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Analysis of Factors Related to Gastroesophageal Reflux After Gastric Bypass at 10-Year Follow-up: A Retrospective Single-institutional Study

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Abstract. *Background/Aim: Long-term gastroesophageal reflux (GERD) after gastric bypass for obesity is underestimated. The present study aimed to evaluate the rate of treated GERD and the factors influencing it in a cohort of patients who underwent gastric bypass. Patients and Methods: Patients who underwent one-anastomosis gastric bypass (OAGB) or Roux-en-Y gastric bypass (RYGB) as a primary bariatric procedure between 2010 and 2011 at a French private referral center were included in the study. The primary endpoint was the 10-year prevalence of GERD. Results: In total, 422 patients underwent RYGB and 334 underwent OAGB with a biliopancreatic limb of 150 cm. The mean age was 38.9±11.3 years, and 81.6% of patients were female; the mean preoperative body mass index was 42.8±5 kg/m^2. Preoperative GERD was diagnosed in 40.8% of patients in the total cohort, 31.7% in the RYGB group versus 49.1% in the OAGB group (p<0.0001). At 10-year follow-up, the rate of GERD was 21.1%, with no difference between the two groups. Remission of preoperative GERD and de novo GERD were comparable between the two types of bypass. Surgery for GERD resistant to medical treatment was more frequent in the OAGB group. At multivariate analysis, factors significantly correlated with long-term GERD were: Preoperative GERD, total weight loss at 120 months <25%, glycemic imbalances and anastomotic ulcers. Conclusion: Identification and correction of modifiable factors may help reduce the incidence of long-term GERD.*

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Key Words: Bariatric surgery, single-anastomosis gastric bypass, obesity, Roux-en-Y gastric bypass, long-term outcomes, reflux, gastroesophageal reflux.

Obesity represents a worldwide epidemic, and bariatric surgery has proven to be the most effective treatment for morbid obesity and obesity-related complications (1). Gastric bypasses, including Roux-en-Y (RYGB) and one-anastomosis gastric bypass (OAGB), have demonstrated to be effective surgical techniques able to control chronic obesity with sustainable results in the majority of patients (2-4). However, a non-negligible rate of long-term complications/adverse events or failures exist after both procedures, some requiring revisional surgery or chronic medical treatment (5-9). Among them, gastroesophageal reflux disease (GERD) is emerging as a frequent event in long-term follow-up, and an Achilles' heel not only after sleeve gastrectomy, but also after bypass (10). After gastric bypass, GERD is not considered a complication but more a potential occurrence. RYGB is considered the preferred procedure to treat GERD and associated obesity (11). Antireflux mechanisms of RYGB include diverting the bile from the Roux limb, promoting weight loss, lowering acid production in the gastric pouch and reducing abdominal pressure over the lower esophageal sphincter. However, 20-30% of patients complain of GERD after RYGB (2, 12), and several hypotheses have been formulated to explain GERD symptoms after RYGB. Firstly, the persistence of acid-secreting parietal cells in the gastric pouch (13). Secondly, the potential endoscopic evidence of bile reflux in the pouch in some patients complaining of upper gastrointestinal symptoms (14). Thirdly, impaired motility of the Roux limb as

hypothesized by Rebecchi *et al*., who demonstrated a high rate of esophagitis after RYGB, a high number of weakly acidic reflux at pH-impedancemetry, with no abnormalities in lower esophageal sphincter pressure or body motility (15). Fourthly, the appearance of a hiatal hernia with pouch migration in the mediastinum (16). After RYGB, even duodenogastric bile reflux to the excluded stomach has been demonstrated in 36% of patients, exposing the gastric mucosa in the excluded stomach to the potential deleterious effects of bile (17), with uncertain clinical significance. After the introduction of OAGB by Rutledge (18), concerns of GERD and its long-term consequences on the gastric and esophageal mucosa have been expressed, due to the historical experiences following Billroth II reconstruction after subtotal gastrectomy (19). The incidence of reflux after OAGB varies widely in the literature, ranging between 7.8 and 55.5% (20). In addition, the possibility of both acid and bile reflux after OAGB can cause diagnostic dilemma. The majority of patients can be treated successfully using a combination of proton pump inhibitors (PPIs), sucralfate, with or without bile acid sequestrants and elimination of risk factors (21), whereas patients resistant to medical treatment can be treated with conversion to RYGB (22).

The present study aimed to evaluate the rate of long-term GERD after primary bypass and the factors influencing it, in particular the role of the type of bypass.

Patients and Methods

Patient selection. Consecutive patients undergoing RYGB or OAGB with a biliopancreatic limb of 150 cm between January 2010 and December 2011 were identified retrospectively from a prospective database of the private institution Clinique des Cedres, in France, and their data were analyzed retrospectively. Some data on this patients' series have been published previously (2). Only patients who underwent primary bariatric surgery were included, whereas those with history of previous bariatric surgery or previous anti-reflux surgery were excluded, as were patients undergoing concomitant procedures on the diaphragmatic hiatus, such as hiatal hernia repair. The Institutional Review Board of the Institution approved the study, registered as IORG-IRB: IORG0009085 COS-RGDS-2019-11-001-LIAGRE-A. Data were obtained from the institutional database, computerized hospital records, case notes and by contacting the patients at 120 months who filled a standard questionnaire. Previous exams at 8 years follow-up after OAGB in a smaller cohort of patients have already been published (23).

