



Tailored One Anastomosis Gastric Bypass: 3-Year Outcomes of 94 Patients

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Abstract

Background One anastomosis gastric bypass (OAGB) claims its place among bariatric operations, proving itself a safe and effective procedure.

Methods This is a retrospective analysis of prospectively collected data regarding 94 patients who underwent surgery in a single surgical unit. Tailoring of the biliopancreatic limb length decided upon preoperative BMI was applied. Patients' excess weight loss and resolution of comorbidities were evaluated. Data on patients' nutritional status is also presented.

Results Mean BMI reduction at 36 months postoperatively was 21.7 ± 6.3 kg/m². Mean excess weight loss (%EWL) was 83.6%, 91.8%, and 92.5% at 12, 24, and 36 months postoperatively, respectively. When controlling for preoperative BMI, a 36-month %EWL of 89.1% for the 2-m subgroup, a 95.3% for the 2.5-m subgroup, and a 104.7% for the 3-m subgroup were found. Operation's success, defined as %EWL greater than 50%, was 97.9% 36 months postoperatively. All patients suffering from hypertension, diabetes, and dyslipidemia achieved full remission. Furthermore, the percentage of patients with obstructive sleep apnea and gastroesophageal reflux disease, achieving full remission was 91.7% and 86.7%, respectively. An incidence of 5.3% new onset regurgitation was noted. Iron deficiency presented in 26 (27.7%) patients postoperatively, vitamin B₁₂ deficiency in 13 (13.8%), folic acid deficiency in 18 (19.1%), and mild hypoalbuminemia in 7 (7.4%). Major early postoperative complications (Clavien-Dindo grade ≥ 3) were reported in 1.7% of our patients. One (1.1%) patient developed marginal ulcer and two (2.2) patients had late dumping.

Conclusions OAGB is a safe and efficient technique; however, careful selection of patients and postoperative surveillance with respect to weight regain and nutritional deficiencies are mandatory for optimal results.

Keywords Bariatric surgery · Metabolic surgery · One anastomosis gastric bypass (OAGB) · OAGB effectiveness · OAGB results · Comorbidities after OAGB · EWL after OAGB · Tailoring OAGB

Introduction

In the 1950s, antral and duodenal exclusion operations were studied as possible therapeutic interventions for peptic ulcer disease. In this context, in 1967, Mason conceived a subtotal

gastric exclusion operation combined with a PolyA gastroenterostomy as a potential treatment for obese individuals [1]. Despite succeeding satisfactory weight reduction, this procedure's safety regarding gastritis, esophagitis, and subsequent carcinogenesis was questioned; hence, it was finally abandoned.

In 1997, Rutledge resurrected the idea of a single anastomosis bariatric procedure, though with what proved to be a game-changing alteration; Mason's short gastric pouch with the PolyA gastroenterostomy was replaced by Rutledge's long vertical pouch with an end-to-side gastroenterostomy. Thus, Mason's "loop gastric bypass" was evolved to Rutledge's "mini-gastric bypass."

Rutledge introduced mini-gastric bypass as a simpler and safer alternative to the classic Roux-en-Y gastric bypass. The

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first successful results on a series of 1274 patients were presented in 2001. Rutledge heralds mini-gastric bypass as a close approximation to the optimal weight loss operation. In fact, mini-gastric bypass seems to comprise many benefits for the surgeon (a safe and easy-to-perform procedure with shorter learning curve, shorter operative time, and reversibility); the patient (minimal pain, short recovery time, potent weight loss, effective comorbidity resolution); and the health system/insurance companies (lower cost, rapid return to work) [2, 3]. However, the opponents of this procedure highlight the risk of biliary reflux with its long term sequelae [4].

This new procedure became even more sophisticated when Carbajo modified the type of anastomosis to a latero-lateral gastrojejunal anastomosis with suspension of the afferent bowel limb. Carbajo also introduced another point of confrontation and variability; tailoring of the biliopancreatic limb upon patient-related parameters, such as preoperative weight or BMI. And behold, “one anastomosis gastric bypass” (OAGB) was born [5, 6]!

Through an initial period of questioning, OAGB steadily gained popularity among bariatric surgical community. Series of thousands of patients from centers all over the world prove its safety and effectiveness. In fact, a recent meta-analysis shows that it is comparable to the “gold standard” Roux-en-Y gastric bypass (RYGB) regarding postoperative morbidity and mortality, even achieving greater weight reduction, but causing concern about a higher incidence of malnutrition [7]. However, there is still one major issue; OAGB lacks standardization. This lack of standardization becomes evident even in the naming of the procedure [5, 6, 8]. Every center uses a different biliopancreatic limb length and performs a different type of anastomosis, with or without anti-reflux modifications. These technical variations make comparison difficult and the benefits of each approach, if any, still have to be proven.

The aim of the present study is to describe the OAGB as performed in our center and to further evaluate the effectiveness of this technique with long-term results. Moreover, we intend to evaluate the impact of the biliopancreatic limb length tailoring on weight reduction as well as its possible adverse effects on patients’ nutritional status and quality of life.

Methods

This is a retrospective study of prospectively collected data regarding 115 consecutive obese individuals referred to our department since April 2009.

Preoperative Assessment

Preoperative evaluation included detailed medical history and physical examination as well as esophagogastroduodenoscopy

and upper abdominal ultrasound. Patients received counseling by a multidisciplinary team, including a nutritionist, a psychologist, a bariatric surgeon, and an endocrinologist. BMI greater than 40 kg/m² or BMI greater than 35 kg/m² accompanied with relevant comorbidities (in accordance with the international guidelines) were the criteria required for the operation. Smoking was viewed as an absolute contraindication to performing OAGB. Written informed consent regarding operative risks and scientific exploitation was obtained from all patients.

