diaphragmatic crus is achieved. A 48-Fr calibration orogastric bougie is routinely used. Resection is begun approximately 6 cm from the pylorus and continued cephalad reaching the angle of His. A gastric sleeve with a residual capacity of 60–80 mL (as measured by administration of methylene blue saline solution via a nasogastric tube) is achieved.

Roux-en-Y Gastric Bypass

A small gastric pouch of about 30 ml in capacity is created. The jejunum is transected approximately 75 cm distal to the ligament of Treitz, configuring the alimentary limb. A side-to-side stapled anastomosis between the posterior wall of the gastric pouch and the distal end of the jejunum is performed. The gastric remnant in continuity with the duodenum and proximal jejunum represents the bilio-pancreatic limb which is then connected to the alimentary channel through a side-to-side stapled jejuno-jejunostomy about 100 cm distal to the gastro-jejunostomy. Mesenteric and Petersen defects are routinely closed.

One Anastomosis Gastric Bypass

Dissection is performed on the lesser curvature in correspondence of the crow's foot in order to enter the lesser sac. The stomach is transected horizontally and then vertically along a 38 F bougie reaching the angle of His, thus completing a long gastric pouch. The small bowel is measured approximately 200 cm from the ligament of Treitz and a stapled antecolic side-to-side gastrojejunal anastomosis is performed on the posterior wall of the gastric pouch. Petersen's space is then closed.

Statistical analysis

Continuous variables were expressed as mean ± SD for parametric data. GORD risk and its complications were calculated for each treatment group, and differences among procedures were assessed using Pearson's chi-square test for categorical variables. A P value < 0.05 was considered statistically significant. Additionally, a multivariate analysis was carried out using logistic regression models, in order to take into account the effect of different variables. Finally, BMI after surgery was studied, comparing the four groups within a multiple linear regression model and adjusting for age and initial BMI. Logistic regression analyses were performed and results are presented as β coefficients with 95% CI. Data analysis was performed in SPSS version 25 (IBM, Armonk, NY).

Results

Between October 2006 and December 2010, a total of 498 patients underwent the following bariatric surgical procedures: 117 patients underwent AGB, 100 patients RYGB, 165 patients SG; while between January 2015 and December 2018, 116 patients underwent OAGB. Of these, 14 subjects (2.8%) were excluded from the study due to early onset of postoperative complications (such as leaks, bleeding, anastomotic stricture) and 28 (5.6%) patients due to revisional bariatric procedures.

Re-do surgery was more common after AGB (13.9%, n=16), followed by OAGB (4.5%, n=5) and SG (4.3%, n=7). Band removal was performed at an average 7.8±5.3 years after primary surgery, due to different causes (port infection, weight regain, band erosion or slippage). These patients were converted either to RYGB (25%), SG (25%) or OAGB (50%). In the SG group, 7 patients (4.3%) were converted to RYGB due to severe GORD, approximately 8.1±2.6 years after primary surgery; 3 of these had a diagnosis of Barrett's oesophagus and 4 patients presented with GORD symptoms unresponsive to medical therapy. Five patients (4.5%) in the OAGB group were converted to RYGB approximately 4.4±1.7 years after primary surgery. A modification of the surgical technique was

implemented by performing a longer pouch and no other conversion was necessary after this adjustment. No revisional bariatric surgery was performed in the RYGB group.

Of the remaining 456 subjects, 241 were enrolled in the present study. The flow chart of the study is depicted in Figure 1. A minimum follow-up of 10 years after surgery (mean follow-up 11.4±1.2 years) was reached by 193 patients; of these, 57 subjects in the AGB group, 95 in the SG group and 41 in the RYGB group. A postoperative follow-up of at least 3 years (mean follow-up, 3.9 ±0.8 years) after OAGB was completed by 48 patients.