Preoperative workup. Indications for primary surgery were established following the French National Health Authority (Haute Autorité de Santé) recommendations (24). Preoperative workup included upper gastrointestinal endoscopy, abdominal ultrasound, clinical, biochemical, nutritional, and psychological assessment and a multidisciplinary evaluation by the Obesity Board of the Institution. The operating surgeon in accordance with the patient did the choice between RYGB and OAGB. Preoperative GERD was not considered a contraindication to OAGB or RYGB.

Surgical technique. The OAGB technique has been described elsewhere (23). RYGB was performed in a standard fashion with a biliopancreatic limb of 50 cm and an alimentary limb of 150 cm. The gastrojejunal anastomosis was hand-sewn and the jejuno-jejunal was stapled.

Postoperative outcomes and follow-up. Postoperative complications were classified according to the Clavien-Dindo classification (25). PPIs were prescribed for 3 months after surgery then they were prescribed only in the presence of GERD symptoms.

Reflux after bypass was defined as clinically diagnosed reflux needing treatment with medications, including PPIs or sulfacrate, or needing revisional surgery. Weight-loss outcomes were expressed as the percentage total weight loss (%TWL) and percentage excess weight loss (%EWL) and calculated as [initial weight − follow-up weight]×100/initial weight and [initial weight − follow-up weight]×100/[initial weight − ideal weight], respectively. Ideal weight was set as that equivalent to a body mass index (BMI) of 25 kg/m^2. Follow-up consisted of clinical and biochemical assessment at 1, 3, 6, 12, 18, and 24 months postoperatively, and once a year thereafter.

Obesity-related comorbidities were evaluated during follow-up to identify remission or improvements according to previously reported criteria (2).

Definitions. Long-term GERD was defined by the presence of clinical symptoms of GERD, requiring specific medical or surgical treatment. Glycemic imbalances were defined by a clinical symptomatology of post-prandial malaise altering the quality of life (>2 episodes/month). Ulcers were defined by the specific endoscopic findings during the patient's follow-up (excluding postoperative complications in the first 30 days). Major %TWL (Weight loss) at 120 months was defined by %TWL >25%. Significant weight regain during follow-up was defined as follows:

Δ BMI >6 kg/m^2 between maximum BMI and BMI at 120 months;
Δ %EWL >40% between maximum %EWL and %EWL at 120 months;
Δ %TWL >15% between maximum %TWL and %TWL at 120 months.

Statistical analysis. Continuous data are reported as means, standard deviations, and ranges. Nominal data are expressed as numbers and percentages. Comparisons were made using the chi-square test for nominal data or Student's *t*-test for continuous data. Patient characteristics and outcomes were compared between patients who underwent RYGB and those who underwent OAGB. Univariate and multivariate logistic regression analyses were performed to identify the factors correlated to postoperative long-term reflux, including as variables the patient's characteristics and type of surgery. Significant factors at univariate analysis were included in the multivariate analysis. A *p*-value of 0.05 or less was considered to be statistically significant. All statistical analyses were performed using IBM SPSS Statistics software for Windows (version 25; IBM, Armonk, NY, USA).

Results

Patients characteristics and surgical procedures. During the study period, 422 patients underwent RYGB and 334 underwent OAGB with a biliopancreatic limb of 150 cm as

Table I. *Patients' characteristics, and perioperative and midterm outcomes.*

	Overall population (n=756)	RYGB (n=422)	OAGB (n=334)	*p*-Value
Female, n (%)	81.6%(n=612)	350 (82.9%)	267 (79.9%)	0.291
Mean age±SD (range), years	38.9±11.3 (18-66)	40±11.4 (18-65)	37.4±11 (18-65)	**0.002**
Mean weight±SD (range), kg	117.5±19 (75-198)	117.2±20.1 (77-187)	117.7±20.1 (75-198)	0.719
Mean BMI±SD (range), kg/m^2	42.8±5 (33.8-65)	42.8±4.7 (33.8-59)	42.8±5 (35-65)	0.827
Preoperative GERD, n (%)	260/637 (40.8%)	96/303 (31.7%)	164/334 (49.1%)	**<0.0001**
Arterial hypertension, n (%)	144 (19%)	82 (19.4%)	62 (18.5%)	0.763
Diabetes, n (%)	91 (12%)	54 (12.7%)	37 (11%)	0.386
Obstructive sleep apnea syndrome, n (%)	90 (11.9%)	53 (12.5%)	37 (11%)	0.441
Septic complications at the gastrojejunal anastomosis, n (%)	22 (2.9%)	13 (3%)	9 (2.7%)	0.754
Non septic complications at the gastrojejunal anastomosis, n (%)	22 (2.9%)	21 (4.9%) (ulcers in 7, stenosis in 13, twist in 1)	1, ulcers (0.3%)	**0.0001**
Complications at the jejunojejunal anastomosis, n (%)	4 (0.5%)	4 (0.9%)	0	0.0746
Mean minimum weight±SD (range), kg	68.9±146 (37-130)	70.5±149 (37-126)	68.7±142 (42-130)	0.145
Mean minimum BMI±SD (range), kg/m^2	25.5±43 (14.5-43.4)	25.7±44 (15.4-43.2)	25.2±4 (14.5-43.4)	0.068
Mean maximum %EWL±SD (range)	100.2±243 (24.1-194.8)	98.6±239 (24.1-181.9)	102.2±234 (30-198.8)	0.050
Mean maximum %TWL±SD (range)	40.3±8 (11-65)	39.7±9 (11.2-63.2)	41.1±8 (13-65)	**0.029**