A total of 115 patients had a postoperative period of 36 months or more, with complete follow-up data being available for 94 of these patients (follow-up rate = 81.7%) (Table 1).

Operative Technique

All procedures were performed by a single surgeon in the first Propaedeutic Surgical Department’s Laparoendoscopic and Bariatric Unit at the Hippocraton General Hospital of Athens, Greece. Since the surgical technique for OAGB is described in great detail throughout surgical literature, we just wish to point out several crucial steps that govern our technique and that can, in our opinion, determine a favorable outcome.

A laparoscopic approach entailing five trocars is the standard technique. For liver retraction, laparoscopic forceps, instead of retractor, suffices. The gastric reservoir is constructed using either an Ethicon Echelon or a Covidien iDrive 60-mm stapler, according to the principles introduced by Rutledge [2]. A 38-Fr orogastric tube (bougie) is used for calibration, similar to sleeve gastrectomy. We advocate a tailored approach for the bypassed biliopancreatic loop length, based on the patient’s preoperative BMI. The surgeon locates the Treitz ligament and measures either 200, 250, or 300 cm of small bowel when preoperative BMI (kg/m²) is < 50, 50–60, or > 60, respectively. In order to eliminate postoperative biliary reflux, we suspend the small bowel loop from the proximal gastric reservoir, according to the technique originally described by Carbajo et al. [5, 9]. A suture thread is secured on the gastric wall and the needle is passed twice between the small bowel loop and the stomach, one third along the length of the gastric

Table 1 Patient characteristics

Age, mean ± SD (range) (years)	41.5 ± 10.7 (19–61)
Sex	
Men, <i>n</i> (%)	26 (27.7%)
Women, <i>n</i> (%)	68 (72.3%)
Preoperative BMI, mean ± SD (range) (kg/m ²)	49.2 ± 7.3 (32.6–66.3)
Preoperative TBW, mean ± SD (range) (kg)	139.4 ± 25.0 (92–210)

BMI body mass index, TBW total body weight, SD standard deviation

tube. Passing the needle twice creates two anchoring points for traction, functioning like a pulley, thus protecting against tearing of the bowel wall. This same thread, advanced in a continuous suturing line, serves both for fixation of the intestinal loop along the gastric reservoir as well as consists the posterior wall of the single-layered, laterolateral, and isoperistaltic anastomosis. The anterior wall of the anastomosis is approximated using a second thread and performing a continuous submucosal suturing line. Finally, the two threads are tied together. We use either 0PDS or 2/0PDS suture material for both the suspensory suture and the anastomosis itself. The orogastric tube is advanced through the gastrojejunal orifice to the small bowel to ensure patency of the newly created hand-sewn anastomosis and, finally, a methylene blue leak test is performed. If jejunal loop suspension cannot be attained due to a bulky omentum or redundant intraperitoneal fat (which can be observed, regardless of preoperative BMI) original Rutledge's anastomosis is performed. Drainage of the abdomen typically is not required, though being at surgeon's preference (Fig. 1).

Early Postoperative Period—Follow-Up

In our institution, there is a straightforward approach regarding perioperative management during both the early and late postoperative period, involving all the relevant aspects, such

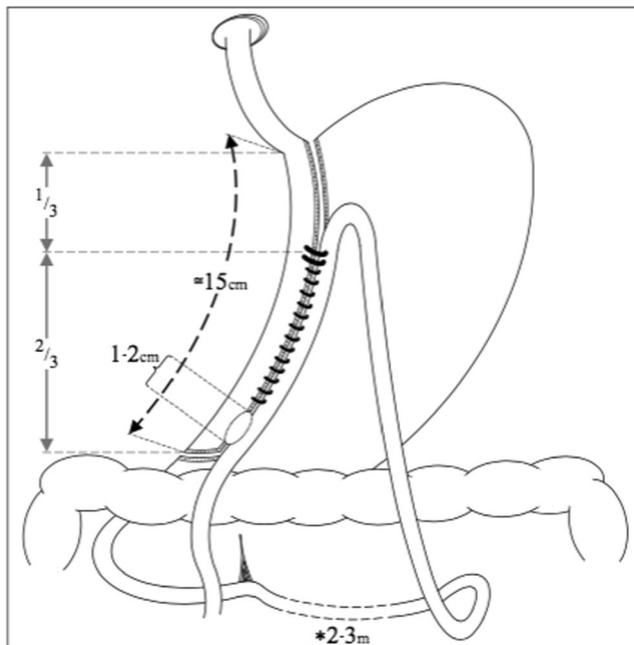


Fig. 1 Diagrammatic representation of the one anastomosis gastric bypass (OAGB) with tailored bypassed afferent small bowel limb. The small bowel loop is suspended one third along the length of the sleeved gastric reservoir, approximately 10 cm above the anastomosis. Asterisk = tailored afferent loop length. BMI < 50 kg/m² → 200 cm. BMI 50–60 kg/m² → 250 cm. BMI > 60 kg/m² → 300 cm

as postoperative analgesia, oral feeding institution, antithrombotic prophylaxis, and discharge plan.

Postoperative analgesia is achieved either by intravenous administration of acetaminophen (1000 mg q6h) and tramadol (up to 100 mg daily, if the patient still suffers pain), or a patient controlled analgesia (PCA) pump for the first 24 h postoperatively (250 mL of a 10γ/mL fentanyl solution).