GORD symptoms, PPI medication and postoperative endoscopic findings are shown in Tables 1 and 2. A significant increase in postoperative VAS scores was registered in the AGB and SG groups (from 14.0% to 31.6% and 26.3% to 58.9% respectively; P<0.0001). On the contrary, after RYGB there was a substantial reduction in referred postoperative reflux symptoms (from 36.6% to 14.6%; P<0.0001). A slight but not significant increase was found in subjects undergoing OAGB (39.6% to 52.1%). PPI use was significantly greater after SG compared to all other groups. Additionally, utilization of PPIs was substantially greater after SG compared to the preoperative period in the same group (Table 1).

Based on endoscopic findings, the overall prevalence of erosive oesophagitis was significantly greater after SG (74.7%) compared to AGB (42.1%), RYGB (22.0%) and OAGB (22.9%), (Table 2). Barrett's oesophagus was found only after SG but not after other bariatric procedures. In this group, 16 subjects (16.8%) were diagnosed with a histologically demonstrated Barrett's oesophagus and 2 (12.5%) of these also developed low grade dysplasia (Table 2). Biliary-type reflux into the oesophagus was present in as many as 74.7% of subjects undergoing SG and in 12.5% of subjects after OAGB, while no evidence of bile in the oesophagus was found after AGB and RYGB (Figure 2). Presence of biliary-like gastric stagnation, resulting from duodenal-gastro-oesophageal biliary

reflux, was found in a more patients after SG and OAGB (79.7% and 69.4%, respectively) than AGB (8.7%) or RYGB (0%) patients (Figure 2, Table 2).

Anastomotic mucosal abnormalities were assessed endoscopically and by histological examination on biopsies performed at this level. The presence of inflammation at the anastomosis site, macroscopically highlighted and histologically confirmed, was present only in 4.9% of RYGB patients, compared to 48.9% of patients in the OAGB group (P<0.0001). Anastomotic ulcers were found in 14.6% of RYGB patients and in 10.4% of patients after OAGB. However, perforation of anastomotic ulcerative lesions occurred only in 1 patient in the OAGB group (2.08%) (Table 2).

In terms of weight-related outcomes, there was a significant difference between the AGB group compared to the other analysed groups, where AGB patients had a substantially greater BMI at follow-up (P <0.0001). Change in BMI was -8.0, -16.7, -16.8, -17.3 kg/m^2 after AGB, SG, RYGB and OAGB, respectively (Figure 3).

Discussion

Outcomes emerging from the present study underline how SG exposes the patient to GORD and related oesophageal mucosal lesions. Specifically, GORD symptoms significantly increased after SG and AGB, while there was only a slight but not significant rise after OAGB. In contrast, RYGB was the sole procedure which showed a substantial reduction in postoperative reflux symptoms. Although weight loss was not the primary outcome to be analysed, this parameter should not be overlooked when considering bariatric surgery results. There was no significant difference in terms of BMI reduction between SG, RYGB, and OAGB but AGB was better.

In a recent systematic review and meta-analysis, the prevalence of de novo GORD was 9.3% following SG and 2.3% after RYGB [25]. Another found a significant reduction of GORD (from

33.7% to 7.7%) and PPI use (from 27.5% to 9.5%) after AGB. Some highlight the possibility of de novo GORD in the longer-term, often attributable to band-related complications (i.e. slippage and erosion) [26-27]. A multi-institutional survey with a mid-term follow-up (5 years), demonstrated GORD in 4% of patients after OAGB. The authors underline how the type of reflux after OAGB, called duodenal-gastro-oesophageal reflux (DGER), is mainly a reflux of duodenal/biliary content at the level of the gastric pouch and of the gastrojejunostomy. Interestingly, this study also showed the distribution of DGER over time from surgery, highlighting how this usually develops during the first 16 months postoperatively [16]. The present study was prospective but not randomized and the follow-up period was longer after AGB, SG and RYGB than OAGB so it is acknowledged that there is that inherent weakness.