BMI: Body mass index; EWL, excess weight loss; GERD: gastroesophageal reflux disease; OAGB: one-anastomosis gastric bypass with a biliopancreatic limb of 150 cm; RYGB: Roux-en-Y gastric bypass; SD: standard deviation; TWL: total weight loss. Statistically significant *p*-values are shown in bold.

a primary procedure. The characteristics and comorbidities of patients are listed in Table I. The mean age was 38.9±11.3 years, and 81.6% of patients were female; mean preoperative BMI was 42.8±5 kg/m^2. Preoperative GERD was diagnosed in 40.8% of patients in the total cohort, 31.7% in the group of patients who underwent RYGB *versus* 49.1% in the OAGB group ($p<0.0001$). Patients in the OAGB group were significantly younger ($p=002$).

Perioperative and postoperative outcomes. Non-septic complications at the gastrojejunal anastomosis were significantly more frequent after RYGB (Table I). Maximum %EWL was comparable, whereas maximum %TWL was significantly higher after OAGB. Long-term complications and outcomes at 10-year follow-up are reported in Table II.

Considering the entire cohort, 24.2% (183/756) of patients were lost at the 10-year follow-up, without significant differences between the two groups. Rates of internal hernia and bowel obstruction for adhesions were significantly higher in the RYGB group. Weight loss outcomes at 10 years demonstrated significantly higher %EWL and %TWL after OAGB. Surgery for weight regain during follow-up was more frequent in the RYGB group. At the 10-year follow-up, the GERD rate was 21.1%, with no difference between the two groups. Rates of remission of preoperative GERD and *de novo* GERD were comparable between the two groups. Surgery for GERD resistant to medical treatment was significantly more frequent in the OAGB group (0.5% *versus* 3.2%, respectively).

Univariate and multivariate analyses. Univariate and multivariate analyses to detect factors significantly correlated with the presence of GERD at 10 years are reported in Table III. At univariate analysis, the following factors were significantly correlated with GERD at 10 years: Preoperative GERD,%TWL at 120 months <25, glycemic disbalance, anastomotic ulcer, Δ%TWL >15%, Δ%EWL >40%, Δ BMI >6 kg/m^2. At multivariate analysis, the independent factors related to GERD at 10 years of follow-up were: Preoperative GERD,%TWL at 120 months <25, glycemic imbalance and anastomotic ulcer.

Discussion

Bariatric surgery still represents the most effective and durable treatment for obesity and obesity-related comorbidities. The last report from the International Federation for Obesity and Metabolic Disorders (IFSO) reported approximately 700,000 procedures worldwide from five IFSO Chapters in 2018, demonstrating the crucial role of surgery in the treatment of obesity (26). Among the most performed surgical techniques, sleeve gastrectomy represents the most performed procedure (approximately 55%), even if concerns exist about the long-term rates of esophagitis and Barrett's esophagus, and weight regain (27). More long-term

Table II. *Long-term outcomes at 10-year follow-up.*

	Overall population (n=756)	RYGB (n=422)	OAGB (n=334)	*p*-Value
Lost to follow-up at 10 years, n (%)	24.2%	109 (25.8%)	74 (22.1%)	0.242
Death during a 10-year follow-up, n (%)	1.4%	8 (1.8%)	3 (0.9%)	0.256
Cholecystectomy, n (%)	12.7%	56 (13.2%)	40 (11.9%)	0.596
Internal hernia, n (%)	6.7%	38 (9%)	13 (3.9%)	**0.005**
Anastomotic ulcer, n (%)	8.4%	43 (10.2%)	21 (6.2%)	0.056
Bowel obstruction for adhesions, n (%)	1.2%	8 (1.9%)	1 (0.3%)	**0.020**
Small intestinal bacterial overgrowth, n (%)	3.5%	20 (4.7%)	7 (2%)	0.052
Need for intravenous iron supplementation, n (%)	12.9%	51 (12%)	47 (14%)	0.420
Severe malnutrition, n (%)	0.8%	5 (1.1%)	1 (0.3%)	0.173
Surgery for weight regain, n (%)	1.4%	10 (2.3%)	1 (0.3%)	**0.018**
Mean weight±SD (range) at 10 years, kg	–	82.4±173 (44-135)	77.5±159 (50-140)	**0.0007**
Mean BMI±SD (range) at 10 years, kg/m^2	–	30.2±53 (18-49)	28.5±49 (19.5-50.2)	**0.0002**
Mean %EWL±SD (range) at 10 years	–	72.7±27 (−24-152)	82.2±255 (−8-153)	**<0.0001**
Mean %TWL±SD (range)at 10 years	–	29.5±11 (−8-56)	33.3±10 (−3-58)	**<0.0001**
Episodes of hypoglycemia, n (%)	11%	38/290 (13.1%)	22/252 (8.2%)	0.106
Smoking at 10 years, n (%)	24.3%	69/282 (24.4%)	56/231 (24.2%)	0.938
Compliance with vitamin treatment, n (%)	79.5%	246/303 (81.2%)	194/252 (77%)	0.197
Diarrhea, n (%)	7.1%	20/282 (7.2%)	7.1% (18/252)	0.982
Remission of diabetes, n (%)	37/60 (61%)	21/35 (60%)	16/25 (64%)	0.755
Remission of obstructive sleep apnea syndrome, n (%)	43/52 (82.6%)	26/30 (86.6%)	17/22 (77.2%)	0.381
Remission of arterial hypertension, n (%)	43/89 (48.3%)	20/48 (41.6%)	23/41 (56%)	0.177
GERD at 10 years follow-up, n (%)	21.1%	60/275 (21.8%)	51/245 (20.8%)	0.781
Remission of preoperative GERD, n (%)	68%	56/82 (68.3%)	80/118 (67.7%)	0.941
De novo GERD, n (%)	14.7%	34/192 (17.7%)	13/127 (10.2%)	0.066
Surgical treatment for GERD resistant to medical therapy, n (%)	2.5%	2 (0.5%)	11 (3.2%)	**0.003**

