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ORIGINAL CONTRIBUTIONS

Biliopancreatic Diversion for Severe Obesity: Long-Term Effectiveness and Nutritional Complications

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Abstract
Background Bariatric surgery is currently the treatment of choice for those patients with severe obesity, but the procedure of choice is not clearly established. We describe weight loss and nutritional parameters in severely obese patients after biliopancreatic diversion for 10 years of follow-up.
Methods Patients were followed by the same multidisciplinary team, and data are shown for 10 years. Bariatric Analysis and Reporting Outcome System (BAROS) questionnaire, data regarding the evolution of obesity-related diseases, and nutritional parameters are reported.
Results Two hundred ninety-nine patients underwent biliopancreatic diversion, 76.1 % women, initial BMI 50.1 kg/m^2 (7.2). Weight loss was maintained throughout 10 years with EWL% around 65 % and EBMIL% around 70 %. More than 80 % of the patients showed EWL higher than 50 %. Blood pressure, glucose metabolism, and lipid profile clearly improved after surgery. Mean nutritional parameters remained within the normal range during follow-up. Protein malnutrition affected less than 4 % and anemia up to 16 %. Fat-soluble vitamin levels decreased along the time, with vitamin D deficiency in 61.5 % of patients. No significant differences were found either in nutritional parameters or weight loss regarding gastrectomy or gastric preservation, or common limb length longer or shorter than 55 cm
Conclusions Biliopancreatic diversion is an effective surgical procedure in terms of weight loss, quality of life, and evolution of obesity-related diseases. Nutritional deficiencies are less frequent than feared for a malabsorptive procedure, but must be taken into account, especially for fat-soluble vitamins.

Keywords Severe obesity · Bariatric surgery · Biliopancreatic diversion · Long-term · Nutritional complications

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Introduction

Bariatric surgery is currently the treatment of choice for those patients with severe obesity and acceptable surgical risk; in spite of that, limited food intake and malabsorption may lead to nutritional deficiencies. Biliopancreatic diversion (BPD) is one of the most efficacious surgical procedures for obesity [1], but it is not much widespread because of technical requirements and also the fear of long-term nutritional complications, but not many papers describe results on the long run [2–4]. Our objective is to assess long-term effectiveness and nutritional complications in our series of severely obese patients who underwent BPD.

Patients and Methods

This is a retrospective cohort study in patients who underwent BPD from 1998 to 2013, followed at least for 1 year and up to 15 years. Two additional patients who required reoperation during this period (one for an excessive weight loss and another one for an insufficient weight loss) were excluded from the study. For this type of study formal consent is not required. BPD is the procedure of choice in our hospital as most of our patients are either superobese or suffer from a major metabolic comorbidity such as diabetes.

The procedure consists of creating a 300-cc gastric pouch either by gastrectomy or gastric section and distal gastric preservation (228, 76 %). Whether or not the distal stomach was resected, changed along the time, as gastrectomy was performed for the first 71 cases (24 %) and distal gastric preservation (228, 76 %) for the rest of them. The small bowel transection was performed 250–310 cm proximal to the ileocecal valve, anastomosing the distal ileal section end to the posterior wall of the gastric pouch in a Roux-en-Y fashion with the entero-enteric anastomosis some 50–100 cm proximal to the ileocecal valve. Therefore, we construct three loops: the alimentary loop (200–150 cm), the common loop (50–100 cm), and the biliopancreatic loop, which length will depend on the total bowel length but without absorptive function. The length of the common limb ranged from 50 to 100 cm. During the first years, every patient had a 50-cm common limb. Then, we thought that nutritional complications could have been reduced with a longer limb, so the common limb length was increased to 55 and then to 65 cm in most patients.

Patients were followed by the same multidisciplinary team of endocrinologists, surgeons and dietitian, and data are shown for each yearly visit for 10 years. Patients received dietary assessment and education after surgery and were prescribed a multivitamin-multimineral supplement containing twice the recommended dietary allowances (RDA), following international recommendations [5]. Whenever a patient developed a nutritional deficiency, the appropriate supplement was also prescribed as considered by the responsible endocrinologist.

Weight loss is reported as percentage of excess weight loss (%EWL), percentage of excess of body mass index (BMI) loss (%EBMIL), and percentage of initial BMI loss (%BMIL). Body fat was assessed by TANITA TBF-300A Body Composition Analyzer (TANITA Corporation, Japan). Bariatric surgery was considered successful if patients reached at least 50 % of %EWL [6] and/or patients achieved a BMI lower than 35 kg/m^2 (Table 1). Bariatric Analysis and Reporting Outcome System (BAROS) questionnaire was carried out to assess the efficacy of the bariatric procedure, and scores higher than 3 were considered to have very good or excellent results [7, 8].