A higher cumulative incidence of erosive oesophagitis was observed in the SG group (74.7%), compared to OAGB (22.9%), RYGB (21.9%) and AGB (21.1%) ($P<0.0001$). Furthermore, SG patients had a greater severity of erosive oesophagitis, with Los Angeles grades A through C, while following other procedures patients were mainly diagnosed with grade A and only in a smaller portion grade B oesophagitis. In addition, a histologically documented BE was confirmed only in the SG group.

The present endoscopic findings in patients undergoing SG are comparable to those previously found [28-29]. However, compared to our previous report, where the presence of intestinal metaplasia was not accompanied by any grade of dysplasia, the present study shows how the continuous biliary reflux on the oesophageal mucosa can cause an evolution from metaplasia to dysplasia. The chronic insult on the distal oesophagus if left untreated, could also eventually degenerate into adenocarcinoma [18]. Several reports have confirmed this alarming fact, suggesting how Barrett's oesophagus might represent a long term complication (> 5 years postoperatively) of SG, with a calculated incidence of 8% from the latest published meta-analysis [17]. On the contrary, no cases of Barrett's oesophagus

were found after other bariatric procedures. This is corroborated by current evidence that it is uncommon after AGB, OAGB, and RYGB [25, 30-31]. Duodeno-gastric reflux may be the origin [32-33]. Biliary-type reflux into the oesophagus was found in the greatest proportion of patients after SG (Figure 4) while none of the patients in the RYGB and AGB groups were affected.

Exposure to duodenal juice can cause a progression to oesophageal adenocarcinoma even more rapidly compared to patients who are affected by acid reflux alone. This is consistent with the evidence that oesophageal adenocarcinoma is the most common malignancy in SG patients and several cases have been documented [18]. On the other hand, the presence of bile content in the stomach, as a consequence of a biliary-type duodeno-gastric or jejuno-gastric reflux, was found in a greater portion of patients after SG and OAGB than AGB or RYGB.

The endoscopic evidence of bile in the gastric pouch of patients who underwent OAGB has been confirmed by hepatobiliary scintigraphy [34]. Interestingly, the presence of bile tracer during scintigraphy was found in the gastric tube after OAGB but did not reach the oesophagus. Technical aspects in the creation of the gastric pouch have a prominent role in the possible development of duodeno-gastro-oesophageal reflux. Rutledge et al. emphasize the need for creating a long pouch and avoiding a twisted or stenotic gastric tube, which are often sufficient to prevent persistent reflux [35].

Figure legends

Figure 1. Study flow chart

Figure 2. Presence of biliary-type reflux into the stomach and/or oesophagus after each bariatric procedure.

*P<0.0001

Figure 3. Weight loss outcomes at baseline, nadir and at maximum follow-up

NB. BMI is shown at >10 years postoperatively after AGB, SG, RYGB and at >3 years after OAGB.

Data are expressed as mean±SD.

(BMI: body mass index; %TWL: percent total weight loss; %EWL: percent excess weight loss).

Figure 4. Representative endoscopic images after AGB (A-B), SG (C-D), RYGB (E-F) and OAGB (G-H).

(A) Normal gastro-oesophageal (g-e) junction and narrowing of the gastric lumen at the level of the AGB; (B) presence of a correctly placed AGB with normal overlying gastric mucosa; (C) biliary-type reflux into the distal oesophagus associated with an upward migration of the Z-line; (D) Barrett's oesophagus with mucosal tongues clearly visible above the g-e junction; (E) gastro-jejunal anastomosis with no mucosal alterations; (F) gastro-jejunostomy with a small marginal ulcer but no oedema or inflammatory changes of the mucosa at the anastomosis site; (G) mild oesophageal biliary reflux; (H) biliary reflux at the level of the gastric pouch and severe oedema of the gastro-jejunal anastomosis.

