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ORIGINAL CONTRIBUTIONS

Biliopancreatic Limb Length in One Anastomosis Gastric Bypass: Which Is the Best?

Francesco Pizza[1] · Francesco Saverio Lucido[2] · Dario D'Antonio[1] · Salvatore Tolone[2] · Claudio Gambardella[2] · Chiara Dell'Isola[3] · Ludovico Docimo[2] · Alberto Marvaso[1]

Abstract

Background The use of one anastomosis gastric bypass (OAGB) is rapidly spreading. Concerns about biliary reflux and malabsorption with consequent nutritional deficits exist, so studies on biliopancreatic limb (BPL) adequate length in OAGB are required to balance excess weight loss in percentage (% EWL), resolution of comorbidities, and nutritional deficit. The purpose was to evaluate, at 2 years after OAGB, the effects of BPL length on weight loss, resolution of comorbidity, and nutritional deficiencies in patients.

Methods From January 2015 to January 2017, 180 patients were collected into three groups based BPL length: group A, 150 cm; group B, 180 cm; and group C, 200 cm. Aims were to compare %EWL, co-morbidity resolution rates, nutritional parameters, and morbidity/mortality in the three groups.

Results The total number of patients was 180: 60 for each group. One hundred seventy-two (95%) patients attended the 1-year follow-up (group A = 58; group B = 58, group C = 56). One hundred fifty-seven (87%) patients attended the 2-year follow-up (group A = 52 (87%); group B = 53 (88%); group C = 52 (87%)). There was no statistically significant difference in %EWL, %TWL, T2DM, and hypertension resolution rates among the groups. About vitamin deficiency, differences were not statistically significant. Iron and ferritin deficiency rate were statistically significant only between A and C groups.

Conclusions According to our evidence, standardization of BPL length shorter than 200 cm is suggested, potentially minimizing malnutrition-related outcomes. Our study seems to show that a BPL of 150–180 cm is safe and effective in terms of EWL and comorbidity improvement with low malnutrition effects even in BMI > 50.

Keywords One anastomosis gastric bypass · Obesity surgery · Malabsorption · Nutritional deficiencies

Introduction

The one anastomosis gastric bypass (OAGB) has currently gained a widespread diffusion among bariatric surgeons, being the third commonest procedure worldwide performed after sleeve gastrectomy and Roux-en-Y gastric bypass (RYGB) [1]. OAGB gained many supporters but also several criticisms for the possible onset of biliary reflux and malabsorption with consequent nutritional deficits. Moreover, the American Society for Metabolic and Bariatric Surgery has not yet approved OAGB, for concerns regarding long-term "nutritional deficiencies" and "carcinogenic effects" [2]. Many studies have been published trying to establish a consensus on the adequate length of BPL in OAGB, balancing excess weight loss in percentage (%EWL), resolution of comorbidity, and nutritional deficiency [3]. The purpose of the present retrospective review of a prospective collected database is to evaluate, after 2-year follow-up, the effect of BPL length on weight loss, resolution of comorbidity, and nutritional deficiencies in patients affected by morbid obesity undergone OAGB.

✉ Francesco Pizza
Francesco_pizza@libero.it

[1] Division of Surgery, Hospital "A. Rizzoli", Lacco Ameno, Naples, Italy

[2] Division of General, Mininvasive and Bariatric Surgery, University of Campania "Luigi Vanvitelli", Naples, Italy

[3] Department of Infectious Diseases, AORN "Dei Colli", Naples, Italy

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Material and Methods

Patient Selection

This is a single-institution study comparing outcomes of patients undergoing elective laparoscopic OAGB for morbid obesity conducted from January 2015 to January 2017 in the Department of General and Emergency Surgery at "A. Rizzoli" Hospital, in Lacco Ameno (Naples, Italy). The same surgeon performed all surgical operations. Patient characteristics, perioperative work-up, intraoperative results, and postoperative outcomes were recorded into a prospective database by a blinded observer.

We divided patients into three groups: in group A, gastroenteric anastomosis was performed at a fixed BPL of 150 cm from the LT; in group B, BPL was 180 cm long; and in group C, BPL was 200 cm. Details of enrollment procedure are presented in Fig. 1. Authorization was requested and acquired from the local regional ethics committee.

Study dataset is available on Mendeley (Pizza, Francesco (2020), "Study: One anastomosis gastric bypass," Mendeley Data, V2, https://doi.org/10.17632/779vdgfmvm.2).

Inclusion criteria were as follows: morbid obesity defined as body mass index (BMI) over 40 kg/m2, age between 25 and 50 years old, and obesity-related comorbidities (including type 2 mellitus diabetes (T2DM), hypertension, hyperlipidemia, bronchial asthma, osteoarthritis, and degenerative joint disease).