Table 1 Percentage of patients completing follow-up in each yearly visit and data regarding weight loss and BAROS

	Before surgery	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years	10 years
Follow-up (% patients)	–	81.6	81.3	80.7	73.5	84.5	83.8	74.1	73.0	67.6	80.9
Number of patients followed/total number of patients	–	244/299	200/246	172/213	136/185	131/155	109/130	80/108	75/89	46/68	34/42
Weight (kg)*	132.3 (21.2)	85.2 (15.7)	83.4 (15.3)	83.4 (13.8)	83.1 (15.7)	84.6 (17.7)	85.1 (17.4)	86.3 (15.8)	85.5 (14.2)	83.4 (14.7)	86.7 (16.3)
BMI (kg/m^2)*	50.1 (7.2)	32.8 (5.5)	32.2 (5.4)	32.5 (4.9)	32.3 (5.2)	32.8 (6.0)	33.2 (6.3)	33.3 (5.9)	33.6 (5.7)	32.8 (6.4)	33.9 (6.3)
Body fat (%)*	48.0 (5.1)	36.1 (7.1)	35.2 (7.6)	36.5 (7.1)	34.6 (11.1)	38.1 (7.6)	39.0 (6.5)	38.2 (7.0)	39.0 (7.8)	39.5 (9.5)	39.9 (8.4)
EWL (%)	–	64.7 (17.6)	67.3 (17.8)	65.6 (16.7)	67.2 (16.8)	65.3 (17.3)	65.3 (17.2)	63.7 (16.9)	62.7 (16.5)	66.1 (20.0)	63.7 (17.5)
%EBMIL	–	70.3 (16.0)	73.2 (17.6)	71.1 (17.0)	73.5 (1.8)	71.4 (19.2)	71.4 (19.0)	69.8 (18.6)	68.9 (18.2)	72.7 (22.8)	69.8 (19.4)
BMIL (%)	–	34.1 (7.1)	35.9 (9.0)	35.1 (9.1)	37.2 (10.2)	36.5 (10.6)	36.9 (10.4)	35.5 (9.8)	35.5 (10.2)	37.2 (11.3)	36.5 (10.6)
% patients EWL >75 %	–	21.4	27.8	22.8	33.3	27.2	27.4	25.0	22.2	26.2	29.0
% patients EWL >50 %	–	83.9	85.6	84.6	89.1	87.6	85.2	82.3	76.6	86.4	80.6
% patients EWL <25	–	0	0.5	0.7	1.0	1.0	0	1.6	0	2.4	3.2
% patients BMI <35	–	74.4	75.5	77.1	75.5	73.2	66.7	72.6	63.8	72.7	68.1
BAROS score	–	6.6 (1.4)	6.7 (1.4)	6.5 (1.6)	6.6 (1.6)	6.5 (1.4)	6.3 (1.6)	6.2 (1.3)	6.1 (1.4)	5.9 (1.5)	6.3 (1.5)
% patients BAROS >3	–	100	98.6	97.2	97.5	98.7	95.1	97.8	97.4	97.4	96.0

*$p<0.001$, ANOVA test found significant changes in data

Data regarding blood pressure, glucose metabolism, lipid profile, uric acid, liver enzymes (alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transpeptidase (GGT)), and C-reactive protein (CRP) are reported as a way to assess the evolution of obesity-related diseases. Hemoglobin (Hb), albumin (Alb), prealbumin (PAB), iron, ferritin, folic acid, vitamin B12, PTH, vitamins A and E, magnesium, and zinc levels were yearly measured. Vitamin E was corrected by serum cholesterol using the method of Thurnham [9], where a vitamin E/cholesterol ratio of <0.024 mcg/mmol (2.22 mcmol/mmol) was taken as the threshold for deficiency [10]. Percentages of patients are shown for deficiencies regarding Hb (<10 g/dL), ferritin (<10 ng/mL), PTH (>100 pg/mL), 25 OH vitamin D (<20 ng/mL), vitamin A (<0.2 mg/L), vitamin E/cholesterol (<0.024 mcg/mmol) (Table 3).

Kolmogorov-Smirnov tests were used to assess the adjustment to a normal distribution, and data are shown as mean (standard deviation) in this case or median (interquartile range (IQR)) if not (glucose, HbA1c, and CRP). ANOVA tests were used to compare data among visits. Data were compared by Student's *t* test regarding technical modifications of BPD (gastrectomy or gastric preservation and length of the common limb higher or lower than 55 cm). A *p* value less than 0.05 was considered as statistically significant difference.