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Bariatric procedure	Preoperative GERD symptoms	Postoperative GERD symptoms	*P* value	Preoperative PPI use	Postoperative PPI use	*P* value
AGB (%)	14.0	31.6	< 0.0001	7.0	21.1	NS
RYGB (%)	36.6	14.6	< 0.0001	9.8	24.4	NS
SG (%)	26.3	58.9	< 0.0001	18.9	51.6	< 0.0001
OAGB (%)	39.6	52.1	NS	14.6	27.1	NS

Table 1. Pre and postoperative PPI use and GERD symptoms as evaluated by VAS scores.

A significantly greater portion of subjects were under PPI medication after SG compared to other procedures (P<0.0001) and to preoperative levels in the same group (P<0.0001).

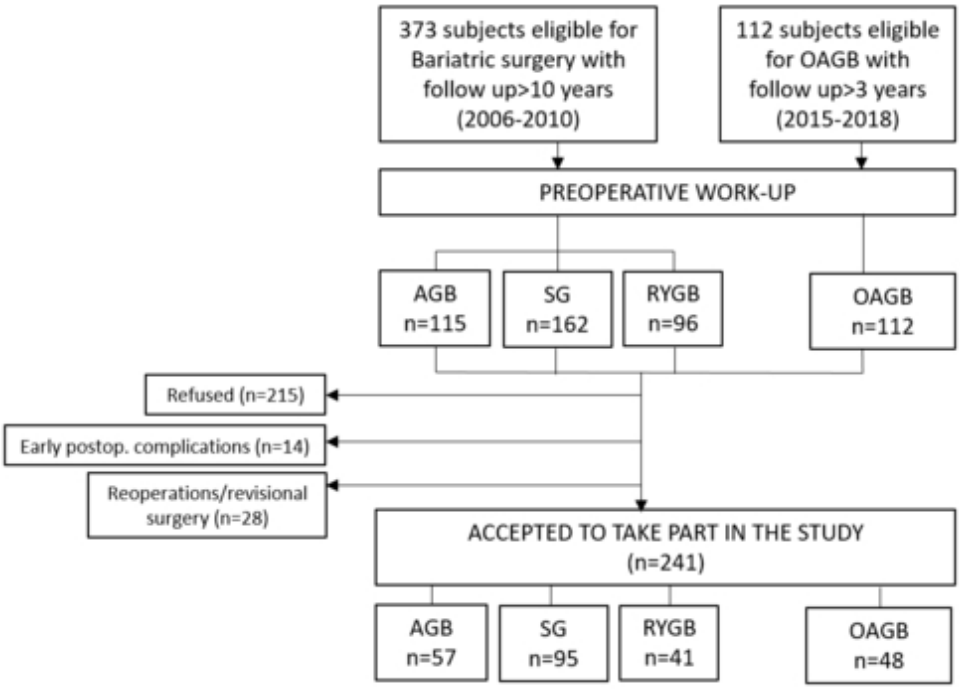
Values are expressed as percentages (%).

Table 2. Endoscopic outcomes

(Erosive oesophagitis grading is according to Los Angeles Classification)

