

## **Long Term Results and Protein Caloric Malnutrition in Morbid Obesity Patients Underwent Biliopancreatic Diversion with Duodenal Switch**

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### **Abstract**

The aim of this study is to evaluate the body weight loss, malnutritional condition and resolution of type 2 diabetes mellitus (T2DM), arterial hypertension (AH), obstructive sleep apnea syndrome (OSAS), dyslipidemia, and arthropathy among patients with morbid obesity, who underwent Biliopancreatic Diversion with Duodenal Switch in different common channel.

This retrospective study follows 141 patients, underwent BPDDS between January, 2003 and June, 2012 in University Hospital Center - Albacete.

We report % excessive weight loss (% EWL) 67,6% on the 6<sup>th</sup> postoperative year and stay stable until the ninth year. Resolving of T2DM in 81.2% and AH in 71.9% of the patients. 95% of the patients with OSAS improved after the first year and they stayed stable on the 6<sup>th</sup> year postoperatively. The resolution of hypercholesterolemia and hypertriglyceridemia was observed in 100% and 93.6% of the patients respectively.

Arthropathy of lower extremities major joints was not greatly improved after bariatric surgery.

**Keywords:** Protein Caloric Malnutrition (PCM); Obesity; Biliopancreatic Diversion; Duodenal Switch

### **Introduction**

Biliopancreatic Diversion with Duodenal Switch (BPDDS) is an improved version of the initial Biliopancreatic Diversion - Scopinaro type (BPDSC). In order to improve the restrictive part and preserve gastric function, distal gastrectomy is replaced by sleeve gastrectomy, and bowel bypass is preserved as in the classic operation (malabsorptive part). These two aspects of BPDDS are not standardized for all bariatric centers [1]. Because food bypasses the proximal intestine and directly reaches the distal intestine, the intestinal hormone secretions are altered, which in turn contributes to treating diabetes and obesity [2,3]. According to literature BPD-DS is known to lead to excellent long term weight loss results as well as to high resolution rates of obesity related diseases. The goal of the present study is to evaluate the resolution of type 2 diabetes mellitus (T2DM), arterial hypertension (AH), obstructive sleep apnea syndrome, dyslipidemia, and arthropathy of major joints of the lower extremities, among patients with morbid obesity, who underwent BPD DS with different common channel lengths.

**Materials and Methods**

**Patients and Data Collection**

Between January, 2003 and June, 2012 in University Hospital Center of Albacete 141 patients with morbid obesity underwent biliopancreatic diversion with duodenal switch (BPDDS). Indications for surgery were a body mass index (BMI)  $\geq 40$  or a BMI  $\geq 35$  with obesity related comorbidities. The patients were separated in groups by four factors: common channel (CC) length, gender, age and preoperative BMI.

	<b>N</b>	<b>Mean</b>	<b>Range</b>
<b>Sex</b>			
• Male	40 (28.4%)		
• Female	101 (71.6)		
<b>Age groups</b>	141	41.8	21-60
• < 25y	6		
• 26 - 45y	82		
• 45 - 65y	53		
Weight		139.13	100 - 193 kg
Height		163.2	141 - 192 cm
<b>Body Mass Index (BMI)</b>		51.91 kg/m <sup>2</sup>	41.6 - 75.1 kg/m <sup>2</sup>
• 40 - 60 kg/m <sup>2</sup>	98 (69.5%)		
• > 60 kg/m <sup>2</sup>	43 (30.5%)		
<b>Length of the common channel</b>		BMI	BMI
• 50 cm common channel	34 (24.1%)	53 kg/m <sup>2</sup>	41.6 - 75.1 kg/m <sup>2</sup>
• 75 cm common channel	51 (36.2%)	53.9 kg/m <sup>2</sup>	43.6 - 70.5 kg/m <sup>2</sup>
• 100 cm common channel	56 (39.7%)	50 kg/m <sup>2</sup>	42.1 - 62.2 kg/m <sup>2</sup>
Hospital stay		10.2 days	7-41
Operative time		4:04h	2:20h - 7:00h

**Table 1:** Main features of studied group.

Preoperatively as major comorbidities were defined diabetes, arterial hypertension, syndrome of obstructive sleep apnea, arthropathy of major joints of lower extremities, and dyslipidemia. A comorbidity is considered resolved when the symptoms disappear entirely, there is a lack of objective laboratory or imaging indications of the disease, or there is no need for medication. Improvement is considered when there is a reduction in the dose or number of medicaments used for treatment.

Type 2 Diabetes Mellitus (T2DM) was defined as serum glucose levels above 126 mg/dl or independently of the glucose levels if the patient had an antidiabetic therapy. The diabetes status was subdivided into controlled by diet, per oral therapy, or insulin therapy. Remission of the diabetes was accepted if the serum glucose level was < 126 mg/dl and HbA1c < 6.5% without medical treatment [4,5]. Duration of the diabetes mellitus was between 1.5 - 11 years; 5.3 year on average. One patient developed T2DM while was in the waiting list.