Results

Our series includes 299 patients who underwent biliopancreatic diversion from 1998 to 2013, with a minimum of 1 year of follow-up and a maximum of 15 years, although we report the data for the visits until the tenth year of follow-up. Our patients were mainly women (76.1 %), with a mean age of 43.0 years old (10.7). Regarding comorbidities, 60.8 % had high blood pressure (HBP), 27.1 % high uric acid levels, 34.3 % elevated cholesterol, 41.2 % high triglycerides, 20.3 % sleep apnea syndrome, 36.3 % osteoarthritis, and 23.4 % chronic venous insufficiency. Glucose metabolism was normal only in 25.9 % of the patients, 39.1 % were diagnosed as diabetics, 17.5 % of prediabetes following the American Diabetes Association criteria and 17.5 % were insulin resistant following reported criteria for Spanish population [11].

Although the technical procedure performed for these patients was BPD, in 228 patients (76.3 %), gastric preservation was performed, and the other 71 had the classical biliopancreatic diversion with gastrectomy. The length of the common limb was also different, and measured 50 cm in 49.2 % of the patients and for the other ones was longer than 60 cm (range 60–100 cm).

In Table 1, data of the percentage of patients completing follow-up in each yearly visit and data regarding weight loss and BAROS score are shown. BAROS score classified the surgical procedure as very good or excellent in more than 95 % of the patients. Glucose metabolism parameters are shown in Table 2 for all the patients and also for the subgroup of diabetic patients, showing that levels tended to normalize after surgery and maintained in the normal range for 10 years, and the same happened for blood pressure and lipid profile. We found no significant changes in liver enzymes, and CPR constantly decreased after surgery.

Nutritional deficiencies are shown in Table 3. Mean levels of Hb, iron, ferritin, Alb, PAB, folic acid, vitamin B12, calcium, Mg, and zinc remained within the normal range during follow-up. Protein malnutrition, one of the more feared complications of this surgical procedure, affected less than 4 % of the patients in any visit and anemia less than 16 %. On the other hand, fat-soluble vitamin levels decreased along the time. The percentage of patients showing levels in the range of deficiency was maximum for vitamin D, as 61.5 % of patients developed insufficiency in any of the visit. It should be noticed, however, that 38.3 % of patients presented vitamin D insufficiency before surgery. Vitamin A and E deficiency also increased during follow-up, although only one patient developed clinical symptoms. No significant differences were found either in nutritional parameters or weight loss regarding gastrectomy or gastric preservation, or common limb length longer or shorter than 55 cm.

Discussion

Although bariatric surgery is currently a hot topic, not many papers have reported long-term follow-up [2, 3], and even less is known about BPD [12]. The same team of three surgeons, two endocrinologists, and one dietitian has followed up our patients. We believe that a multidisciplinary approach is the key for achieving the best possible outcomes, especially when malabsorptive procedures are carried out. We have a high dropout rate, although this seems to be the rule in bariatric surgery series reporting long-term results [13]. However, we have been able to follow up nearly 80 % of our patients on the long run, which makes our results consistent enough, from our point of view. Otherwise, we should point out that the number of potential patients is not exactly the same in each visit, as we have included in the study patients with a range of follow-up from 1 to 15 years. We understand that this is one of the main limitations of the present study.

Bariatric surgery has been considered to be successful, regarding weight loss, when patients were able to lose more than 50 % of their excess weight [6]. This happened in more than 85 % of our patients (Table 1), and the most important thing is that the same weight loss was maintained for at least 10 years of follow-up. Mean %EWL was constantly maintained around 65 % from the first to the tenth year and %EBMIL around 70 %, similar results than other series with similar procedures [2, 3]. In the systematic review carried out by Buchwald comparing bariatric