We prefer a “fast track” approach regarding oral feeding institution, with the patients being placed on a liquid diet the first 4–5 h following operation. Routine upper GI gastrografin swallow is not performed prior to feeding.

Patients with an uneventful postoperative course get discharged on the 1st or 2nd postoperative day. They are given dietary instructions for a stepwise advance from a liquid diet (1st week postop), to grounded (2nd week postop), and to soft foods (3rd week postop). They are also prescribed high-caloric (≈ 1.5 kcal/mL) and high-protein (≈ 10 g/100 mL) energy drinks and are advised to consume about 400 mL/day. They are also encouraged to take over the counter multivitamin supplements, especially rich in vitamins B₁₂ and D as well as trace minerals. Patients are also placed on proton pump inhibitors (PPIs) for the first 6 months and are given anti-thrombotic prophylaxis with low-molecular-weight heparin (LMWH) for the first 20 days postoperatively.

Our department advocates making use of sequential measurements of WBC count and C-reactive protein (CRP) as indices for a potential anastomotic leak. Blood samples are drawn on the 1st, 3rd, 5th, 7th, 9th, 11th, and 13th postoperative day and a CRP value greater than 200 mg/L is interpreted as pathognomonic of leak, as described in a previously published study of ours [10].

Patients are followed up on the 1st month postoperatively and then on the 3rd, 6th, 12th, 18th, 24th, and 36th month. All patients are evaluated by a multidisciplinary team involving a bariatric surgeon, an endocrinologist, a nutritionist, and a psychologist. Weight loss progression; current medical treatment; blood tests results (including full blood count, serum levels of glucose, cholesterol, iron and ferritin, calcium and vitamin D, albumin, and trace minerals) are noted.

Statistical Analysis

In addition to simply providing the descriptive statistics regarding weight reduction, comorbidity resolution, nutritional parameters, and complications for the whole group of patients, a statistical analysis was performed comparing the outcomes among the different biliopancreatic limb length subgroups, on the grounds of weight reduction and incidence of nutritional deficiencies (e.g., for serum albumin, iron, and vitamin D).

Statistical analysis was conducted using the Statistical Package for the Social Sciences (IBM, SPSS, version 23.0). For normally distributed data, *t* test or one-way ANOVA (for comparing multiple groups) were used. To inquire about

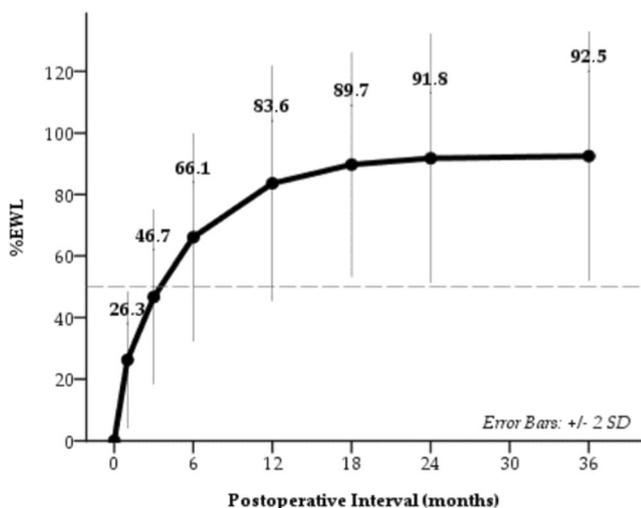


Fig. 2 Mean %EWL progression during the first 3 years after surgery. The operation is considered successful if %EWL is greater than 50%

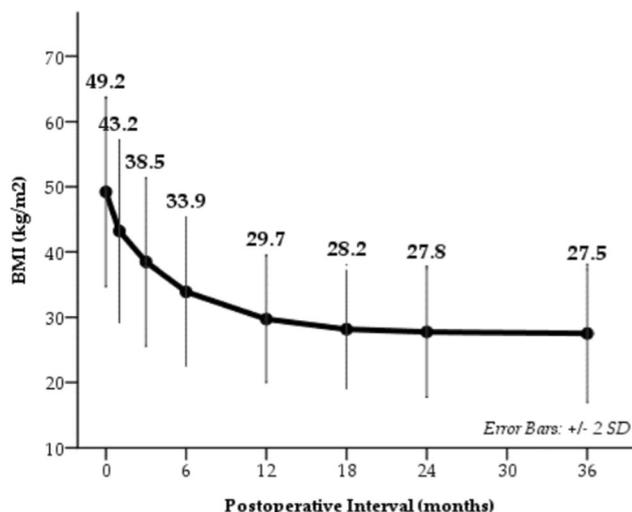


Fig. 3 Mean BMI values during the first 3 years after surgery

possible correlations between patient values, Pearson product-moment correlation coefficient was performed. One-way ANCOVA was entailed to explore differences between groups while statistically removing the influence of a suspected covariate. To determine whether two categorical variables are related chi-square for independence was used. For all statistical tests, a *P* value < 0.05 was considered significant.

Results

A total of 282 obese individuals have undergone OAGB in our department since April 2009. Among them, 115 patients, who have completed a postoperative interval of at least 36 months, have been enrolled for this study. Complete follow-up is available for 94 of these patients (follow-up = 81.7%). Gender distribution is 68 women (72.3%) and 26 men (27.7%), with an average age of 41.5 ± 10.7 years (range 19–61). Mean weight at time of operation was 139.4 ± 25.0 kg (range = 92–210) with a corresponding mean BMI of 49.2 ± 7.3 kg/m² (range = 32.6–66.3) (Table 1).