Arterial hypertension was defined as blood pressure levels > 140/80 mmHg or regardless of the blood pressure if the patient was prescribed antihypertensive therapy. Hypertension was divided into hypertension without medication, treated with 1 drug, and treated with 2 or more drugs. Hypertension requiring 2 or more drugs was defined as a severe form of hypertension. Remission of arterial hypertension (AH) was defined as blood pressure levels < 140/90 without medication. For improvement of AH was considered a reduction in the dose or number of medications used for treatment [5].

The syndrome of obstructive sleep apnea (SOSA) is defined as a disease, which leads to somnolence, neuropsychological, and cardiorespiratory disorders as a result of anatomophysiological changes in the upper respiratory tract. To diagnose SOSA, Apnea Hypopnea Index (AHI) was applied. SOSA was defined in all cases where AHI was > 5, and classified:

- **Mild:** AHI = 5 - 14.9
- **Moderate:** AHI = 15 - 30
- **Severe:** AHI > 30

Indication for using a night time device for continuous positive air pressure (CPAP) was:

1. AHI > 30 (severe) "absolute indication"
2. AHI between 5-30 with Epworth sleepiness scale  $\geq$  12 and/or symptoms due to cardiovascular disease and the symptoms did not resolve by other treatment (proper evaluation of each patient).

After the surgery polysomnography was routinely done and CPAP was suspended if the levels of AHI were < 30 and there was improvement of the patients' symptoms.

All patients with arthropathy of lower extremities major joints had prominent clinical symptoms and radiographic diagnosis, proving the condition.

To define dyslipidemia were considered the criteria of International Diabetes Federation (IDF) as follows: triglyceride levels > 1.7 mmol/l, HDL cholesterol < 1.0 mmol/l in men and < 1.3 mmol/l in women. Resolution of dyslipidemia was defined as levels of low-density lipoprotein (LDL) < 2.6 mmol/l and triglyceride levels < 1.7 mmol/l without medication [5].

The CC length was empirically set to be 50, 75 or 100 cm without taking into consideration the total intestinal length. The different lengths were used in three chronological periods of time: January 2003 - October 2004, October 2004 - August 2006, and February 2006 - June 2012 for the three groups respectively. The size of the sleeve was calibrated using a gastric tube of 34 French. The small intestine was divided 250 - 300 cm proximally of the ileocecal valve depending on the length of the CC, leaving approximately 200 cm (175 - 225 cm) digestive loop.

128 patients were operated conventionally with transversal supraumbilical laparotomy. 13 patients underwent laparoscopic BPD DS. All laparoscopically operated patients had a CC of 100 cm. The average blood loss in all cases was estimated to be 50 - 100 ml. Four surgeons performed the operations.

In the postoperative period, according to guidelines, all patients were followed up by endocrinologist and surgeon and received dietary support including multivitamins, minerals, calcium, vitamin D<sub>3</sub>, vitamin A, zinc, folic acid and iron if necessary, starting supplementing therapy before discharge of the hospital. Afterward the visits were scheduled every month in the first 3 months, every three months until the first year, every 6 months from the first to the third year, and afterward once annually [6]. Each visit included the following laboratory tests: hemogram, biochemistry, albumin, total protein, liver function, ionogram: sodium, potassium, calcium, magnesium, copper, zinc. Levels of Vit A, Vit B<sub>1</sub>, Vit E, Vit D (25(OH)D), Vit B<sub>12</sub>, Folic Acid, parathyroid hormone were measured, and supplementation was adjusted [7].

15 patients were lost to follow-up on average on the fourth year. The average follow-up of all operated patients was 6 years (range 1 - 9 years).

### Statistical analysis

Statistical analysis was done using IBM SPSS 21 Statistics program. All "p" values were two-sided, and values under 0.05 were considered statistically significant. Pearson chi-squared and Fisher exact tests were used to compare categorical variables, ANOVA and Student t test - for continuous variables, and linear mixed model - to compare nutritional deficiencies between groups.

### Results

Surgical complications were observed in 18 patients (12.8%), and surgical treatment was necessary in 13 of them (9.2%). In early postoperative period surgical complications were recorded in 7 patients. Intestinal fistulas caused by an anastomotic leakage was presented in three patients (2.1%). In one of them the leakage was from the stomach remnant, resulting in subphrenic abscess managed by relaparotomy. The other 2 patients presented low output small intestinal fistulas and did not require surgical intervention. Those patients were managed by total parenteral nutrition (TPN). Intraabdominal abscess was recorded in 2 patients (1.4%). In both of them the abscess were resolved using percutaneous drainage and antibiotic treatment. Two patients (1.4%) developed hemoperitoneum in the early postoperative period and required relaparotomy.