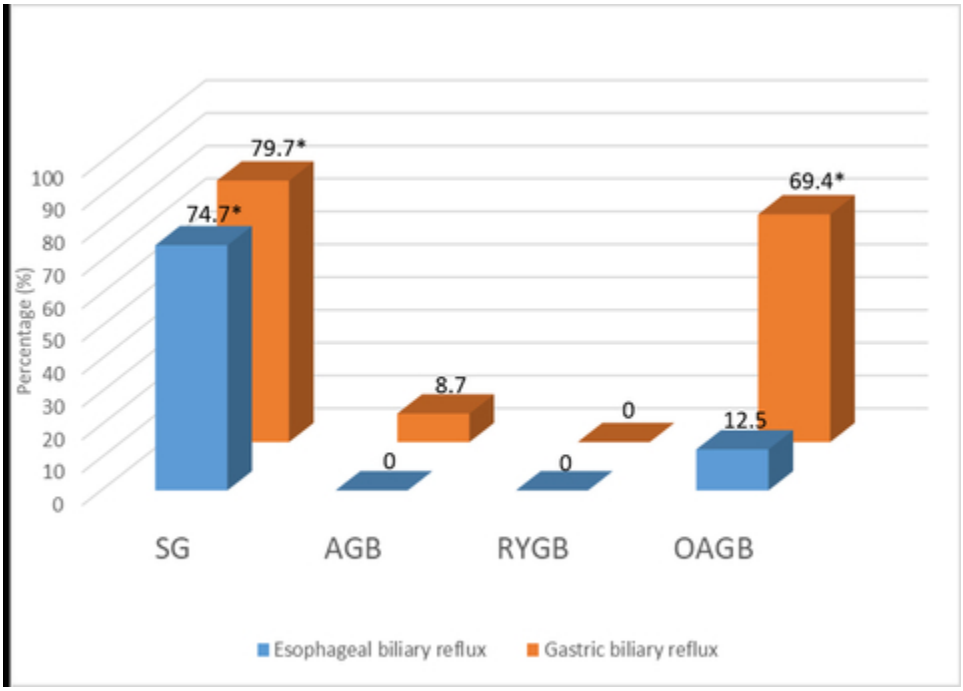
Data are expressed as percentages and total number of patients (n)

ENDOSCOPIC FINDINGS	SG n=95	AGB n=57	RYGB n=41	OAGB n=48	*P* value
Cumulative incidence of erosive oesophagitis % (n)	74.7 (71)	42.1 (24)	22.0 (9)	22.9 (11)	<0.0001
Grade A oesophagitis	59.1 (42)	79.2 (19)	100 (9)	90.9 (10)	NS
Grade B oesophagitis	31.0 (22)	20.8 (5)	0 (0)	9.1 (1)	NS
Grade C oesophagitis	9.9 (7)	0 (0)	0 (0)	0 (0)	NS
Gastritis	28.4 (27)	0 (0)	12.2 (5)	37.5 (18)	<0.0001
Barrett's oesophagus	16.8 (16)	0 (0)	0 (0)	0 (0)	<0.0001
Low grade dysplasia on BE	12.5 (2)	0 (0)	0 (0)	0 (0)	<0.0001
Biliary reflux into the oesophagus	74.7 (71)	0 (0)	0 (0)	12.5 (6)	<0.0001
Biliary reflux into the stomach	79.7 (76)	8.7 (5)	0 (0)	69.4 (33)	<0.0001
Anastomotic inflammation	NA	NA	4.9 (2)	48.9 (23)	<0.0001
Marginal ulcers	NA	NA	14.6 (6)	10.4 (5)	NS