Table 2 Evolution of data related to obesity-related diseases during follow-up

Follow-up	Before surgery	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years	10 years
Glucose (mg/dL) (median, IQR) (NR 70–110)	93.0 (11.5)	82.0 (10.0)	82.0 (9.0)	84.0 (12.5)	81.5 (13.3)	85.0 (5.0)	82.0 (7.5)	83.0 (7.0)	78.0 (10.0)	76.0 (12.3)	86.0 (7.0)
Glucose in diabetic patients (mg/dL)* (median, IQR)	126.0 (47)	80.0 (14.7)	86.0 (16.5)	80.0 (17.0)	81.0 (27.5)	87.5 (2.5)	84.0 (19.5)	87.0 (13.0)	87.0 (55.0)	83.5 (32.8)	93.0 (16.8)
Insulin (mcU/mL) (median, IQR)* (NR 2.6–24.9)	18.3 (14.7)	6.4 (5.3)	4.7 (3.5)	6.6 (4.3)	5.6 (4.5)	4.9 (4.6)	6.7 (6.0)	6.0 (3.4)	6.9 (4.0)	4.8 (0.8)	8.0 (4.2)
Insulin (diabetic patients not in insulin)* (median, IQR)	26.0 (19.3)	8.1 (6.9)	8.2 (4.5)	7.7 (6.8)	6.4 (8.1)	5.5 (7.5)	6.3 (6.4)	6.3 (9.1)	5.7 (3.4)	6.9 (4.9)	5.4 (3.5)
Hb A1c%* (median, IQR) (NR 4.8–5.9)	5.5 (0.7)	5.1 (0.5)	5.0 (0.5)	5.1 (0.5)	5.1 (0.7)	5.2 (0.9)	5.1 (0.5)	5.1 (0.8)	5.0 (0.7)	4.8 (0.8)	5.0 (0.6)
Hb A1c% in diabetic patients* (median, IQR)	6.8 (1.7)	5.1 (0.7)	5.0 (0.9)	5.1 (1.3)	4.8 (1.2)	4.9 (1.5)	5.0 (0.7)	5.1 (0.7)	4.9 (1.0)	5.3 (0.9)	5.1 (0.7)
Systolic blood pressure (mmHg)*	143.0 (20.0)	125.5 (19.0)	127.6 (17.7)	126.9 (17.3)	127.2 (18.7)	126.4 (16.0)	128.5 (20.5)	128.2 (23.6)	130.1 (16.6)	133.3 (18.4)	128.8 (22.8)
Systolic blood pressure in patients HBP (mmHg)*	149.8 (19.7)	131.0 (19.6)	130.7(18.4)	129.7(17.4)	130.9 (19.0)	129.5 (15.3)	131.6 (20.5)	135.1 (17.2)	133.4 (17.7)	137.4 (17.2)	133.6 (22.2)
Diastolic blood pressure (mmHg)*	90.85 (11.8)	74.8 (12.9)	76.2 (12.7)	76.9 (13.3)	78.1 (14.9)	78.6 (10.0)	77.3 (14.7)	79.5 (11.9)	80.4 (11.7)	79.3 (10.3)	75.9 (15.1)
Diastolic blood pressure in patients HBP (mmHg)*	93.1 (11.8)	78.6 (11.0)	78.0 (12.1)	78.3 (14.3)	77.7 (10.8)	80.8 (9.4)	78.1 (15.6)	82.2 (11.0)	82.2 (11.7)	80.3 (9.8)	76.7 (15.3)
Total cholesterol (mg/dL)* (NR <200)	192.4 (36.1)	138.9 (32.9)	142.0 (31.0)	142.8 (30.3)	141.3 (32.8)	142.6 (34.0)	138.8 (28.6)	138.8 (28.6)	137.5 (28.4)	141.1 (24.9)	138.6 (31.1)
Triglycerides (mg/dL)* (NR <150)*	138.7 (69.0)	106.3 (47.1)	102.6 (44.8)	98.1 (68.8)	86.5 (32.6)	95.1 (37.8)	91.8 (36.7)	91.8 (36.7)	86.2 (28.7)	102.0 (60.1)	97.6 (36.7)
HDL cholesterol (mg/dL)* (NR >45)	48.8 (12.0)	46.8 (10.8)	50.2 (12.7)	53.8 (16.3)	54.7 (14.0)	53.3 (15.7)	53.7 (13.7)	53.7 (13.7)	55.4 (16.4)	57.1 (17.6)	58.1 (22.1)
Uric acid (mg/dL) (NR 3.4–7.0)*	6.0 (1.5)	4.4 (1.2)	4.2 (1.1)	4.1 (1.3)	4.1 (1.3)	3.9 (1.1)	4.1 (1.0)	4.1 (1.0)	4.0 (1.0)	4.0 (1.2)	4.4 (1.5)
AST (UI/L)* (NR 10–50)	22.6 (9.0)	22.3 (8.9)	23.1 (8.1)	23.7 (13.3)	20.5 (5.1)	22.5 (7.4)	21.9 (10.2)	21.9 (10.2)	23.4 (11.4)	22.2 (8.3)	27.1 (16.0)
ALT (UI/L)* (NR 0–41)	33.0 (25.7)	26.6 (16.3)	29.8 (30.9)	27.1 (18.2)	21.5 (8.6)	24.1 (11.8)	25.5 (19.0)	25.5 (19.0)	23.6 (12.8)	23.4 (9.8)	26.9 (12.1)
GGT (UI/L)* (NR 10–71)	34.4 (27.6)	27.1 (31.5)	25.3 (39.2)	20.3(26.4)	19.2 (28.0)	17.0 (15.9)	19.3 (22.5)	19.3 (22.5)	15.6 (10.6)	19.7 (17.2)	21.6 (24.2)
C-reactive protein (mg/L) (median, IQR)* (NR 0–5)	6.6 (7.6)	1.0 (3.0)	1.1 (2.7)	0.9 (1.6)	0.95 (3.2)	0.9 (1.9)	1.0 (1.1)	0.9 (2.4)	1.1 (2.9)	1.0 (2.0)	2.1 (3.2)