BMI: Body mass index; EWL: excess weight loss; GERD: gastroesophageal reflux disease; OAGB: one-anastomosis gastric bypass with a biliopancreatic limb of 150 cm; RYGB: Roux-en-Y gastric bypass; SD: standard deviation; TWL: total weight loss. Statistically significant *p*-values are shown in bold.

follow-up data (>10 years) after sleeve gastrectomy need to be reported and analyzed to better clarify the potential drawbacks of the procedure. On the other hand, longer and more solid follow-up data are available for RYGB (approximately 29% of all bariatric procedures) (28), which is still considered the 'gold standard' bariatric procedure by several authors (1, 2, 4, 5, 29). RYGB guarantees sustained weight loss results in the majority of patients, with a low rate of long-term morbidity/adverse events (30, 31). OAGB is a less "mature" bariatric surgical procedure, now representing 6.7% of bariatric interventions worldwide (26). OAGB has been recognized as a mainstream bariatric procedure by IFSO since 2018 (32) and several studies, including thousands of patients, have demonstrated its efficacy and safety in treating obesity and its related co-morbidities (33-35). Recently, our team compared the 10-year results of RYGB *versus* OAGB, demonstrating that both are effective in the long term (2).

Despite of the efficacy of gastric bypass, long-term complications and adverse events still affect a large number of patients and represent a challenge for bariatric surgeons in the near future. Among them, GERD has great importance as it strongly affects quality of life (12, 36) and incurs costs related to long-term use of medications, with potential side-effects (37) and the need for additional revisional surgeries (38). Recent reports have demonstrated that among gastric bypasses, OAGB may be associated not only with biliary reflux but also with acid reflux (39), and RYGB, even if it is the gold standard procedure to treat associated obesity and GERD, is associated with a non-negligible rate of long-term reflux (12, 16, 40-42).

The present study demonstrates a rate of treated GERD of 21.1% at 10 years of follow-up after gastric bypass surgery. No significant differences emerged in the GERD rate between RYGB and OAGB concerning overall GERD at 10 years, *de novo* GERD, nor remission of preoperative GERD. The only significant difference in GERD outcomes was observed in the rate of revisional surgery, which was 3.2% after OAGB *versus* 0.5% after RYGB. The majority of patients were treated medically for GERD, with an overall low rate of surgical treatment. The rate of surgical treatment for GERD after RYGB was very low and consistent with most of the literature. The higher incidence of biliary reflux after OAGB

Table III. *Univariate and multivariate analyses of predictive factors of gastroesophageal reflux at 10 years follow-up on the overall study population.*