For all patients, compliance with nutritional supplementation and long-term follow-up were assured. Exclusion criteria were represented by previous gastrointestinal tract (GIT)-related abdominal surgery or previous bariatric surgical procedure; endocrine disorders causing obesity (e.g., hypothyroidism and Cushing disease); pregnancy or lactation; psychiatric illness; recent diagnosis of malignancy; inflammatory bowel disease; Barrett's esophagus; severe GERD needing PPIs; and large hiatal hernia (> 5 cm). Patients with total small bowel length (TSBL) < 600 cm were excluded from the study.

Patients were divided into 3 groups based on the length of the BPL measured from the LT: group A 150 cm, group B 180 cm, and group C 200 cm (control group). Results were obtained at 1- and 2-year follow-up. The primary aim was to compare weight loss outcomes between the groups. The secondary aim was to evaluate comorbidity resolution rate, nutritional parameters, and morbidity/mortality among the three groups (OAGB 150-cm BPL (group A), OAGB 180-cm BPL (group B), and OAGB 200-cm BPL (group C, control group)).

Statistical Analysis

Statistical analysis was performed using Graphpad QuickCalcs (GraphPad version 6.04 for Windows, GraphPad Software, La Jolla, CA, USA). Baseline comparisons were performed using chi-square tests and *t* tests. Continuous variables are expressed as mean ± SD. Differences between preoperative and postoperative parameters were compared by Wilcoxon paired rank test. For all tests, a two-sided $p < 0.05$ was considered as statistically significant. As secondary endpoints, we assessed whether there were statistically significant differences between groups A, B, and C.

Included Data

Physicians in charge of patients' management were not involved in the operating room and were blinded to the surgical procedure. Data were included and analyzed by physicians who were not involved in the patient's management during the study.

For all patients enrolled in the study, a detailed letter of the protocol was sent to general practitioners; a detailed calendar of clinical and/or instrumental follow-up data to be performed at the bariatric surgery center was scheduled.

Surgical Technique

Closed pneumoperitoneum was established using our standard technique of Veres needle at the Palmer site and optical insertion of a 12-mm port at a supraumbilical site (10–15 cm from the umbilicus). Two additional 15-mm and 12-mm ports were placed, respectively, in the left and right hypochondrium as operating ports. A subxiphoid track was created using a 5-mm port for placement of liver retractor. The operation starts with the measurement of the entire small bowel from LT to the ileocecal valve. Patients < 600 cm long were excluded and underwent GBP or SG, according to the indications given during the administration of informed consent.

A long, narrow gastric pouch was built starting from beyond the crow's foot to just lateral to His' angle over a 36-Fr orogastric tube, using a Medtronic Tri-Staple® SIGNA (Medtronic Inc., Dublin, Ireland) with GORE®SEAMGUARD® Bioabsorbable Staple Line Reinforcement. A BP limb of 150 or 180 or 200 cm was then measured from the LT using a stripe of 25 cm as a guide. Gastrojejunostomy was subsequently performed using a Medtronic® Tri-Staple® SIGNA (Medtronic Inc., Dublin, Ireland) 45-mm linear stapler followed by suture closure of the stapler entry opening. There was no difference in the construction of gastrojejunostomy between the groups. A leak and patency test was performed at the end of the anastomosis using a dilute methylene blue solution. No nasogastric tube was used. One drain was positioned in left hypochondrium. Patients were generally allowed 1.0 L of water orally on day 1; they were discharged on day 4 within instructions to stay on a pureed diet for 4 weeks according to our standard protocol. Food consistency was gradually increased over the next few months. Patients were advised to take lansoprazole 30 mg daily for 6 months. Patients were further recommended to assume multivitamin/mineral