Normal range (NR) is shown into parentheses

*p<0.001, ANOVA test found significant changes in data

Table 3 Nutritional data in the follow-up

Follow-up	Before surgery	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years	10 years
ALB (g/dL)* (NR 3.5–5.2)	4.3 (0.3)	4.1(0.4)	4.2(0.5)	4.1(0.3)	4.2(0.4)	4.2(0.4)	4.1(0.4)	4.2 (0.5)	4.0 (0.3)	4.1 (0.2)	4.1 (0.3)
% ALB <3 g/dL	0	2.4	2.1	1.1	0	1.2	2.6	1.8	0	2.4	3.4
PAB (mg/dL)* (NR 10–40)	25.0 (5.0)	21.5(5.4)	21.7 (5.4)	21.1 (5.4)	20.2 (4.9)	20.4 (4.8)	19.6 (5.0)	19.2 (4.4)	18.7 (3.8)	22.5 (8.2)	20.3 (4.3)
% PAB <10 g/dL	0	0.7	0	0	1.3	0	1.4	1.9	0	0	0
Hb (g/dL)* (NR 12.2–16.8)	13.9 (1.5)	12.8 (1.4)	12.6 (1.5)	12.4 (1.5)	12.2 (1.7)	12.1 (1.6)	12.2 (12.4)	12.2 (1.6)	11.7 (1.4)	11.9 (2.0)	12.6 (1.3)
% HB <10 g/dL*	1.1	1.3	4.2	2.2	9.9	8.9	7.7	5.5	15.6	11.6	3.2
Fe (μg/dL)* (NR 59–158)	77.5 (28.0)	64.6 (29.1)	62.9 (27.4)	69.6 (59.7)	53.0 (25.2)	49.4 (23.4)	56.7 (26.5)	48.7 (28.0)	58.8 (21.1)	45.5 (25.0)	52.4 (22.5)
Ferritin (ng/mL)* (NR 10–400)	113.4 (114.5)	105.9 (137.6)	98.1 (113.2)	80.0 (90.0)	58.7 (82.7)	37.8 (55.4)	41.2 (56.6)	31.6 (26.3)	56.8 (58.7)	81.4 (91.5)	53.3 (95.3)
% Ferritin <10 ng/mL*	1.8	8.6	13.8	15.3	22.9	21.3	22.8	31.6	20.9	9.5	16.1
PTH (pg/mL) (NR 20–64)*	67.3 (38.5)	84.2 (45.6)	97.4 (45.3)	106.0 (55.9)	123.6 (59.0)	111.0 (54.6)	118.8 (54.6)	116.0(51.2)	118.2 (43.4)	121.2(6.6)	96.1 (48.3)
%PTH >100 pg/mL*	9.6	24.2	35.0	31.8	50.7	46.1	51.5	56.6	50.0	47.7	42.3
Calcium (mg/dL)* (NR 8.2–10.2)	9.3 (0.5)	9.0 (0.5)	9.0 (0.4)	8.8 (0.4)	8.8 (0.5)	8.8 (0.5)	8.8 (0.5)	8.7 (0.6)	8.7 (0.5)	8.7 (0.5)	9 (0.3)
% calcium <8 mg/dL*	0	0	0.7	1.1	6.9	4.8	5.3	5.3	6.8	4.7	3.4
25 OH vit D (ng/mL)*	30.1 (24.2)	30.1 (19.7)	28.2 (18.2)	30.9 (32.8)	22.7 (14.8)	28.7 (26.3)	19.0 (13.8)	17.2 (9.1)	20.3 (10.0)	29.2 (14.2)	20.0 (9.5)
% 25 OH D <20 ng/mL*	38.3	34.8	34.2	47.1	40.6	52.4	61.5	59.1	57.1	46.9	48.1
Vit A (μg/mL) (NR 0.30–1)*	0.54 (0.23)	0.44 (0.35)	0.36 (0.17)	0.32 (0.16)	0.32 (0.15)	0.29 (0.14)	0.28 (0.16)	0.28 (0.16)	0.25 (0.14)	0.30 (0.19)	0.36 (0.32)
% vit A <0.2 μg/mL*	4.8	10.4	17.7	22.1	26.9	31.5	34.4	39.6	30.0	23.7	17.9
Vit E/col (μg/mmol)* (NR >0.0243 μg/mmol)	0.069 (0.019)	0.071 (0.028)	0.064 (0.022)	0.062 (0.015)	0.063 (0.016)	0.057 (0.015)	0.064 (0.060)	0.057 (0.027)	0.047 (0.016)	0.049 (0.019)	0.037 (0.015)
Vit E/col <0.0243 μg/mmol*	0.4	0	1.2	0	0	1.7	4	2.7	10.3	6.7	10.7
Vitamin B12 (pg/mL)* (NR 174–900)	518.0 (249.9)	520.7 (259.0)	515.6 (248.6)	563.2 (336.5)	555.6 (276.0)	539.7 (276.7)	555.8 (295.0)	552.6 (245.5)	524.2 (274.9)	556.3 (291.1)	535.7 (215.9)
% B12 <174 pg/mL*	0	0.6	1.4	1.0	1.3	0	0	0	2.5	0	0
Folic acid (ng/mL)* (NR 2.1–19.9)	8.4 (4.5)	11.1 (4.7)	11.5 (4.5)	11.3 (4.4)	11.1 (6.3)	10.8 (4.7)	11.7 (4.8)	12.3 (4.7)	12.5 (4.9)	13.1 (4.8)	11.4 (5.0)
% folic acid <2.1 ng/mL	0	0	0	0	0	0	0	0	0	0	0
Magnesium (mg/dL)* (NR 1.6–2.6)	2.0 (0.3)	2.0 (0.2)	2.1 (0.2)	2.1 (0.2)	2.1 (0.2)	2.1 (0.2)	2.0 (0.2)	2.0 (0.2)	1.9 (0.2)	1.8 (0.2)	1.9 (0.3)
% Mg <1.6 mg/dL*	1.4	0	0.8	0	0	1.3	0	0	2.4	2.9	3.3
Zinc (mcg/dL)* (NR 68–107)	98.9(30.9)	77.6 (20.8)	75.5 (23.2)	78.1 (28.4)	78.1 (28.4)	78.3 (23.1)	77.9 (24.1)	78.3 (23.5)	67.4 (11.4)	62.4 (25.8)	89.7 (13.9)
% zinc <68 mcg/dL*	4.1	36.2	41.3	37.5	42.9	30.0	32.2	42.9	51.7	51.4	19