Weight Reduction

Mean excess weight loss (%EWL) was 26.3% at 1 month, 66.1% at 6 months, 83.6% at 12 months, 91.8% at 24 months, and 92.5% at 36 months (Fig. 2). The corresponding operation success (defined as the percentage of patients with a %EWL greater than 50%) is 80.9%, 98.9%, and 97.9% at 6, 12, and 36 postoperative months, respectively (Table 2). The average BMI 36 months postoperatively is 27.5 kg/m², implying a mean reduction of 21.7 kg/m² compared to the starting value. Furthermore, 83.0% of our patients attained a BMI less than 35 kg/m² at 12 months, with the respective percentage 36 months postoperatively being 92.6%, thus providing another measure of the operation success. Thus, 73.4% of our patients achieved the ideal target of a BMI less than 30 kg/m² at 36 months postoperatively (Fig. 3, Table 2).

Two characteristics of weight loss progression are of great interest. When comparing the portion of total %EWL during the first 18 months to that of the subsequent ones, mean values are 99.4% and 0.6%, respectively (Fig. 4). At the same time, a significant portion of our group of patients achieved their maximum weight loss at 36 months postoperatively (Fig. 5).

Table 2 Postoperative values of body-weight associated parameters

Postop interval (months)	Weight loss mean (SD) (kg)	BMI mean (SD) (kg/m ²)	%EWL mean (SD) (%)	Operation success (% of patients with %EWL > 50%)
1	17.0 (6.7)	43.2 (7.0)	26.3 (11.1)	4.2
3	30.3 (8.7)	38.5 (6.4)	46.7 (14.2)	35
6	43.2 (11.4)	33.9 (5.7)	66.1 (16.9)	80.9
12	55.1 (14.8)	29.7 (4.9)	83.6 (19.1)	98.9
18	59.5 (16.5)	28.2 (4.5)	89.7 (18.3)	100.0
24	60.6 (17.3)	27.8 (5.0)	91.8 (20.3)	98.9
36	61.3 (18.9)	27.5 (5.3)	92.5 (20.3)	97.9

EWL excess weight loss, *BMI* body mass index, *SD* standard deviation

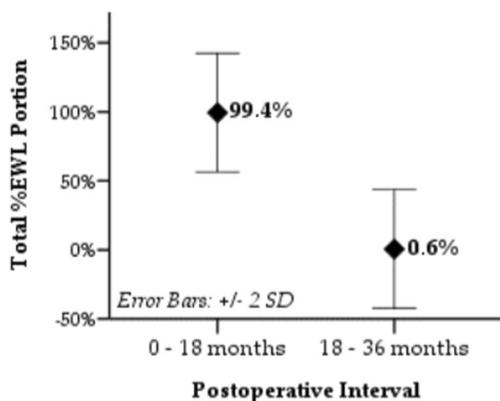


Fig. 4 Portion of total %EWL during the first and second 1.5 year postoperatively [EWL₀₋₁₈ = EWL₁₈/EWL₃₆ and EWL₁₈₋₃₆ = (EWL₃₆ - EWL₁₈)/EWL₃₆]

Combining these two facts, we get a clear view of the dramatic weight reduction taking place during the first postoperative 1.5 year, along with the continuation of weight reduction (in a profusely lower rate, though) during the following 1.5 year, which adds durability to weight reduction effect.

In order to deepen our understanding regarding weight reduction and better assessing the impact of tailoring on it, a comparative analysis for the three different biliopancreatic limb patient subgroups was carried out. As previously stated, patients are divided into three groups of biliopancreatic limb lengths; 2 m, 2.5 m, and 3 m, based upon preoperative BMI (Figs. 6 and 7, Tables 3 and 4).

Our data seem to imply a more effective weight reduction for the shorter biliopancreatic limb lengths, with the greatest %EWL for the 2-m group and the lesser for the 3-m group at each postoperative interval (Fig. 7). However, this seems a rather unfair comparison, since an estimation of tailoring’s efficacy is attempted on, by definition, diverse patient populations, thus distorting any drawn conclusion.

Hence, the relationship between preoperative BMI and weight loss (as expressed by %EWL 36 months postoperatively) was investigated using Pearson correlation coefficient. There was a medium, negative correlation between the two

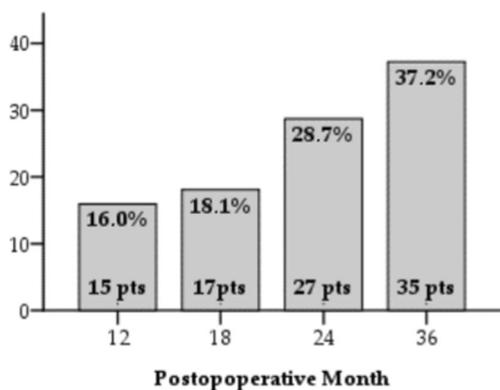


Fig. 5 Postoperative month of maximal %EWL

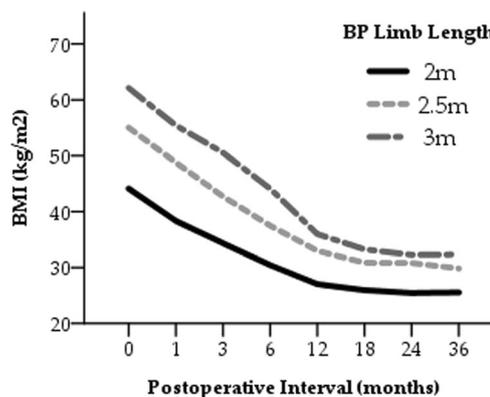


Fig. 6 Mean BMI values during the first 3 years after surgery, for the different BP limb length subgroups

variables [$r = -0.47$, $n = 94$, $P < 0.01$], with higher preoperative BMI values associated with lower %EWL 36 months postoperatively (Fig. 8).