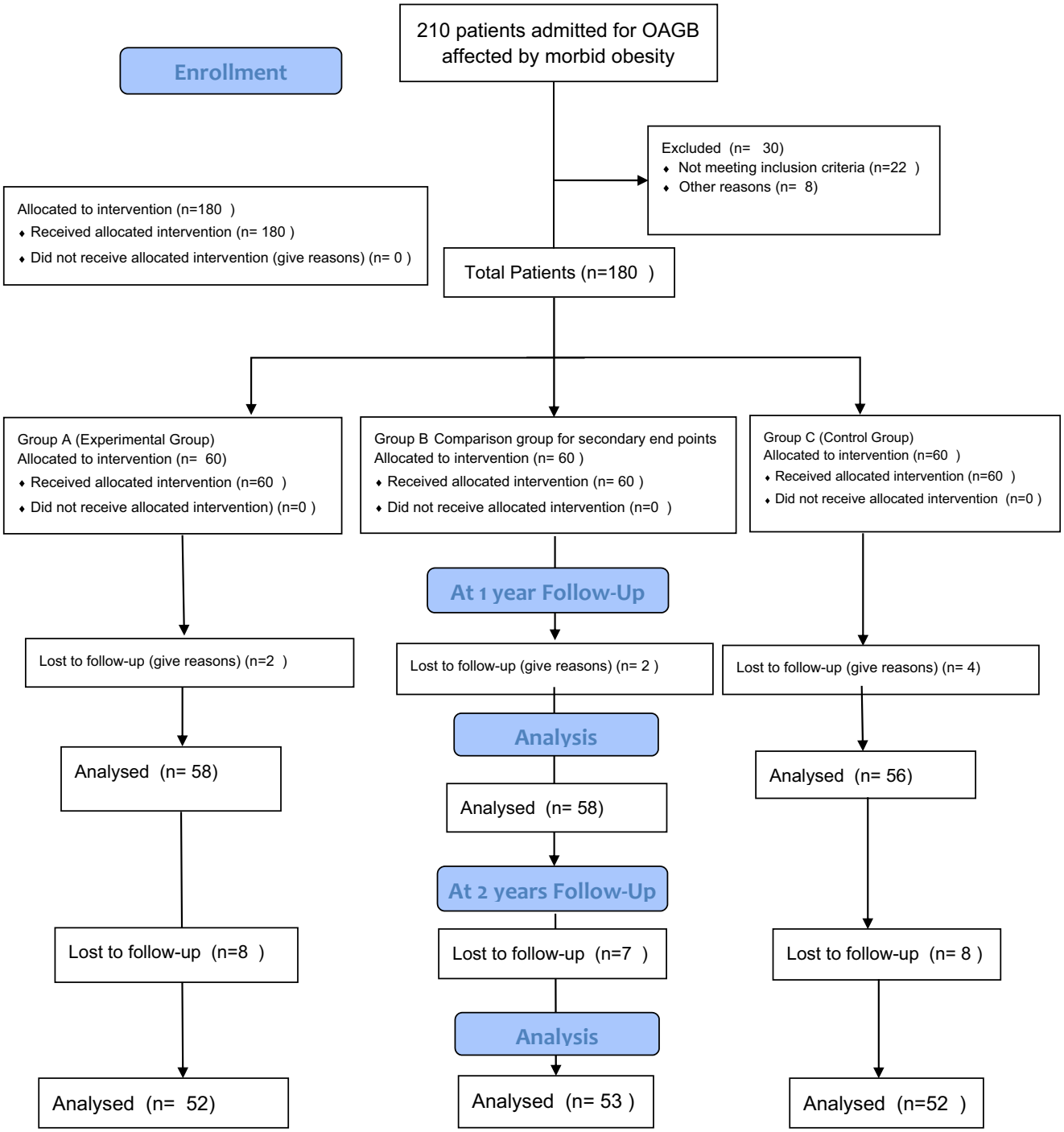

Fig. 1 Flow diagram

tablets, vitamin D/calcium tablets, iron tablets every 3 months lifelong, and vitamin B12 injections for 2 years.

Preoperative Evaluation

Preoperative evaluation included anthropometric measurements (height in cm, weight in kg, BMI in kg/m2), comorbidity evaluation (HbA1c, C-peptide, stimulated C-peptide, ECG, echocardiography, bilateral lower limbs color doppler, thyroid profile), upper gastrointestinal endoscopy with *Helicobacter pylori* test, abdomen ultrasound, chest X-ray, and nutritional status evaluation (Hb, total protein, serum albumin, serum globulin, serum ferritin, serum iron, B12, and D3 vitamin). Preoperatively, there was no significant difference among the groups regarding nutritional status. Patients with hemoglobin level < 12 g/dL and/or iron deficiency and/or hypoalbuminemia and/or calcium deficit were excluded from the study.

Postoperative Evaluation

All patients were actively followed up regularly at POD 10 and, then, at 1, 3, 6, 12, 18, and 24 months. Patients were advised to take a high protein diet (minimum 1 g/kg body weight daily) and vitamin supplements regularly (oral multivitamin tablets) for the first 24 months (Table 1). We advise patients to assume PPI in the first 6 months of the postoperative period.

During each follow-up visit, anthropometric measurements were performed. Blood investigations for nutritional status evaluation were carried out at 1,6,12, 18, and 24 months. Postoperative outcomes were assessed as follows: morbidity (scored according to Clavien–Dindo classification [4]), mortality, length of hospital stay, and surgical reinterventions.

Remission criteria for T2DM included HbA1c < 6.5 without any medications for 1 year, as described by Buse et al. [5]. Hypertension remission was defined as a blood pressure lower than 140/80 mmHg with no medication [6]. Hemoglobin (Hb) deficiency was diagnosed in case of Hb concentration < 12 g/dL. Iron deficiency was diagnosed if < 40 μg/dL in females or < 55 μg/dL in males. Calcium deficit was diagnosed if < 8.5 mg/dL. Hypoalbuminemia was diagnosed when the albumin level was < 3 g/dL. Quality of life was assessed employing a translated version of the gastrointestinal quality of life index (GIQLI) [7] after surgery at 3, 6, and 12 months. A 36-item questionnaire was used. Each item is quoted from 0 to 4; scores range from 0 to 144, with higher scores indicating better function. The questionnaire measures 5 principal domains: upper gastrointestinal symptoms (12 items), lower gastrointestinal symptoms (7 items), physical status (7 items), psychological status (5 items), and social status (5 items).