Normal range (NR) is shown into parentheses for each determination. Mean/median levels and percentage of patients showing levels in the range of deficiency)

*$p<0.001$, ANOVA test found significant changes in data (reviewer #1, comment #5)

procedures [14], BPD was found to be the most effective technique, with a %EWL of 73 % at 2-year follow-up, followed by gastric bypass (GBP) with 63 % and gastric banding 49 %. Long-term results seem to be better for BPD than for GBP or gastric banding [3]. More than two thirds of our patients achieved a BMI under 35 in our series. Few reports have addressed direct comparison between different procedures long-term. Skroubis et al. [15] designed a prospective randomized trial comparing GBP against BPD. Mean %EWL was significantly higher following BPD (76.89±1.53) as compared to GBP (67.17±1.43), and the percentage of patients who reached %EWL >50 % was also better for BPD (95.85 vs 5.9, p=0.0001). Their results are better than ours, but the dropout rate was much higher in their series, around 40 % in 8 years postoperatively, so perhaps more non-compliant patients with worse weight losses are included in our series and not in theirs.

Weight loss, however, is not the only outcome to address when assessing the success of a bariatric procedure. Metabolic and cardiovascular comorbidities greatly improve after bariatric surgery. Although it is beyond the scope of the present paper to assess remission in such diseases, glucose and HbA1c levels improved in both nondiabetic patients and of course in the diabetes subgroup, and similar results were shown for blood pressure and lipid profile. BAROS score classified the surgical procedure as very good or excellent in more than 95 % of the patients. As this score includes not only weight loss but also quality of life and obesity-related diseases, we could say that surgery has been successful for most patients, in accordance with other reports of BPD [16].

Although nutritional complications are more feared in malabsorptive procedures, such as BPD, our series shows they are as prevalent as reported with other surgical procedures [15, 17]. In the reported series, protein malnutrition ranges from 7.7 to 11.9 %, even 17.8 % when gastric pouch is smaller than 200 cc [18]. In Scopinaro's series, protein malnutrition has been reduced to less than 3 % adapting gastric pouch and the length of the common limb in risk patients [19]. Dietary education carried out by a dietitian in our center, and close follow-up have been important for our low rate of protein malnutrition, around 3 %. In our experience, protein malnutrition is nearly always related to an underlying problem. Our patients developing protein malnutrition were diagnosed either as having an infection of a mesh used to repair an umbilical hernia, intestinal tuberculosis, colon cancer, or lung cancer. Albumin returned to normal levels when the underlying problem was solved. In two other patients, the reason for hypoalbuminemia was a total lack of adherence to nutritional recommendation and required nutritional re-education and protein supplements.