Factor	Subgroup	GERD at 10 years, n (%)	Univariate logistic regression	Multivariate logistic regression			
			p-Value	Standard error	OR	95% CI	*p*-Value
Sex	Male	14/82 (17%)	0.293				
	Female	97/438 (22.1%)					
Age	<40 Years	57/280 (20.3%)	0.553				
	≥40 Years	54/240 (22.5%)					
Preoperative BMI	<43 kg/m^2	63/290 (21.7%)	0.813				
	≥43 kg/m^2	48/230 (20.8%)					
Preoperative GERD	No	47/319 (14.7%)	**<0.0001**	0.234	2.648	1.675-4.187	**<0.0001**
	Yes	64/200 (32%)					
Maximum %TWL	<40	43/234 (18.3%)	0.133				
	≥40	68/286 (23.7%)					
Maximum %EWL	<100	50/244 (20.4%)	0.655				
	≥100	61/276 (22.1%)					
BMI at 10 years	<30 kg/m^2	61/303 (20.1%)	0.426				
	≥30 kg/m^2	61/276 (23%)					
%TWL at 10 years	<25	40/131 (30%)	**0.004**	0.280	0.524	0.302-0.907	**0.021**
	≥25	71/387 (18.3%)					
%EWL at 10 years	<70	18/70 (25%)	0.110				
	≥70	33/175 (19%)					
Compliance with vitamin treatment	Yes	82/407 (20.1%)	0.443				
	No	25/6 (23.5%)					
Glycemic imbalance	No	88/457 (19.2%)	**0.003**	0.321	2.419	1.290-4.536	**0.006**
	Yes	21/56 (37.5%)					
Preoperative diabetes	No	100/445 (22%)	0.341				
	Yes	11/65 (17%)					
Preoperative hypertension	No	56/296 (21.9%)	0.419				
	Yes	17/93 (18.3%)					
Remission of diabetes at 10-year follow-up	No	2/21 (9.5%)	0.326				
	Yes	8/34 (23.5%)					
Obstructive sleep apnea syndrome	No	100/459 (21.8%)	0.853				
	Yes	11/54 (20.3%)					
Type of bypass	RYGB	60/275 (21.8%)	0.781				
	OAGB	51/245 (20.8%)					
Anastomotic ulcer	Yes	23/45 (51.1%)	**<0.0001**	0.346	5.262	2.673-10.357	**<0.0001**
	No	90/479 (18.7%)					
Δ %TWL	≥15	35/112 (31.2%)	**0.006**	0.748	0.835	0.193-3.619	0.809
	<15	88/475 (18.5%)					
Δ %EWL	≥40	32/101 (31.6%)	**0.006**	0.521	0.848	0.306-2.355	0.752
	<40	79/419 (18.8%)					
Δ BMI	≥6 kg/m^2	38/124 (30.6%)	**0.005**	0.578	1.646	0.530-5.112	0.389
	<6 kg/m^2	73/394 (18.5%)					
Smoking habit	Yes	29/114 (25.4%)	0.346				
	No	78/368 (21.1%)					
Cholecystectomy	Yes	13/78 (16.6%)	0.262				
	No	98/442 (22.1%)					
Need for iron injections	Yes	23/87 (26.3%)	0.214				
	No	88/433 (20.3%)					

BMI: Body mass index; CI: confidence interval; EWL: excess weight loss; GERD: gastroesophageal reflux disease; OAGB: one-anastomosis gastric bypass with a biliopancreatic limb of 150 cm; OR: odds ratio; RYGB: Roux-en-Y gastric bypass; SD: standard deviation; TWL: total weight loss; Δ: difference at 10-year follow-up. Statistically significant *p*-values are shown in bold.

may likely be responsible for the difference between RYGB and OAGB, as in the majority of patients undergoing conversion symptoms improved after revisional surgery, as we previously reported (22). A significant difference should also be highlighted: the preoperative reflux rate. Actually, the selection for RYGB *versus* OAGB in the inclusion period did

not take into account the presence of preoperative GERD but only the surgeons' choices, explaining this result (2).

Several interesting findings arise from data analysis: at univariate and multivariate analysis, factors influencing long-term GERD were a major weight loss (defined as %TWL>25% at 120 months) as a protective factor, and, as favoring factors, weight regain during follow-up, preoperative GERD, glycemic imbalance and anastomotic ulcer.

The type of bypass, smoking habit and initial BMI do not seem to influence the rate of long-term GERD. Major long-term weight loss seems a protective factor for GERD by reducing intra-abdominal pressure. On the other hand, weight regain during follow-up seems related to GERD by the increase of intra-abdominal pressure and the potential de-compensation of a hiatal hernia; pre-operative GERD due to an impaired hiatal continence system at the time of primary surgery; glycemic disorders unrelated to diabetes as the result of an imbalanced diet; anastomotic ulcers as a result of potential mucosal fragility due to individual factors. According to our personal experience, in the case of poor eating habits, patients with a history of OAGB develop reflux and experience a deterioration of their alimentary quality of life more than those with a history of RYGB. Therefore, for patients with a history of OAGB complaining of reflux, our approach, initially consists of careful dietary evaluation. Then, we correct the patient's bad eating habits as the first step, and we often observe resolution of reflux symptoms. We do not recommend rapid conversion to RYGB in patients with history of OAGB complaining of reflux in the absence of careful dietary evaluation and advice. Conversion to RYGB for reflux resistant to medical treatment after OAGB may result in significant weight gain, and in a non-negligible rate of GERD recurrence in the medium term (22).

More data are needed on the incidence of *de-novo* reflux after RYGB and OAGB, including comparative meta-analyses. A recent meta-analysis on new-onset reflux after OAGB reported a 6% incidence of GERD, with esophagitis and Barrett's esophagus rates of 15% and 1%, respectively (43). In our study the incidence of GERD was higher but we highlight that a longer follow-up may be responsible for this difference.

Long-term GERD needing treatment after bypasses is a frequent finding, and is complex and multifactorial. In the majority of cases, it may be treated by medication and rebalancing eating habits. In the case of GERD resistant to medical and dietary treatment, a new surgical approach may improve GERD after either bypass type, especially in the case of hiatal hernia: a fundoplication with the excluded stomach after closure of the hiatal orifice. Pilot studies have been published with interesting results (44) and we are also evaluating our data on this topic.

This study is limited by its monocentric and non-randomized design. Furthermore, it is limited by the lack of endoscopic examinations for the entire cohort at 10-year follow-up: the diagnosis of GERD was clinical and we took into account patients with treated GERD to establish the rate of long-term GERD. Endoscopic long-term follow-up is still rarely performed and difficult to achieve after bariatric surgery for several reasons: patient refusal [in a recent study only 10.2% of patients agreed to undergo upper gastrointestinal endoscopy after bariatric surgery (45)], for economic reasons (whether the patient or the health system pays for the examination) and for logistic reasons.