An upper gastrointestinal endoscopy was recommended to all patients at 2-year follow-up even in the absence of gastroesophageal symptoms. UE was performed by high-definition gastroscope with lidocaine spray and under conscious sedation (midazolam i.v.) fasting for 6 h. In all patients, the distance from the upper incisors both to the "Z" line (squamous–columnar junction) and to the diaphragmatic impression on the esophagus was measured. Esophagitis, when present, was classified according to the Los Angeles Classification [7]. Barrett's esophagus was evaluated according to the guidelines of the American Gastroenterological Association (AGA) [8]. All endoscopic examination included esophageal and gastric pouch biopsies. The presence of bile in the esophagus and gastric pouch was also detected at the UE. The primary outcome was the %EBWL and resolution of obesity-associated comorbidities. The secondary outcome was the frequency of nutritional deficit and quality of life.

Table 1 Vitamins and mineral supplementation oral value taken pro die for the first 3 months

Vitamins	Amount
Vitamin A	1200 μg RE
Vitamin B1	3 mg
Vitamin B2	3,1 mg
Niacin (B3)	32 mg NE
Acid pantotenic (B5)	18 mg
Vitamin B6	1,12 mg
Biotina (B8)	100 μg
Acid folic (B11)	800 μg
Vitamin B12	500 μg
Vitamin C	140 mg
Vitamin D3	75 μg
Vitamin E	36 mg α-ET
Chrome	160 μg
Copper	3 mg
Iron	85 mg
Iodine	225 μg
Manganese	3 mg
Molibdeno	112,4 μg
Selenium	105 μg
Zinco	30 mg
Vitamin D3	6 μg
Calcium citrate	1000 mg

Results

A total of 210 patients were assessed for eligibility between January 2015 and January 2017: 8 withdrew the consent to participate, and 22 did not meet inclusion criteria. A total of 180 patients were included: 60 for each group (Fig. 1). Patients who completed 2-year follow-up were analyzed. Table 1 summarizes patients' characteristics.

The female rate was 65%; patients' mean age was 35.2 ± 9 years. Mean height, preoperative weight, and preoperative BMI were 154.2 ± 19, 119.9 ± 28.9 kg, and 44.93 ± 7.56 kg/m2, respectively. Table 2 summarizes demographics and preoperative clinical data.

Patients were categorized into three groups (A, B, and C) based on BPL length used. Each group included 60 patients. At 1 year, 1 patient of group A, 2 of group B, and 2 of group C missed follow-up; at 2 years, patient's drop-out was 4 in group A, 3 in group B, and 5 in group C. Eight patients (3 during the first year of follow-up) were excluded during the study because undergone lap cholecystectomy for symptomatic gallbladder stones disease. Pregnancy occurred in three patients during the second year follow-up, and they were, then, excluded. A total of 172(95%) patients attended the 1-year follow-up (clinical and hematological) (group A = 58; group B = 58, group C = 56). A total of 157 (87%) patients attended the 2-year follow-up (clinical and hematological) (group A = 52 (87%); group B = 53 (88%), group C = 52 (87%). Average %EWL achieved in 150 cm, 180 cm, and 200 cm groups were

Table 2 Preoperative demographics data

Patients	Total	Group A ($n = 60$)	Group B ($n = 60$)	Group C ($n = 60$)	p
Age	35.2 ± 9	35.2 ± 9	34.2 ± 9	34.2 ± 9	$p > 0.05$
Male	35%	34%	35%	35%	$p > 0.05$
Female	65%	66%	65%	65%	$p > 0.05$
Height	154.2 ± 19	152.2 ± 16	153.2 ± 28	153.2 ± 14	$p > 0.05$
Weight (kg)	119.9 ± 28.9	114.5 ± 26.7	117.3 ± 23.5	118.9 ± 29.2	$p > 0.05$
BMI	44.93 ± 7.56	44 ± 6 (40–55)	43 ± 5 (40–56)	44 ± 5 (40–58)	$p > 0.05$
ASA (I–II) (%)	65%	64%	66%	65%	$p > 0.05$
ASA (III–IV) (%)	35%	36%	34%	35%	$p > 0.05$
Diabetes mellitus (%)	33 (18%)	11 (19%)	12 (20%)	10 (16%)	$p > 0.05$
Chronic obstructive pulmonary disease (%)	7 (4%)	2 (3%)	3 (5%)	2 (3%)	$p > 0.05$
Heart ischemia	1	0	0	1	$p > 0.05$
Hypertension (%)	99 (55%)	34 (56%)	33 (55%)	32 (54%)	$p > 0.05$

BMI body mass index, *%EWL* percentage excess weight loss, *%TWL* percentage total weight loss

55.9 ± 13.1, 56.60 ± 13.7, and 58.02 ± 14.1 at 1-year follow-up and 60.7 ± 16.1, 61.6 ± 13.5, and 61.2 ± 12.1 at 2-year follow-up, respectively; TWL% achieved in 150 cm, 180 cm, and 200 cm groups was 36.8 ± 8.6, 38.55 ± 9.1, and 39.74 ± 8.7 at 1-year follow-up and 40.7 ± 9.4, 41.6 ± 9.2, and 41.8 ± 8.9 at 2-year follow-up, respectively.