Iron deficiency is also a frequent complication in bariatric surgery [20]. Although low ferritin levels are seen in up to one third of our patients, similar to what has been reported in the literature, severe anemia is infrequent. Vitamin D is deficient, also before surgery [21], and secondary hyperparathyroidism is therefore frequent [22, 23], as reported in our series. Calcium and vitamin D supplements are prescribed already before surgery, but in our experience, the adherence is very low so this deficiency is difficult to overcome.

Fat malabsorption also determines low-fat-soluble vitamin levels [24]. Although we have noticed no relevant clinical consequences, vitamin A levels are low up to nearly 40 % of our patients. Unexpectedly, deficiency was higher after some years, when malabsorption is not as important, perhaps reflecting a lower adherence to supplementation as time goes by. The same thing has been observed for vitamin E, which deficiency, after correction by cholesterol levels, was higher in the last years of follow up and not at the beginning, where malabsorption could be really a problem.

Zinc deficiency was also one of the most prevalent ones in our patients, probably because of its dependence on fat absorption. Although low zinc levels have been reported up to 40–68 % of patients, clinical symptoms are uncommon [25]. On the other hand, levels of vitamin B12 and folic acid maintained in the normal range, and deficiency was infrequent. These deficiencies are more commonly reported after GBP than after BPD, in relation with a smaller gastric pouch [26, 27].

No significant differences were found either in nutritional parameters or weight loss regarding gastrectomy or gastric preservation, or common limb length longer or shorter than 55 cm in our series. Crea et al. [28] neither found any significant difference in weight loss or nutritional deficiencies regarding gastrectomy.

We think that reporting our series is important, as not many papers inform about long-term outcomes and complications. However, our study has some limitations, being the most important one the high dropout rate, although it is frequent in bariatric series [15, 29]. Besides, we do not have a control group, either without surgery or with a different surgical procedure, to understand the magnitude of the nutritional deficiencies or the evolution in those parameters related to major comorbidities, such as glucose metabolism or blood pressure. Regarding nutritional parameters, we did not systematically control the adherence to the supplements prescribed as required, so it is impossible to know if deficiencies could have been solved with the adequate supplementation.

Our results show that BPD requires a close follow-up and multiple vitamin and mineral supplements, especially regarding fat-soluble vitamins, although it is not easy to adjust the amount required to get normal serum concentrations, as other series also found [30]. The risk of deficiencies, however, should be taken into account whichever the bariatric procedure is.

Conflict of Interest Ballesteros-Pomar MD, González de Francisco T, Urioste-Fondo A, González-Herraez L, Calleja-Fernández A, Vidal-Casariego A, Simó-Fernández V, and Cano-Rodríguez I declare no conflict of interest. For this type of study formal consent is not required