Finally, a one-way analysis of covariance (ANCOVA) was conducted to determine a significant difference between a 2 m, 2.5 m, and 3 m biliopancreatic limb length regarding the %EWL 36 months postoperatively, while removing the influence of patient’s preoperative BMI. Though not reaching statistical significance, there seems to be a trend towards greater %EWL 36 months postoperatively for larger biliopancreatic limb lengths after controlling for preoperative BMI (adjusted $M_{2m} = 0.89$, 95% CI 0.81–0.97; adjusted $M_{2.5m} = 0.95$, 95% CI 0.86–1.05; adjusted $M_{3m} = 1.05$, 95% CI 0.86–1.24; $F(2, 91) = 0.83$, $P = 0.44$) (Fig. 9).

Effect on Comorbidities

A number of obesity-related disorders were evaluated. The presence of these comorbidities was assessed clinically (Table 5). A patient was considered to be hypertensive either if having abnormal blood pressure during preoperative evaluation or if being under anti-hypertensive medication. Reflux symptoms or systematic treatment with PPIs was considered

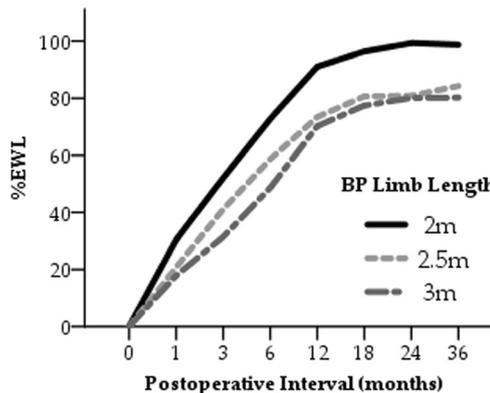


Fig. 7 Mean %EWL progression during the first 3 years after surgery, for the different BP limb length subgroups

Table 3 Patient characteristics and preoperative values for the different BP limb length subgroups

BP limb (m)	Number (patients)	Sex (men/women)	Age mean (SD) (years)	Preop BMI mean (SD) (kg/m ²)	Preop TBW mean (SD) (kg)
2	56	18 / 36	41.7 (11.2)	44.1 (3.7)	125.9 (17.6)
2.5	29	5 / 24	41.5 (10.6)	55.0 (2.5)	152.1 (16.3)
3	9	3 / 6	40.6 (9.6)	62.1 (1.9)	182.3 (17.0)

EWL excess weight loss, *BMI* body mass index, *SD* standard deviation

as gastroesophageal reflux disease, abnormal lipid levels, or lipid-lowering medication was considered dyslipidemia and apneustic respirations at sleep with daytime somnolence or CPAP device use as sleep apnea. At the time of operation, the incidence of arterial hypertension (HTN), diabetes mellitus (DM), dyslipidemia (DYSL), and obstructive sleep apnea (OSA) was 35.1%, 25.5%, 19.1%, and 12.8%, respectively. At 36 months postoperatively, the incidence of OSA was reduced to 1.1% (91.7% remission). At the same time, a complete resolution was observed regarding HTN, DM, and DYSL. Remission of metabolic disorders is also certified by normalization of patients' blood test values (Table 6). In regard to gastroesophageal reflux disease (GERD), the initial incidence of 16% was reduced to 2.1% (86.7% reduction) at 36 months postoperatively.

Effect on Nutritional Status

The impact of OAGB on patients' nutritional status can be estimated on the basis of the resulting supplementation needs for various essential dietary ingredients. All patients were assessed with sequential blood tests during the 36-month follow-up period and abnormal biochemical values requiring correction via supplementation at any time postoperatively

were noted (Table 7). These nutrient deficiencies were also assessed for possible variation in incidence among the three biliopancreatic limb length patient subgroups, with none of iron [$\chi^2(2, 94) = 0.348, P = 0.840$]; vitamin B₁₂ [$\chi^2(2, 94) = 0.615, P = 0.735$]; folic acid [$\chi^2(2, 94) = 0.132, P = 0.936$]; vitamin D [$\chi^2(2, 94) = 3.251, P = 0.197$]; trace minerals [$\chi^2(2, 94) = 2.782, P = 0.249$]; and albumin [$\chi^2(2, 94) = 0.196, P = 0.907$] showing a statistically significant difference (Table 8).

Surgical Complications

Data regarding early postoperative complications is available for the total of 115 patients. The overall complication rate was 6.1%. Major complications (Clavien-Dindo grade ≥ 3) occurred in two of these patients (1.7%). The first patient developed postoperative dysphagia, due to anastomotic stricture, and was treated with endoscopic balloon dilatation (three sessions). The second patient was readmitted to our institution on the 9th postoperative day due to an intra-abdominal leak. Two reoperations, the first for drain placement and a second for hand-sewing of the leak site along the greater curvature of the gastric tube, were performed. In addition, an upper GI endoscopy ensued, where a clip was placed.