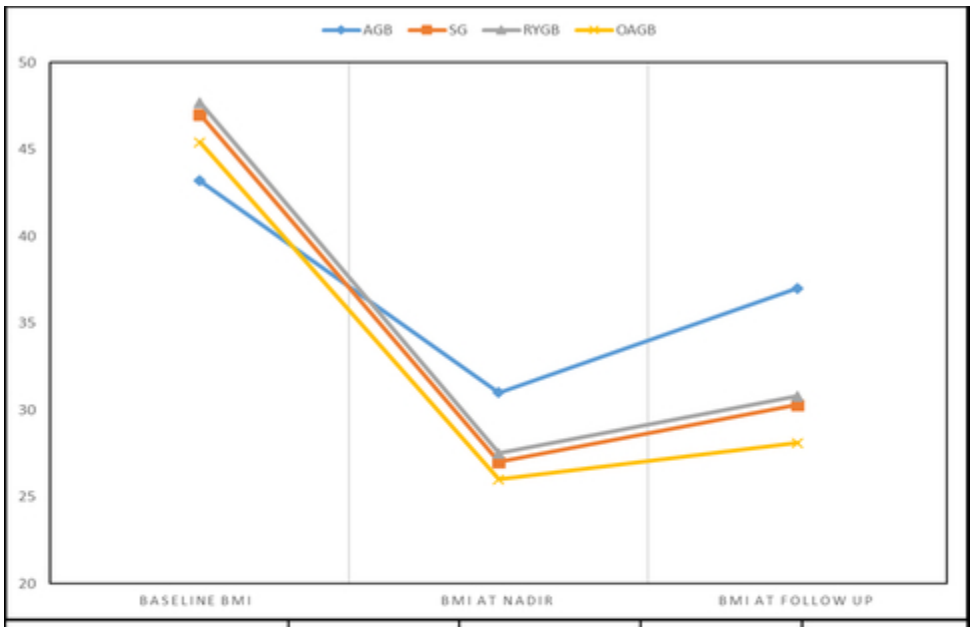
Study flow chart

85x60mm (150 x 150 DPI)



Presence of biliary-type reflux into the stomach and/or oesophagus after each bariatric procedure.*P<0.0001

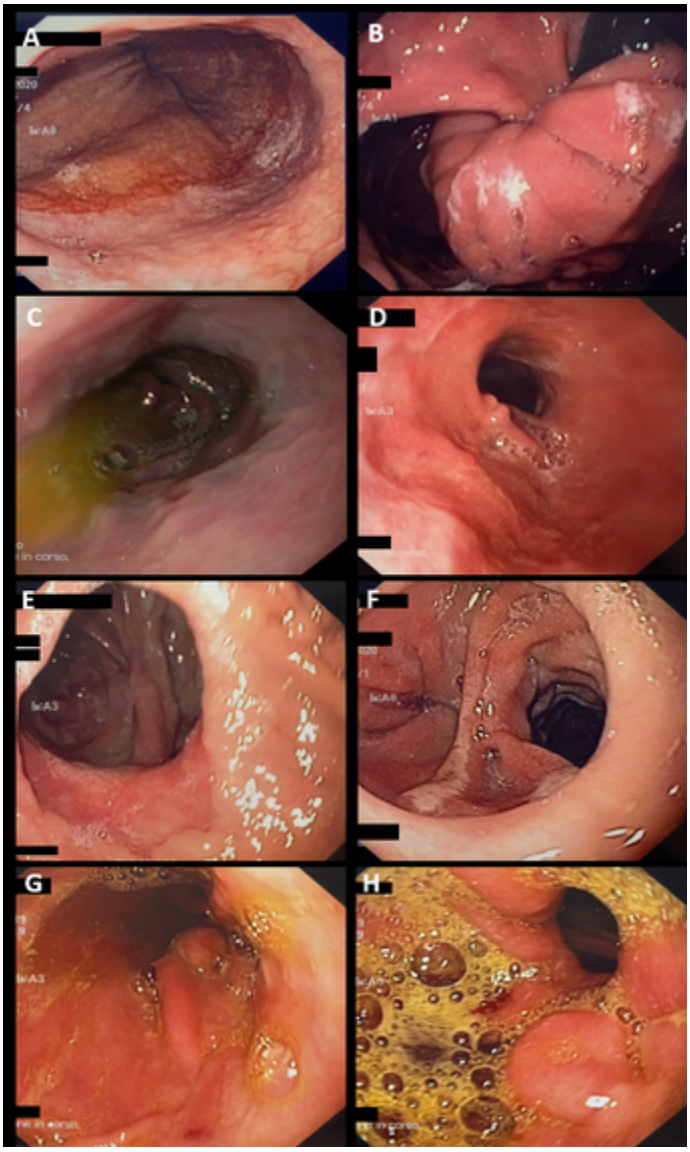
81x57mm (150 x 150 DPI)