Conclusion

Treated GERD represents a frequent occurrence after gastric bypass surgery. Several factors including preoperative GERD, 10-year %TWL <25, glycemic imbalance and anastomotic ulcer are correlated with long-term GERD. Identification and correction of modifiable factors may help reduce the incidence of long-term GERD.

Conflict of Interest

The Authors have no conflicts of interest to disclose. They declare that there are no financial or personal relationships that could inappropriately bias the work. No funding was received for the present study.

Authors' Contributions

Niccolò Petrucciani, Francesco Martini and Arnaud Liagre made substantial contributions to the conception of the work, to the acquisition, analysis and interpretation of data, and to drafting the work or reviewing it critically for important intellectual content. Marine Benois, Paolo Aurello, Hubert Boudrie, Olivier Van Haverbeke, Sara Claudia Barone made substantial contributions to the conception of the work, to the acquisition of data, and to reviewing the work critically for important intellectual content. All Authors gave final approval for the version to be published.

References

1 Sjöström L, Narbro K, Sjöström CD, Karason K, Larsson B, Wedel H, Lystig T, Sullivan M, Bouchard C, Carlsson B, Bengtsson C, Dahlgren S, Gummesson A, Jacobson P, Karlsson J, Lindroos AK, Lönroth H, Näslund I, Olbers T, Stenlöf K, Torgerson J, Agren G, Carlsson LM, Swedish Obese Subjects Study: Effects of bariatric surgery on mortality in Swedish obese subjects. N Engl J Med 357(8): 741-752, 2007. DOI: 10.1056/NEJMoa066254

2 Liagre A, Benois M, Queralto M, Boudrie H, Van Haverbeke O, Juglard G, Martini F, Petrucciani N: Ten-year outcome of one-anastomosis gastric bypass with a biliopancreatic limb of 150 cm *versus* Roux-en-Y gastric bypass: a single-institution series of 940 patients. Surg Obes Relat Dis 18(10): 1228-1238, 2022. DOI: 10.1016/j.soard.2022.05.021

3 Carandina S, Soprani A, Zulian V, Cady J: Long-term results of one anastomosis gastric bypass: a single center experience with