Table 4 Postoperative values of body weight associated parameters for the different BP limb length subgroups

BP limb (m)	Weight loss mean (SD) (kg)	BMI mean (SD) (kg/m ²)	%EWL mean (SD) (%)	Operation success (% of patients with %EWL > 50%)
6 months postoperatively				
2	39.0 (10.3)	30.4 (3.4)	72.8 (17.0)	91.1
2.5	48.5 (10.6)	37.5 (3.5)	58.7 (11.4)	75.9
3	52.8 (8.3)	44.1 (2.8)	48.7 (7.3)	33.3
18 months postoperatively				
2	51.7 (11.2)	26.0 (3.0)	96.4 (18.0)	100.0
2.5	66.5 (12.3)	30.9 (4.3)	80.7 (14.2)	100.0
3	85.1 (21.0)	33.2 (4.5)	77.4 (12.8)	100.0
36 months postoperatively				
2	52.8 (11.0)	25.5 (3.1)	98.7 (17.7)	100.0
2.5	69.5 (18.3)	29.8 (6.4)	84.3 (21.8)	93.1
3	88.0 (24.7)	32.3 (6.2)	80.2 (17.2)	100.0

BP biliopancreatic, *EWL* excess weight loss, *BMI* body mass index, *SD* standard deviation

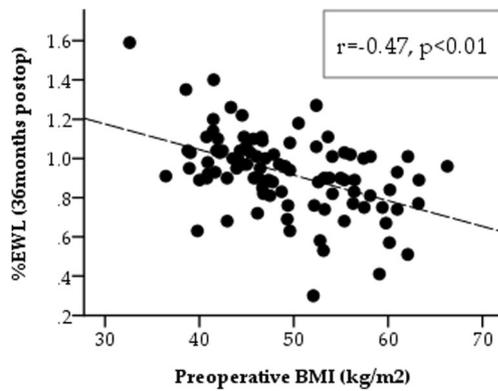


Fig. 8 Relationship between preoperative BMI values and %EWL 36 months postoperatively

Minor early complications refer to one patient with postoperative atelectasis/pneumonia, one patient with hemorrhage, and also two patients with intra-abdominal leak or abscess. All these were treated conservatively. Finally, one patient suffered an anterior abdominal wall cellulitis at the LMWH injection sites, requiring readmission and proper antibiotic treatment (Table 9).

Concerning late complications, of note is a group of five patients complaining about regurgitation of food and gastric contents or chest pain which subsides with anti-secretory medication. Symptoms started within the first few months postoperatively. These patients had neither clinical nor endoscopic features of reflux disease preoperatively, thus producing an incidence of new-onset regurgitation of 5.3%. A case of marginal ulcer was identified within the first year postoperatively. Nevertheless, no intervention, apart from prolonged PPI use was required. Moreover, six patients suffered postprandial vomiting, while nine patients complained about loose foul-smelling stool and diarrhea. For the majority, symptoms

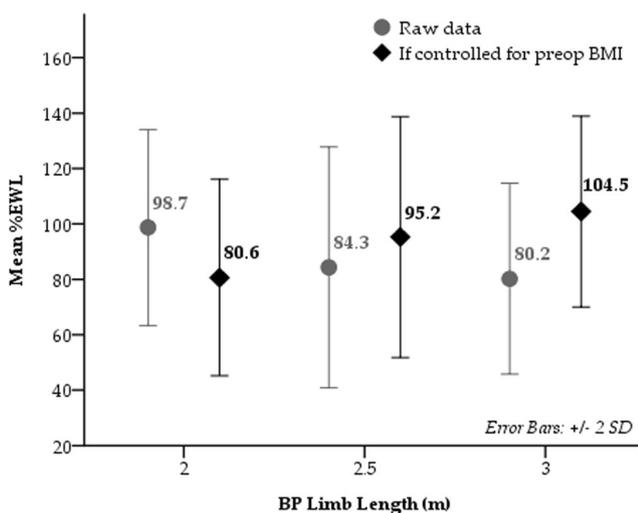


Fig. 9 Mean %EWL values 36 months postoperatively for the different BP limb length subgroups. Values are given both for raw data and after statistically controlling for the preoperative BMI values

subsided as patients became familiar with their operation and adopted proper dietary habits. Only one woman with intractable diarrhea and steatorrhea needed to be placed on pancrelipase (Creon) for her symptoms to be adequately controlled. Interestingly, she had a 2-m diversion. Among our patients, two cases of late dumping were identified. For the first patient, dietary adaptation including smaller, more frequent, low glycemic index meals, sufficed, whereas the second patient had to be placed on metformin, following endocrinologist's consultation, in order to manage postprandial hypoglycemia and its accompanying symptoms. No surgical conversion of the procedure has been required till now (Table 9).

Discussion

Obesity, along with its relating disorders and its impact on morbidity and mortality, is a challenging threat to public health worldwide. In Western societies, great funds are provided for managing obesity's complications. Conservative approaches such as lifestyle modification and dietary counseling failed to exhibit efficient and long-standing results. Since the advent of weight loss operations in 1954, bariatric surgery has proven itself as the most effective way for weight reduction, comorbidity amelioration, and improvement of quality of life. That being said, it is not a surprise that the field is gaining such a popularity among both surgeons and patients.

Bariatric operations have been evolving over the past 50 years. However, bariatric surgeons are still far from standardizing the optimal bariatric procedure. Today, RYGB is considered as the gold standard. Nevertheless, it is a technically demanding procedure with a steep learning curve and a well-recorded incidence of potentially life-threatening complications [11, 12]. At the same time, SG, though being a technically easier procedure, has suboptimal efficacy in obesity-related comorbidities, mainly diabetes, and the potential for troublesome reflux esophagitis [11].

OAGB conceptually offers the same benefits to RYGB with several advantages. OAGB is a safer and simpler procedure entailing one anastomosis, which is created in an antecolic fashion, thus minimizing the risk for internal herniation, as well as preserving intestinal continuity and allowing for potential revision or reversal in the future. Furthermore, when compared to other bariatric procedures, it presents with a favorable outcome in terms of weight reduction and comorbidity resolution. Therefore, OAGB has many of the characteristics of the requested "ideal" operation [2, 13]. Although the operation is not considered highly demanding, surgical expertise and advanced laparoscopic skills (e.g., laparoscopic suturing) are required for splendid results.