There was no statistically significant difference for %EWL and TWL% among the three groups (Tables 3 and 4). T2DM was present in 32 (18%) patients preoperatively (11(19%) in group A, 12(20%) in group B, and 10(16%) in group C). Among these, at 2-year follow-up, 54.0% ($n = 6$) in group A, 50% (n = 6) in group B, and 50% ($n = 5$) in group C were able to stop all their medications, respectively. A further 18% ($n = 2$) in group A, 25% ($n = 3$) in group B, and 30% ($n = 3$) in group C were able to reduce their medication need. Hypertension resolution occurred in 18/34 (52%) in group A, 17/33 (51%) in group B, and 17/32(53%) in group C, respectively at 2-year follow-up, being able to stop all their medications. There are no statistically significant differences in T2DM and hypertension resolution rates between the three groups.

The mean operative time was 75 ± 35 minutes: no statistically significant difference was found among the groups (A, 73 ± 25; B, 71 ± 29; C, 80 ± 32; $p > 0.05$). The median hospital stay was 5 days for each group (group A, IQR 4–5; group B, IQR 4–5; group C, IQR 4–5). Intraoperative and perioperative complications, within and after 30 days, are reported in Table 5. All outcome surgical indicators were within global bariatric benchmark cutoffs [9]. Intraoperative complications occurred in 5 (2.7%) out of 180 patients in the three groups (hemorrhage $n = 4$, bowel injury $n = 1$): all of them were recognized and treated during the operation; complications were all managed laparoscopically. There was no 30-day mortality in either group. There were three reoperations within 30 days (3/180; 1.6%): two for bleeding (1 in group A and 1 in group C) and 1 in group A for small bowel obstruction due to a hernia on trocar site. All reoperations were performed laparoscopically. One patient in group B was readmitted to the hospital for melena: upper GI endoscopy diagnosed an anastomotic ulcer that was medically treated. The latter patient showed poor compliance with PPI therapy and smoking habit.

Table 3 Weight, body mass index, and the percentage of excess body weight loss and the percentage total weight loss of the three groups at 1 and 2 years after surgery

Patients	1-year follow-up				2-year follow-up			
	Group A ($n = 58$)	Group B ($n = 58$)	Group C ($n = 56$)	p	Group A ($n = 52$)	Group B ($n = 53$)	Group C ($n = 52$)	p
Weight kg	92.5 ± 18.7	95.5 ± 13.5	93.4 ± 16.2	$p > 0.05$	83.5 ± 14.5	80.8 ± 13.5	81.2 ± 11.2	$p > 0.05$
BMI	28.2 ± 4.4	27.5 ± 2.3	*27.1 ± 1.1*	$p > 0.05$	26.2 ± 3.1	25.5 ± 2.4	*25.1 ± 1.8*	$p > 0.05$
EBWL%	55.9 ± 13.1	56.60 ± 13.7	58.02 ± 14.1	$p > 0.05$	60.7 ± 16.1	61.6 ± 13.5	61.2 ± 12.1	$p > 0.05$
TWL(%)	36.8 ± 8.6	38.55 ± 9.1	39.74 ± 8.7	$p > 0.05$	40.7 ± 9.4	41.6 ± 9.2	41.8 ± 8.9	$p > 0.05$

BMI body mass index, *%EWL* percentage excess weight loss, *%TWL* percentage total weight loss

Table 4 Total small bowel length (cm)

Total small bowel length (cm)	Total	Group A	Group B	Group C	p
Mean ± SD	720 ± 155	7218 ± 135	721 ± 133	736 ± 115	$p > 0.05$
Range	620–950	630–1000	650–930	630–950	$p > 0.05$

In our bariatric unit, smoking is unconsidered an absolute contra indication to OAGB. All smokers were informed that their habit can increase the incidence of anastomotic ulcers and are encouraged to quit smoking or, at least, to cut it back. At 2-year follow-up, no patient was reoperated for internal hernias.

The frequency of gastroesophageal reflux disease symptoms was 9/172(5.2%) at 1-year follow-up and 8/157(5%) at 2-years follow-up, without differences between the groups. Symptoms were responsive to PPI. These patients reported taking PPI daily because symptoms recurred upon its withdrawal. We advise patients to take PPI in the first 6 months of the postoperative period. After that, patients resume therapy if necessary. At 1-year 11/172 (7.2%) and at 2-year follow-up 9/157 (5.7%), patients reported to never stop PPI therapy. At 1 and 2 years, 81/172 (47.1%) and 61/157 (38.8%), respectively, reported taking PPI occasionally (< 1 week per month) with no statistically difference between groups, if they deemed it necessary or for preventive purposes, if receiving antibiotics or NSAIDs or steroids, for reasons other than bariatric surgery [3]. No statistically significant difference was evident between groups. Upper gastrointestinal endoscopy at 2 years was performed in 68/157 (43.3%) of patients (Table 8): gastritis was diagnosed in 7/68 (10%) and esophagitis in 2/68 (2.9%). Patients' UE refusal was principally due to the discomfort caused by the procedure.