a minimum follow-up of 10 years. Obes Surg 31(8): 3468-3475, 2021. DOI: 10.1007/s11695-021-05455-1
4 Kothari SN, Borgert AJ, Kallies KJ, Baker MT, Grover BT: Long-term (>10-year) outcomes after laparoscopic Roux-en-Y gastric bypass. Surg Obes Relat Dis 13(6): 972-978, 2017. DOI: 10.1016/j.soard.2016.12.011
5 Obeid NR, Malick W, Concors SJ, Fielding GA, Kurian MS, Ren-Fielding CJ: Long-term outcomes after Roux-en-Y gastric bypass: 10- to 13-year data. Surg Obes Relat Dis 12(1): 11-20, 2016. DOI: 10.1016/j.soard.2015.04.011
6 van Olst N, van Rijswijk AS, Mikdad S, Schoonmade LJ, van de Laar AW, Acherman YIZ, Bruin SC, van der Peet DL, de Brauw LM: Long-term emergency department visits and readmissions after laparoscopic Roux-en-Y gastric bypass: a systematic review. Obes Surg 31(6): 2380-2390, 2021. DOI: 10.1007/s11695-021-05286-0
7 Clapp B, Vo LU, Lodeiro C, Harper B, Montelongo S, Lee I, Tyroch A: Late-term hiatal hernia after gastric bypass: an emerging problem. Surg Obes Relat Dis 16(4): 471-475, 2020. DOI: 10.1016/j.soard.2020.01.018
8 Plamper A, Lingohr P, Nadal J, Trebicka J, Brol MJ, Woestemeier A, Schmitz SM, Alizai PH, Neumann UP, Ulmer TF, Rheinwalt KP: A Long-term comparative study between one anastomosis gastric bypass and sleeve gastrectomy. J Gastrointest Surg 27(1): 47-55, 2023. DOI: 10.1007/s11605-022-05515-6
9 Petrucciani N, Martini F, Kassir R, Juglard G, Hamid C, Boudrie H, Van Haverbeke O, Liagre A: Internal hernia after one anastomosis gastric bypass (OAGB): Lessons learned from a retrospective series of 3368 consecutive patients undergoing OAGB with a biliopancreatic limb of 150 cm. Obes Surg 31(6): 2537-2544, 2021. DOI: 10.1007/s11695-021-05269-1
10 Howard R, Yang J, Thumma J, Arterburn DE, Ryan A, Chao G, Telem D, Dimick JB: Long-term comparative effectiveness of gastric bypass and sleeve gastrectomy on use of antireflux medication: a difference-in-differences analysis. Surg Obes Relat Dis 18(8): 1033-1041, 2022. DOI: 10.1016/j.soard.2022.04.016
11 Ahuja A, Mahawar K: Bariatric surgery in patients with gastroesophageal reflux disease and/or hiatus hernia. Minerva Chir 75(5): 345-354, 2020. DOI: 10.23736/S0026-4733.20.08486-2
12 Santonicola A, Ruggiero L, Palma R, Angrisani L, Iovino P: Gerd symptoms after laparoscopic Roux-en-Y gastric bypass: an emerging scenario. Int J Obes 46(5): 1076-1078, 2022. DOI: 10.1038/s41366-022-01072-9
13 Siilin H, Wanders A, Gustavsson S, Sundbom M: The proximal gastric pouch invariably contains acid-producing parietal cells in Roux-en-Y gastric bypass. Obes Surg 15(6): 771-777, 2005. DOI: 10.1381/0960892054222849
14 Swartz DE, Mobley E, Felix EL: Bile reflux after Roux-en-Y gastric bypass: an unrecognized cause of postoperative pain. Surg Obes Relat Dis 5(1): 27-30, 2009. DOI: 10.1016/j.soard.2008.10.009
15 Rebecchi F, Allaix ME, Ugliono E, Giaccone C, Toppino M, Morino M: Increased esophageal exposure to weakly acidic reflux 5 years after laparoscopic Roux-en-Y gastric bypass. Ann Surg 264(5): 871-877, 2016. DOI: 10.1097/SLA.0000000000001775
16 Suter M: Gastroesophageal reflux disease, obesity, and Roux-en-Y gastric bypass: Complex relationship—a narrative review. Obes Surg 30(8): 3178-3187, 2020. DOI: 10.1007/s11695-020-04690-2
17 Sundbom M, Hedenström H, Gustavsson S: Duodenogastric bile reflux after gastric bypass: A cholescintigraphic study. Dig Dis Sci 47(8): 1891-1896, 2002. DOI: 10.1023/a:1016429603337
18 Rutledge R: The mini-gastric bypass: Experience with the first 1,274 cases. Obes Surg 11(3): 276-280, 2001. DOI: 10.1381/096089201321336584
19 Min JS, Kim RB, Seo KW, Jeong SH: Comparison of the clinical outcomes of reconstruction methods after distal gastrectomy: a systematic review and meta-analysis based on randomized controlled trials. J Gastric Cancer 22(2): 83-93, 2022. DOI: 10.5230/jgc.2022.22.e9
20 Keleidari B, Mahmoudieh M, Davarpanah Jazi AH, Melali H, Nasr Esfahani F, Minakari M, Mokhtari M: Comparison of the bile reflux frequency in one anastomosis gastric bypass and Roux-en-Y gastric bypass: a cohort study. Obes Surg 29(6): 1721-1725, 2019. DOI: 10.1007/s11695-018-03683-6
21 Mahawar KK, Parmar C, Graham Y: One anastomosis gastric bypass: key technical features, and prevention and management of procedure-specific complications. Minerva Chir 74(2): 126-136, 2019. DOI: 10.23736/S0026-4733.18.07844-6
22 Kassir R, Petrucciani N, Debs T, Juglard G, Martini F, Liagre A: Conversion of one anastomosis gastric bypass (OAGB) to Roux-en-Y gastric bypass (RYGB) for biliary reflux resistant to medical treatment: Lessons learned from a retrospective series of 2780 consecutive patients undergoing OAGB. Obes Surg 30(6): 2093-2098, 2020. DOI: 10.1007/s11695-020-04460-0
23 Liagre A, Debs T, Kassir R, Ledit A, Juglard G, Chalret du Rieu M, Lazzati A, Martini F, Petrucciani N: One anastomosis gastric bypass with a biliopancreatic limb of 150 cm: Weight loss, nutritional outcomes, endoscopic results, and quality of life at 8-year follow-up. Obes Surg 30(11): 4206-4217, 2020. DOI: 10.1007/s11695-020-04775-y
24 HAS, Haute Autorite de Sante. Obésité: Prise en charge chirurgicale chez l'adulte. Available at: https://www.has-sante.fr/jcms/c_765529/fr/obesite-prise-en-charge-chirurgicale-chez-l-adulte [Last accessed on February 3, 2020]
25 Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, de Santibañes E, Pekolj J, Slankamenac K, Bassi C, Graf R, Vonlanthen R, Padbury R, Cameron JL, Makuuchi M: The Clavien-Dindo classification of surgical complications. Ann Surg 250(2): 187-196, 2009. DOI: 10.1097/SLA.0b013e3181b13ca2
26 Angrisani L, Santonicola A, Iovino P, Ramos A, Shikora S, Kow L: Bariatric surgery survey 2018: Similarities and disparities among the 5 IFSO chapters. Obes Surg 31(5): 1937-1948, 2021. DOI: 10.1007/s11695-020-05207-7
27 Salminen P, Grönroos S, Helmiö M, Hurme S, Juuti A, Juusela R, Peromaa-Haavisto P, Leivonen M, Nuutila P, Ovaska J: Effect of laparoscopic sleeve gastrectomy *vs*. Roux-en-Y gastric bypass on weight loss, comorbidities, and reflux at 10 years in adult patients with obesity: the SLEEVEPASS randomized clinical trial. JAMA Surg 157(8): 656-666, 2022. DOI: 10.1001/jamasurg.2022.2229
28 Maciejewski ML, Arterburn DE, Van Scoyoc L, Smith VA, Yancy WS Jr, Weidenbacher HJ, Livingston EH, Olsen MK: Bariatric surgery and long-term durability of weight loss. JAMA Surg 151(11): 1046-1055, 2016. DOI: 10.1001/jamasurg.2016.2317
29 Maclellan WC, Johnson JM: Laparoscopic gastric bypass: Still the gold standard? Surg Clin North Am 101(2): 161-175, 2021. DOI: 10.1016/j.suc.2020.12.013