	AGB	SG	RYGB	OAGB
Baseline BMI (kg/m²)	42.6±5.6	46.7±6.7	47.7±6.1	45.2±6.9
BMI at nadir (kg/m²)	30.4±4.8	26.3±5.1	26.9±3.0	27.0±4.7
BMI at follow up (kg/m²)	35.4±6.3	30.0±6.16	30.8±4.79	27.9±5.0
Change in BMI (kg/m²)	8.0±8.5	16.7±6.3	16.8±6.1	17.3±5.8
%TWL (%)	17.1±17.6	35.3±10.8	34.8±9.8	37.7±9.1
%EWL (%)	26.7±29.2	55.6±15.7	53.7±14.0	73.1±15.5

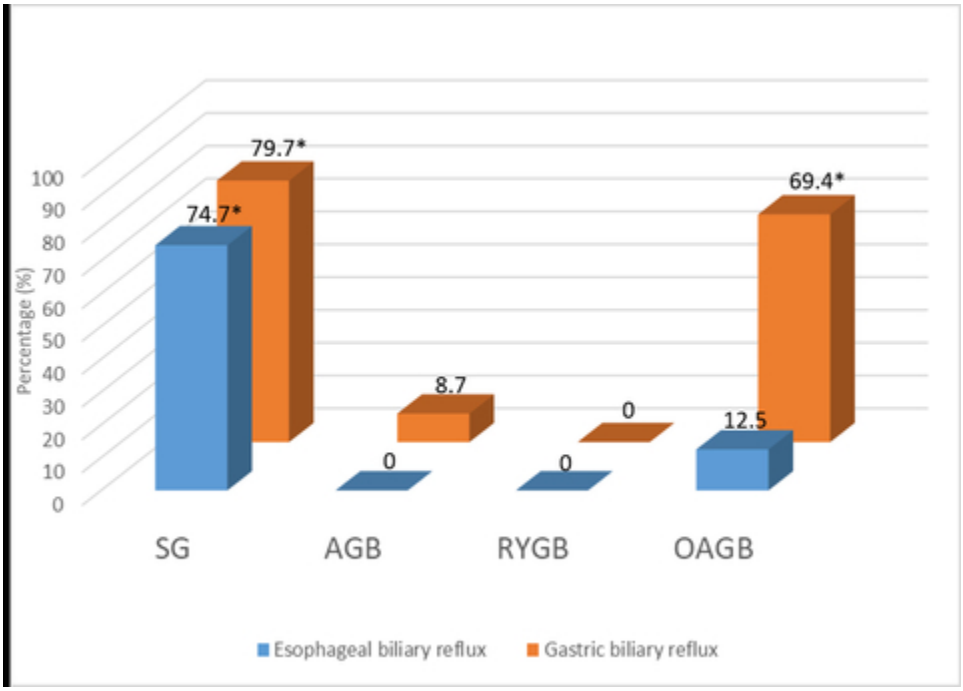
Weight loss outcomes at baseline, nadir and at maximum follow-upNB. BMI is shown at >10 years postoperatively after AGB, SG, RYGB and at >3 years after OAGB. Data are expressed as mean±SD.(BMI: body mass index; %TWL: percent total weight loss; %EWL: percent excess weight loss).

81x75mm (150 x 150 DPI)



Representative endoscopic images after AGB (A-B), SG (C-D), RYGB (E-F) and OAGB (G-H). (A) Normal gastro-oesophageal (g-e) junction and narrowing of the gastric lumen at the level of the AGB; (B) presence of a correctly placed AGB with normal overlying gastric mucosa; (C) biliary-type reflux into the distal oesophagus associated with an upward migration of the Z-line; (D) Barrett's oesophagus with mucosal tongues clearly visible above the g-e junction; (E) gastro-jejunal anastomosis with no mucosal alterations; (F) gastrojejunostomy with a small marginal ulcer but no oedema or inflammatory changes of the mucosa at the anastomosis site; (G) mild oesophageal biliary reflux; (H) biliary reflux at the level of the gastric pouch and severe oedema of the gastrojejunal anastomosis.

57x96mm (150 x 150 DPI)



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