No patient showed the presence of bile inside the esophagus. In the distal part of the gastric pouch, the presence of bile was detected in 8/68 (11.7%) patients. No patient had intestinal metaplasia at gastric and esophageal biopsies (Table 8).

Nutritional/Hematological Outcomes

At 1-year follow-up, vitamin D3 deficiency was reported in 6 (10.3%), 7 (12.0%), and 8 (14.2%) patients; vitamin B12 deficiency was present in 3 (5.1%), 4 (6.8%), and 4 (7.1%) patients in groups A, B, and C, respectively. At 2-year follow-up, D3 and B12 vitamin deficiency were recorded in 6 (11.5%), 7 (13.2%), and 7 (13.4%) and 3 (5.7%), 4 (7.5%), and 4 (7.6%) in the three groups, respectively, with no statistically significant difference. At 1-year follow-up, in group C, 12 (20%) patients developed iron and ferritin deficiencies, while in group B, 11 (18.9%) patients presented the latter deficiencies. In group A, both iron and ferritin were found to be deficient in 8 (14.2%) patients (Table 5). At 2-year follow-up, iron and ferritin deficiencies were, respectively, found in 7 (13.4%), 8 (15.1%), and 11 (21.1%) in the three groups (Table 6). Iron and ferritin deficiency was statistically significant only between A and C groups. Total protein deficiency occurred in 3 (5.1%), 4 (6.8%), and 5 (8.9%) of patients in groups A, B, and C, respectively. Hypoalbuminemia was

Table 5 Morbidity and mortality total and in each group

	Until Discharge				Until 30 days				After 30 days			
	Tot	A	B	C	Tot	A	B	C	Tot	A	B	C
Uneventful postoperative course	> 95%	> 95%	> 95%	> 95%	> 95%	>95%	> 95%	> 95%	> 95%	> 95%	> 95%	> 95%
Readmission	-	-	-	-	-	-	-	-	-	-	-	-
Reoperation	1.6%	1.6%	< 1%	< 2%	1.6%	< 1%	< 2%	0	< 1%	< 2%	0	< 1%
Clavien–Dindo grade I–II	< 2%	< 2%	< 1%	< 1%	< 2%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Clavien–Dindo grade IIIa	<1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Clavien–Dindo grade IIIb	< 2%	< 1%	< 1%	< 1%	< 1%	< 2%	0	0	0	0	0	0
Clavien–Dindo grade IV(a–b)	0	0	0	0	0	0	0	0	0	0	0	0
Clavien–Dindo grade V	0	0	0	0	0	0	0	0	0	0	0	0
Signature complications Number of patients												
Anastomotic leak	0	0	0	1	0	0	1	0	0	1	0	0
Stenosis of the anastomosis	0	0	0	0	0	0	0	0	0	0	0	0
Small bowel obstruction/internal hernia	0	0	0	0	1	0	0	0	0	0	0	0
Postoperative bleeding	4	4	1	1	2	1	1	2	0	0	0	0
Marginal ulcer	0	0	0	0	0	0	0	0	1	0	1	0
Wound infection	3	3	0	1	0	0	0	0	0	0	0	0

Table 6 The frequency of nutritional deficiencies in three groups before surgery at 1 year after surgery

Patients deficiency	1-year follow-up		
	Group A ($n = 58$)	Group B ($n = 58$)	Group C ($n = 56$)
Vitamin D3	6 (10.3%)	7 (12.0%)	7 (14.2%)
Iron and ferritin	8 (14.2%)	11 (18.9%)	12 (20%)
Vitamin B12	3 (5.1%)	4 (6.8%)	4 (7.1%)
Total protein	3 (5.1%)	4 (6.8%)	5 (8.9%)
Hypoalbuminemia	2 (3.4%)	3 (5.1%)	5 (8.9%)

noted in 2 (3.4%), 3 (5.1%), and 5 (8.9%) patients in groups A, B, and C, respectively. Any statistically significant difference was present among the three groups. Similar results were relieved at 2-year follow-up (Table 6). At 1- and 2-year follow-up, only 4 patients showed anemia (1 man and 3 women), 1 in group B and 3 in group C; in all cases, oral intake of iron and B12 improved the deficiency. Nutritional deficient patients have all been treated increasing or improving the adherence to nutritional supplement therapy. No patient required surgical revision. The adherence of patients to PPI therapy in the three groups at 3-month follow-up was respectively 52/58 (90%) in group A, 50/58 (86%) in group B, 51/56 and (91%) in group C at 6-month follow-up it was respectively 50/52 (96%) in group A, 51/53 (96%) in group B, and 49/52 (94%) in group C. The adherence of patients to vitamin supplementated therapy at 1-year follow-up was respectively 30/58 (51%) in group A, 28/58 (48%) in group B, and 29/56 (51%) in group C at 2-year follow-up it was respectively 18/52 (34%) in group A, 16/53 (30%) in group B, and 15/52 (29%) in group C.