References

1. Buchwald H, Estok R, Fahrbach K, et al. Weight and type 2 diabetes after bariatric surgery: systematic review and meta-analysis. Am J Med. 2009;122(3):248–56. doi:10.1016/j.amjmed.2008.09.041.
2. Topart P, Becouarn G, Salle A. Five-year follow-up after biliopancreatic diversion with duodenal switch. Surg Obes Relat Dis. 2011;7(2):199–205.
3. Gracia JA, Martínez M, Elia M, et al. Obesity surgery results depending on technique performed: long-term outcome. Obes Surg. 2009;19(4):432–8. doi:10.1007/s11695-008-9762-x.
4. Skroubis G, Kouri N, Mead N, et al. Long-term results of a prospective comparison of Roux-en-Y gastric bypass versus a variant of biliopancreatic diversion in a non-superobese population (BMI 35-50 kg/m(2)). Obes Surg. 2014;24(2):197–204. doi:10.1007/s11695-013-1081-1.
5. Mechanick JI, Youdim A, Jones DB, et al. American Association of Clinical Endocrinologists; Obesity Society, American Society for Metabolic & Bariatric Surgery. Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient—2013 update: cosponsored by American Association of Clinical Endocrinologists, The Obesity Society, and American Society for Metabolic & Bariatric Surgery. Obesity (Silver Spring). 2013;21 Suppl 1:S1–27. doi:10.1002/oby.20461.
6. Mann JP, Jakes AD, Hayden JD et al. Systematic review of definitions of failure in revisional bariatric surgery. Obes Surg. 2014.
7. Oria HE, Moorehead MK. Bariatric Analysis and Reporting Outcome System (BAROS). Obes Surg. 1998;8:487–99.
8. Moorehead MK, Ardelt-Gattinger E, Lechner H, et al. The validation of the Moorehead–Ardelt–Gattinger quality of life questionnaire II. Obes Surg. 2003;13:684–92.
9. Thumham DI, Davies JA, Crump BJ, et al. The use 01 different lipids to express serum tocopherol:lipid ratios for the measurement of vitamin E status. Ann Clin Biochem. 1986;23:514–20.
10. Ford L, Farr J, Morris P, et al. The value of measuring serum cholesterol-adjusted vitamin E in routine practice. Ann Clin Biochem. 2006;43:130–4.
11. Ascaso JF, Romero P, Real JT, et al. Insulin resistance quantification by fasting insulin plasma values and HOMA index in a non-diabetic population. Med Clin (Barc). 2001;117(14):530–3.
12. Marceau P, Biron S, Hould FS, et al. Duodenal switch: long-term results. Obes Surg. 2007;17(11):1421–30.
13. Moroshko I, Brennan L, O'Brien P. Predictors of attrition in bariatric after care: a systematic review of the literature. Obes Surg. 2012;22(10):1640–7. doi:10.1007/s11695-012-0691-3.
14. Buchwald H, Estok R, Fahrbach K, et al. Weight and type 2 diabetes after bariatric surgery: systematic review and meta-analysis. Am J Med. 2009;122(3):248-256.e5. doi:10.1016/j.amjmed.2008.09.041.
15. Skroubis G, Kouri N, Mead N, et al. Long-term results of a prospective comparison of Roux-en-Y gastric bypass versus a variant of biliopancreatic diversion in a non-superobese population (BMI 35-50 kg/m(2)). Obes Surg. 2014;24(2):197–204. doi:10.1007/s11695-013-1081-1.
16. Marinari GM, Murelli F, Camerini G, et al. A 15-year evaluation of biliopancreatic diversion according to the Bariatric Analysis Reporting Outcome System (BAROS). Obes Surg. 2004;14:325–8.
17. Dalcanale L, Oliveira CP, Faintuch J, et al. Long-term nutritional outcome after gastric bypass. Obes Surg. 2010;20(2):181–7. doi:10.1007/s11695-009-9916-5.
18. Mason EE, Hesson WW. Informed consent for obesity surgery. Obes Surg. 1998;8:419–28.
19. Scopinaro N. Thirty-five years of biliopancreatic diversion: notes on gastrointestinal physiology to complete the published information useful for a better understanding and clinical use of the operation. Obes Surg. 2012;22(3):427–32. doi:10.1007/s11695-011-0554-3.
20. Avinoah E, Ovnat A, Charuzi I. Nutritional status years after Roux-En-Y gastric bypass surgery. Surgery. 1992;111:137–42.
21. Buffington C, Walker B, Cowan Jr GS, et al. Vitamin D deficiency in the morbidly obese. Obes Surg. 1993;3:421–4.
22. Chapin BL, LeMar HJ, Knodel DH, et al. Secondary hyperparathyroidism following biliopancreatic diversion. Arch Surg. 1996;131:1048–52.
23. Marceau P, Hould FS, Simard S, et al. Biliopancreatic diversion with duodenal switch. World J Surg. 1998;22:947–54.
24. Alvarez-Leite JI. Nutrient deficiencies secondary to bariatric surgery. Curr Opin Clin Nutr Metab Care. 2004;7:569–75.
25. Vazquez C, Morejon E, Muñoz C, et al. Repercusión nutricional de la cirugía bariátrica segúntécnica de Scopinaro: análisis de 40 casos. Nutr Hosp. 2003;18:189–93.
26. Berger JR. The neurological complications of bariatric surgery. Arch Neurol. 2004;61:1185–9.
27. Brolin RE, Gorman JH, Gorman RC, et al. Are vitamin B12 and folate deficiencies clinically important after Roux-en-Y gastric bypass? J Gastrointest Surg. 1998;2:436–42.
28. Crea N, Pata G, Di Betta E, et al. Long-term results of biliopancreatic diversion with or without gastric preservation for morbid obesity. Obes Surg. 2011;21(2):139–45. doi:10.1007/s11695-010-0333-6.
29. Vidal P, Ramón JM, Goday A, et al. Lack of adherence to follow-up visits after bariatric surgery: reasons and outcome. Obes Surg. 2014;24(2):179–83. doi:10.1007/s11695-013-1094-9.
30. Topart P, Becouarn G, Sallé A, et al. Biliopancreatic diversion requires multiple vitamin and micronutrient adjustments within 2 years of surgery. Surg Obes Relat Dis. 2014. doi:10.1016/j.soard.2014.02.007.