A recent meta-analysis tested the theoretical advantages of OAGB over RYGB, showing comparable results between the

Table 5 Progression of the incidence of obesity-related comorbidities

	Postoperative interval (months)						Overall change (%)	
	0 [% (n)]	1 [% (n)]	3 [% (n)]	6 [% (n)]	12 [% (n)]	24 [% (n)]		36 [% (n)]
HTN	35.1 (33)	11.7 (11)	4.3 (4)	4.3 (4)	3.2 (3)	0 (0)	0 (0)	100.0
DM	25.5 (24)	7.4 (7)	2.1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	100.0
DYSL	19.1 (18)	1.1 (1)	1.1 (1)	1.1 (1)	0 (0)	0 (0)	0 (0)	100.0
OSA	12.8 (12)	3.2 (3)	1.1 (1)	1.1 (1)	1.1 (1)	1.1 (1)	1.1 (1)	91.7
GERD	16.0 (15)	9.6 (9)	3.2 (3)	2.1 (2)	3.2 (3)	3.2 (3)	2.1 (2)	86.7

HTN arterial hypertension, DM diabetes mellitus, DYSL dyslipidemia, OSA obstructive sleep apnea, GERD gastroesophageal reflux disease

two procedures regarding anastomotic leakage, marginal ulceration, dumping, and need for revision. OAGB heads in terms of weight reduction and type 2 diabetes remission. In addition, as expected, a greater incidence of bowel obstruction and internal herniation was observed with RYGB. On the other hand, OAGB was associated with more cases of malnutrition, especially for the larger biliopancreatic limb lengths [7].

Attention has to be paid to the construction of the gastrojejunal anastomosis with intent to avoid alkaline biliary reflux. It has been suggested that the small gastric pouch, close to the gastroesophageal junction, in the classic loop gastric bypass, exposes the lower esophagus to bile flow leading to worrisome esophagitis [5, 14, 15]. In order to avoid this, OAGB uses a long narrow sleeve gastric tube and places the gastrojejunal anastomosis to its most dependent end. As an additional means of protection against the refractory biliary esophagitis, suspension of the afferent loop along the gastric tube has been proposed by Carbajo et al. [5, 9]. This hypothesis seems reasonable, though not firmly proven, and we have adopted it. The small bowel contents are thought to glide along the suspended loop creating a cascade that rapidly takes away the irritating biliary small bowel contents.

Even without this modification, the initially upsetting possibility of alkaline esophagitis has not been fully assessed yet,

albeit, according to many authors, biliary reflux rarely has been found, and if present, has been symptomatic only in a small number of patients [5, 15, 16].

The fact that OAGB takes advantage of a longer gastric tube may also be ergonomically beneficial in cases of redundant intraperitoneal fat, where the Roux-en-Y suspension of the alimentary limb to the gastric pouch might be challenging and risking tension to the anastomosis.

With regard to weight reduction, our series appears to be in agreement with previously published results [2, 5, 11, 14]. A mean %EWL of 83.6% was observed at 12 months postoperatively, with a corresponding value of 92.5% at 36 months. Furthermore, 98.9% of studied patients achieved a greater than 50% EWL at 12 months and 97.9% of them had a greater than 50% EWL at 36 months. Consequently, not only is a substantial weight reduction evident but also these data are promising regarding durability of the results, even though a still longer follow-up interval is demanded to fully assess that.

In addition to the description of weight reduction for the whole group of patients, a clear insight into the impact of biliopancreatic limb length tailoring upon preoperative BMI was pursued. Regarding the various malabsorptive procedures,

Table 6 Metabolic panel for previously diabetic and dyslipidemic patients at 36 months postoperatively. All patients have discontinued any treatment

	Number	Median	Minimum	Maximum
FBG (mg/dL)	24	93	78	108
HbA1c (%)	24	6.3	5.8	6.7
TC (mg/dL)	18	187	170	208
HDL (mg/dL)	18	36	31	48
LDL (mg/dL)	18	139	120	157
TAGs (mg/dL)	18	123	99	145

FBG fasting blood glucose, HbA1c glycosylated hemoglobin, TC total cholesterol, HDL high-density lipoprotein, LDL low-density lipoprotein, TAGs triacylglycerols

Table 7 Nutritional deficiencies as evident by supplementation needs, for the total number of patients (n = 96)

	Number (%)
Iron deficiency	26 (27.7)
Oral	16 (17.0)
Parenteral (iv)	10 (10.6)
More than once	4 (4.3)
Vitamin B ₁₂ deficiency	13 (13.8)
Oral	11 (11.7)
Parenteral (im)	2 (2.1)
Folic acid deficiency (oral)	18 (19.1)
Vitamin D deficiency (oral)	13 (13.8)
Trace minerals (e.g., Cu, Zn) (oral)	16 (17.0)
Albumin (protein drink dependence)	7 (7.4)

Table 8 Nutritional deficiencies for the different BP limb length subgroups

Deficiency	BP limb length subgroups			P value
	2 m (n = 56) n (%)	2.5 m (n = 29) n (%)	3 m (n = 9) n (%)	
Iron	20 (35.7)	3 (10.3)	3 (33.3)	0.840
Vitamin B ₁₂	7 (12.5)	4 (13.8)	2 (22.2)	0.735
Folic acid	11 (19.6)	5 (17.2)	2 (22.2)	0.936
Vitamin D	7 (12.5)	3 (10.3)	3 (33.3)	0.197
Trace minerals	7 (12.5)	6 (20.7)	3 (33.3)	0.249
Albumin	4 (7.1)	2 (6.9)	1 (11.1)	0.907