Gastrointestinal Quality of Life Index

The gastrointestinal quality of life index (GIQLI) score after surgery was available in 52/60 (86%) patients of group A, 55/60 (91%) group B, and 50/60(83%) in group C, at 3-month follow-up. At 1-year follow-up, GIQLI score after surgery was available in 21/60 (35%) patients of group A, 24/60 (40%) of group B, and 22/60 (37%) of group C (Table 7). There was a statistically significant difference between the first two groups (A and B) and group C at 3-month control. This significance was not present at 1 year (Table 7). Poor motivation to complete the test was the reason adducted by the patients when asked about such high drop-out at 1-year follow-up regarding GIQLI score after surgery.

Discussion

Laparoscopic OAGB was introduced as a simple and effective bariatric operation [7]. This recent procedure initially called mini-gastric bypass or one anastomosis gastric bypass (OAGB) seemed to be less technically demanding and potentially less morbid [60].

This bariatric procedure is based on a restrictive action (gastric pouch) and a malabsorptive component due to the length of the BPL. The initial description of the procedure implies the creation of a loop gastroenterostomy with the small bowel about 200 cm distally to the LT [7].

While the so-called restrictive procedures, like gastric banding, predominantly work through mechanical actions, OAGB- and RYGB-related effects have been linked to changes in circulating levels of gastrointestinal hormones or bile acids through a mechanism that skips duodenal transit, passing the food bolus directly into the small bowel [10–12].

Same authors have shown OAGB to be effective in terms of weight loss and metabolic results with very similar surgical risk to RYGB [13]. Further, many surgeons believe in malabsorption as the main mechanism of action behind OAGB, being, therefore, keen to set the most extended but safe length of the BPL [13]. Within the bariatric surgical community, there is a consensus about pouch size in OAGB, but BPL length is a topic of considerable debate, because of higher postoperative malnutrition reported rates, which may warrant revision surgery [14, 15]. The malabsorptive mechanism in OAGB—as in other bariatric surgery—involves the bypass of a small intestine segment, which remains a significant site of proteins, vitamins, and mineral absorption [16].

Table 7 The frequency of nutritional deficiencies in three groups before surgery at 2 years after surgery

Patients deficiency	2-year follow-up		
	Group A ($n = 52$)	Group B ($n = 53$)	Group C ($n = 52$)
Vitamin D3	6 (11.5%)	7 (13.2%)	7 (13.4%)
Iron and ferritin	7 (13.4%)	8 (15.1%)	11 (21.1%)
Vitamin B12	3 (5.7%)	4 (7.5%),	4 (7.6%)
Total protein	3 (5.7%)	4 (7.5%)	5 (9.6%)
Hypoalbuminemia	1 (1.9%)	1 (1.9%)	2 (3.8%)

Many authors believe that a longer BPL guarantees better results in terms of excess weight loss and comorbidity resolution, exposing however to more significant problems associated with malabsorption [17, 18]. Often, BPL length depends on BMI and comorbidities. Recently, Anmol Ahuja et al. published a prospective study, in which a longer limb length was taken for patients with higher BMI, uncontrolled T2DM, and hypertension and for those on a non-vegetarian diet. On the other hand, in younger patients, female patients at childbearing age and those on a vegetarian diet, a shorter limb length was used.

Results showed that 150-cm BPL length was adequate with minimal complication and good results. A 180-cm BPL can be used in super obese and when greater weight loss is needed. A 250-cm BPL should be used with caution as it might result in higher nutritional deficiencies [2].

In our study, BPL length was assigned independently to BMI, age, or comorbidities. Analyzing the current study data, OAGB seems to be a safe and effective procedure with excellent results in terms of morbidity and mortality both in the short and the long term, even in a low volume (< 200 cases per year) bariatric center like ours.

The primary endpoint was to evaluate if at a 2-year follow-up there were statistically significant differences among the 3 groups (A, B, C) in terms of %EWL or resolution of comorbidity.

The mean height, preoperative weight, and preoperative BMI were similar in the three groups; besides there were 37/180 (20.5%) patients with BMI > 50 (group A = 12/37; group B = 14/37; group C = 11/37).

In comparison with groups B and C, group A was not found to be associated with poorer weight loss outcomes. Though the sample size is limited, the same evaluation was reported for patients with BMI ≥ 50 kg/m2. There was no further difference in the resolution of comorbidities among the three groups. Particularly, T2DM seems to improve significantly at 2 years in the three groups, without significant differences. This, on one hand, confirms the OAGB effectiveness in improving obesity related morbidities; on the other hand, it seems to demonstrate that the BLP length in the three groups does not seem to have such a crucial action. The same conclusions could equally be applied to hypertension. The secondary endpoint was the evaluation of the differences in the absorption of vitamins and minerals in the 3 groups at 1- and 2-year follow-up. Many papers in literature highlight the possibility of multivitamin deficits in patients undergoing OAGB [5, 6], enough to raise concerns about the safety of the latter operation. In our study, there was no statistical difference between the three groups about blood levels of D3 vitamin, B12 vitamin, total protein, and albuminemia. Values of iron and ferritin were significatively lower in group C vs groups A and B. In group C, at 1 year of follow-up, a percentage of patients with doubled hypoalbuminemia was detected compared with groups A and C; this percentage dropped to the second year of follow-up probably due to both an adaptation mechanism and an increased protein diet in these patients. Furthermore, patient's rate with vitamin deficits was compatible with the expectations of a restrictive and malabsorptive treatment; moreover, in all patients, deficient nutritional factors have solved with dietary controls and oral vitamin and mineral implementations.