30 Angrisani L, Ferraro L, Santonicola A, Palma R, Formisano G, Iovino P: Long-term results of laparoscopic Roux-en-Y gastric bypass for morbid obesity: 105 patients with minimum follow-up of 15 years. Surg Obes Relat Dis 17(4): 727-736, 2021. DOI: 10.1016/j.soard.2020.11.028

31 Gorecki P, McClelland PH, Kabata K, Khusid E, Zenilman ME: Weight loss dynamics following laparoscopic Roux-en-Y gastric bypass. An analysis of 10-year follow-up data. Surg Endosc 35(9): 5315-5321, 2021. DOI: 10.1007/s00464-020-08021-5

32 De Luca M, Tie T, Ooi G, Higa K, Himpens J, Carbajo MA, Mahawar K, Shikora S, Brown WA: Mini gastric bypass-one anastomosis gastric bypass (MGB-OAGB)-IFSO position statement. Obes Surg 28(5): 1188-1206, 2018. DOI: 10.1007/s11695-018-3182-3

33 Parmar CD, Mahawar KK: One anastomosis (mini) gastric bypass is now an established bariatric procedure: a systematic review of 12,807 patients. Obes Surg 28(9): 2956-2967, 2018. DOI: 10.1007/s11695-018-3382-x

34 Haddad A, Fobi M, Bashir A, Al Hadad M, Elfawal MH, Safadi B, Taha O, Abouzeid M, Alqahtani A, Nimeri A: Outcomes of one anastomosis gastric bypass in the IFSO Middle East North Africa (MENA) region. Obes Surg 29(8): 2409-2414, 2019. DOI: 10.1007/s11695-019-03881-w

35 Musella M, Apers J, Rheinwalt K, Ribeiro R, Manno E, Greco F, Čierny M, Milone M, Di Stefano C, Guler S, Van Lessen IM, Guerra A, Maglio MN, Bonfanti R, Novotna R, Coretti G, Piazza L: 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. Obes Surg 26(5): 933-940, 2016. DOI: 10.1007/s11695-015-1865-6

36 Hachem A, Brennan L: Quality of life outcomes of bariatric surgery: a systematic review. Obes Surg 26(2): 395-409, 2016. DOI: 10.1007/s11695-015-1940-z

37 Haastrup PF, Thompson W, Søndergaard J, Jarbøl DE: Side effects of long-term proton pump inhibitor use: a review. Basic Clin Pharmacol Toxicol 123(2): 114-121, 2018. DOI: 10.1111/bcpt.13023

38 Chiappetta S, Lainas P, Kassir R, Valizadeh R, Bosco A, Kermansaravi M: Gastroesophageal reflux disease as an indication of revisional bariatric surgery—indication and results—a systematic review and metanalysis. Obes Surg 32(9): 3156-3171, 2022. DOI: 10.1007/s11695-022-06183-w

39 Nehmeh WA, Baratte C, Rives-Lange C, Martineau C, Boullenois H, Krivan S, Guillet V, Le Gall M, Cellier C, Carette C, Czernichow S, Chevallier JM, Poghosyan T: Acid reflux is common in patients with gastroesophageal reflux disease after one-anastomosis gastric bypass. Obes Surg 31(11): 4717-4723, 2021. DOI: 10.1007/s11695-021-05542-3

40 Sánchez-Pernaute A, Pérez-Aguirre E: Gastroesophageal reflux after Roux-en-Y gastric bypass: Is it just related to technical details? Cir Esp (Engl Ed) 101(Suppl 4): S58-S62, 2023. DOI: 10.1016/j.cireng.2023.11.002

41 Memon MA, Osland E, Yunus RM, Alam K, Hoque Z, Khan S: Gastroesophageal reflux disease following laparoscopic vertical sleeve gastrectomy and laparoscopic roux-en-Y gastric bypass: meta-analysis and systematic review of 5-year data. Dis Esophagus: doad063, 2023. DOI: 10.1093/dote/doad063

42 Masood M, Low D, Deal SB, Kozarek RA: Gastroesophageal reflux disease in obesity: Bariatric surgery as both the cause and the cure in the morbidly obese population. J Clin Med 12(17): 5543, 2023. DOI: 10.3390/jcm12175543

43 Esparham A, Ahmadyar S, Zandbaf T, Dalili A, Rezapanah A, Rutledge R, Khorgami Z: Does one-anastomosis gastric bypass expose patients to gastroesophageal reflux: a systematic review and meta-analysis. Obes Surg 33(12): 4080-4102, 2023. DOI: 10.1007/s11695-023-06866-y

44 Colpaert J, Horevoets J, Maes L, Uijtterhaegen G, Dillemans B: Surgical treatment of therapy-resistant reflux after Roux-en-Y gastric bypass. A case series of the modified Nissen fundoplication. Acta Chir Belg 120(4): 291-296, 2020. DOI: 10.1080/00015458.2019.1696028

45 Benvenga R, Roussel J, Cohen R, Bouchoucha M, Bendacha Y, Catheline JM: Long-term endoscopic follow-up after sleeve gastrectomy. J Visc Surg 159(1): 39-42, 2022. DOI: 10.1016/j.jviscsurg.2020.11.003

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