BP biliopancreatic

existing data discuss the optimal bypassed small bowel length, the relative ratio between the biliopancreatic and alimentary limbs, or even whether the bypassed small bowel part (e.g., duodenum or jejunum) per se is crucial for optimal weight loss. According to some authors, small bowel bypassing does lower the threshold for caloric overwhelming and discarding, but this is practically unnecessary, since the coexisting restriction has already set a stricter limit for the consumed energy [17]. In contrast to RYGB, OAGB poses no dilemma regarding the relative biliopancreatic and alimentary limb lengths, since the conceptual alimentary limb is 0 cm, thus the biliopancreatic limb equals the total bypassed bowel. A few other aspects regarding OAGB need to be further enlightened though. Some authors argue that there is a plateau of weight loss effectiveness with increasing bypassed bowel length and that this

plateau is reached for a bypassed small bowel limb of 200 cm, with any greater bypassing adding nothing but worsening beneficial nutrient malabsorption [18, 19]. Others claim that just bypassing jejunum is required for the maximum weight loss effectiveness to be obtained [18, 20]. In either case, large randomized trials with even longer follow-up are mandatory in order to further define the minimum effective small bowel limb length that leads to the plateau weight loss efficacy, while minimizing the risk of nutritional deficiencies.

In our study, plotting %EWL against postoperative interval for the different biliopancreatic limb length subgroups demonstrates a rather counterintuitive finding; the larger the biliopancreatic limb, the lesser the observed %EWL at any postoperative interval (Fig. 7). When considering the physiology of digestion and absorption, a greater bypass of small bowel leading to lesser weight reduction seems unreasonable. Instead, other parameters varying between these subgroups that lead to this paradoxical outcome should be sought. Preoperative weight, definitely varying between the three subgroups, had to be tested as a potential confounding factor. Indeed, statistical analysis revealed that %EWL is inversely related to the starting weight, and that when assessing weight reduction on a factitious patient population of the same preoperative BMI, larger biliopancreatic limb lengths were associated with greater %EWL. However, this difference did not reach statistical significance, presumably because of the moderate number of patients enrolled. Two interesting conclusions can be drawn from the above. First, greater biliopancreatic limb lengths indeed lead to greater weight

Table 9 Postoperative complications

Early Complications (≤30 days postoperatively)		Total of 115 patients	
	Number of cases (%)	Management [n (%)]	
Atelectasis/pneumonia	1 (0.9)	Conservative	[1 (0.9)]
Hemorrhage	1 (0.9)	Transfusion	[1 (0.9)]
Dysphagia	1 (0.9)	Endoscopic Dilatation	[1 (0.9)]
Leak/intra-abdominal abscess	3 (2.6)	Conservative	[2 (1.7)]
		Reoperation	[1 (0.9)]
Abdominal wall cellulitis	1 (0.9)	Conservative	[1 (0.9)]
Total	7 (6.1)		
Late complications (> 30 days postoperatively)		Total of 94 patients	
	Number of Cases (%)	Management [n (%)]	
Regurgitation/chest pain	5 (5.3)	PPIs	[5 (5.3)]
Marginal ulcer	1 (1.1)	PPIs	[1 (1.1)]
Vomiting	6 (6.4)	Dietary adaptation	[6 (6.4)]
Diarrhea/steatorrhea	9 (9.6)	Dietary adaptation	[8 (8.5)]
		Pancrelipase (Creon)	[1 (1.1)]
Late dumping	2 (2.2)	Dietary adaptation	[1 (1.1)]
		Metformin	[1 (1.1)]
Total	21 (22.3)		

PPIs proton pump inhibitors

reduction and partially compensate for the inherent lag of the more obese individuals regarding weight loss. Second, for a given biliopancreatic limb length, less obese individuals respond better to the procedure, thus suggesting that OAGB may not be the ideal operation for super-obese patients.

Concerning obesity-related comorbidities, OAGB exhibits a favorable profile as well [3, 5, 15, 21, 22]. At 3 years postoperatively, all patients being previously treated for hypertension, diabetes, or dyslipidemia were reclassified as normal. A satisfactory reduction in the incidence of sleep apnea was also observed. Knowing that esophagitis has been an issue after many types of bariatric surgery, the observed reduction in clinical gastroesophageal reflux disease should not be overseen. The small incidence of de novo GERD noted should prompt us to closely attend these patients and improve our knowledge about this worrisome sequela. As a prophylaxis, currently, our patients are prescribed PPIs for the first 6 months postoperatively.

Malnutrition, especially for biliopancreatic limb length greater than 230 cm [7], is a major concern for many authors. However, no significant difference in the incidence of nutritional deficiencies was found against greater lengths in our study. The need for regularly reassessing patients' nutritional status, aiming to offer early proper supplementation, cannot be overemphasized.

Despite the intrinsic limitations imposed to this retrospective analysis and the moderate number of patients included, the relatively long follow-up period and the high follow-up rate with the complete set of data available for each patient give credibility to our study. Furthermore, we advocate a consistent way of tailoring the bypassed small bowel loop length based upon preoperative BMI with favorable outcomes. This study adds to the bibliographic evidence regarding the safety and efficacy of OAGB, which emerges as a powerful solution for selected obese patients. However, since limitations and problems do exist, a longer follow-up period and properly randomized studies are needed before getting overexcited about this procedure.

Compliance with ethical standards

Conflict of Interest All authors declare no conflict of interest.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Human and Animal Rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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