No patient required corrective surgical revision. Since Rutledge performed the first OAGB, many variations have been reported, especially to the length of the bypassed limb, being suggested to improve weight loss and reduce protein malnutrition. However, there is currently no consensus on the ideal limb length [19]. Magouliotis et al. in a recent meta-analysis, according to the best currently available evidence on the topic, demonstrated the superiority of OAGB compared with RYGB, in terms of weight loss and T2DM remission. However, OAGB was associated with a significantly more increased incidence of malnutrition, therefore indicating the significant malabsorptive trait of this operation [20]. The latter meta-analysis, as many other works published in the last 3 years [11, 12, 15], deserves reflections. Quite often surgeons do not specify BPL measurement system, do not measure the small bowel total length, and, above all, tend to choose a BMI tailored BPL length, sometimes exceeding 200 cm [21].

Table 8 Endoscopy at 2-year follow-up

Patients 68/180 (37.7%)	Group A 21	Group B 19	Group C 28	$p < 0.05$
Esophagitis	1	0	1	-
A	1	0	1	-
B	0	0	0	-
C	0	0	0	-
Gastric biopsy				
Normal	19	16	26	-
Gastritis	2	3	2	-
Metaplasia	0	0	0	-
Esophageal biopsy				-
Normal	21	19	28	-
esophagitis				-
Metaplasia	0	0	0	-

Table 9 The gastrointestinal quality of life index (GIQLI) score at follow-up 12 months after surgery in the three group

	Group A	Group B	p
GIQLI at 3 months	103.6 ± 15.1	103.7 ± 11.1	$p > 0.05$
GIQLI at 12 months	105.7 ± 12.1	106.1 ± 13.3	$p > 0.05$

Another aspect that should not be underestimated is that patients often undergo instrumental follow-up only after becoming symptomatic. Blood tests to identify nutritional deficits have a considerable cost that patients prefer to postpone. Moreover, the poor compliance to vitamins and mineral support is often related to the fact that—at least in Italy—these products are undispensed free of charge by the national health system, becoming a significant chronic cost. In our study, compliance to follow-up at 1 year (95.5%) and 2 years (87.2%) resulted much higher than the 30% at 3 years previously reported. When asked, patients found very convenient to perform blood tests and clinical examination free of charge, therefore supporting the economic issue. In our experience, even in a small number of patients, vitamins and mineral deficiencies were found in a pre-clinic setting and, thus, promptly corrected. These aspects must be taken into account when enrolling patients on OAGB. This study experiences some limitations to address. Firstly, the number of patients is relatively limited, especially considering patients with a BMI over 50 kg/m2. Another bias was the presence of a limited mean follow-up time; this does not allow investigations in the long term, considering also the loss of more than 15% to patient follow-up at 2 years. Presumably, the patient drop-out data at follow-up was influenced by the patients' home distance that in more than 50% was over 100 km from the hospital. Thirdly, the lack of GIQLI results in all patients (Table 9). Another not negligible aspect is to have included in the study only patients with bowel length > 600 cm. Certainly, this type of patient is less at risk of developing postoperative malabsorption problems. The exclusion of these patients and the vitamin supplementation protocol (oral and intramuscular) should be taken into account when assessing malabsorption. Another consideration could explain the high drop-out at the UE follow-up. Probably the systematic execution of esophageal and gastric biopsies included in the protocol reduced patients' compliance with that. It would certainly have been better to perform biopsies only in the case of a pathological picture, likely leading to a greater adhesion. The high drop-out at follow-up regarding UE could have been also related to the choice to perform esophageal and gastric biopsies in all patients, considering that biopsies and microscopic examination were not free of charge.

Conclusion

According to this evidence, standardization of BPL length shorter than 200 cm is suggested, potentially minimizing malnutrition-related outcomes. Our study seems to show a BPL of 150–180 cm is safe and effective in terms of %EWL and comorbidity improvement with minimizing malnutrition effects even in BMI > 50. Further evaluations with longer-term follow-up and larger population are advocated to draw conclusive results.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Statement of 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.

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

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This observational monocentric study was conducted in a single hospital from January 2015 to January 2017 after obtaining approval from the institutional review boards and ethical committees. After explaining the study procedure, the techniques, the possible side effects, and outcome which may be favorable, an informed consent was obtained from each participant before surgery.