In late postoperative period surgical complications were recorded in 11 patients: Bowel obstruction was observed in 8 patients (5.7%). In 5 patients small intestine resection was done because of small intestinal volvulus (3 pts), intestinal breach (1 pts), and incarcerated postoperative ventral hernia (POVH) (1 pts). In two patients internal hernia of the biliopancreatic loop occurred without necrosis of the intestine. One patient resolved the bowel obstruction with conservative treatment.

In three patients (2.13%) postoperatively a severe form of GERD was recorded with failure of conservative control, and further surgical correction was done. All patients underwent crural diaphragmatic closure as primary operation. Afterwards in two of them because of ongoing chronic GERD symptoms a horizontal gastrectomy with removal of gastric antrum was performed with excellent clinical result.

POVH was found in 19 patients (13.5%). Infection of the operative wound developed in 12 patients (8.57%). There was a strong, statistically significant correlation between infection of the operative wound and POVH ( $p < 0.001$ ).

Protein caloric malnutrition (PCM) were observed in 7 patients (4.96%): six females and one male aged between 27 and 55 years (on average 47 years). Four of these patients belonged to the 75 cm and three patients - to the 100 cm CC group. Six patients (4.26%) required surgical adjustment of the CC. In 5 of them an extension of the CC at the expense of the biliopancreatic loop was performed. In one patient (100 cm CC) initially revision of CC was done, but later because of ongoing symptoms of PCM, a reversal of gastrointestinal tract was carried out. However, no PCM was seen in the patients with 50 cm CC, which is in disagreement with results from literature. In only one (75 cm CC) out of seven patients, the disorder was resolved by TPN without surgery.

Patients with PCM can be divided in two groups. The first one consists of three patients with severe body weight loss and signs of cachexia. The mean BMI of these patients prior to surgery for malnutrition was 21.66 kg/m<sup>2</sup> (19,57 - 21,94 kg/m<sup>2</sup>), average % Excessive Body Weight Loss (% EBWL) - 106,87% (100,7% - 114,5%) and average % Excessive BMI Loss (% EBMIL) - 116,47% ranging between 107% - 129,5%.

The other 4 patients (second group) had a moderate loss of body weight, but a severe deviation of biochemistry, deterioration of their general condition, combined with generalized edema was recorded. Average BMI in this group prior to surgery for malnutrition was 29 kg/m<sup>2</sup> (29.19-32.84), EWL% - 79.8% (69.8% - 85.7%) and EBMIL% - 87% (75.8% - 95%). From laboratory, remarkable hypoalbuminemia

and hypoproteinemia was seen. The serum albumin ranged from 1.7 to 1.9 mg%. Average total protein was 4.9 mg% (4.4 mg% - 5.2 mg%). Anemia was reported in all patients with PCM (Hb 8.7 - 10.2 mg%), hypoglycemia - in 5, low cholesterol - in 5, and low triglycerides - in 4 patients.

Postoperative mortality rate was 2.24% (3 patients). In early postoperative period, one patient died because of rhabdomyolysis and malignant hyperthermia. The second patient deceased on the sixth postoperative month, because of duodenal perforation and septic shock. The third one ended lethally in the sixth year after the bariatric intervention because of cirrhosis, and liver insufficiency.

Time -years	Initial	3 m	6 m	1 y	2 y	3 y	4 y	5 y	6 y	7 y	8 y	9 y
Body weight	139,1	114,3	98,4	82,6	77,6	79,9	81,9	83,1	85,3	86,2	86,5	89,4
%Excess Weight Loss		32%	52,6%	72,8%	78,9%	75,7%	72%	70,1%	67,6%	66,8%	65,1%	64,4%
BMI	51,9	42,6	36,7	30,7	28,8	29,7	30,7	31,3	32,1	32,5	31,7	29,0
% Excess BMI Loss		34,8%	57,1%	79,1%	85,6%	82,2%	78,1%	78%	73%	71,9%	70,4%	70,7%
% Expected BMI		44,7%	73,4%	101,7%	110,1%	105,8%	100,6%	98%	94,5%	93,5%	90,9%	90,4%

Table 2: Body weight loss.

Table 2 shows that excessive weight loss and excessive BMI loss on the 6th postoperative month was more than 50%. The biggest weight loss was observed on the second year: EWL-78.9% and EBML-85.6% (Figure 1). Eventually, these indexes showed a tendency to drop in time, but they stayed stable over 50%, and on the ninth year reached 64.4% of EWL and 70.7% of EBML. Average body mass and BMI were also at their lowest on the second year: 77.5 kg and 28.8 kg/m<sup>2</sup> respectively, after which they rose, so that on the ninth year they reached 89.4 kg and 29 kg/m<sup>2</sup> respectively. Baltasar’s EBMI was 101.7% on the first year, remained over 100% till the fourth year, and also peaked on the second year at 110.1%. On the ninth year the EBMI was 90.4%.

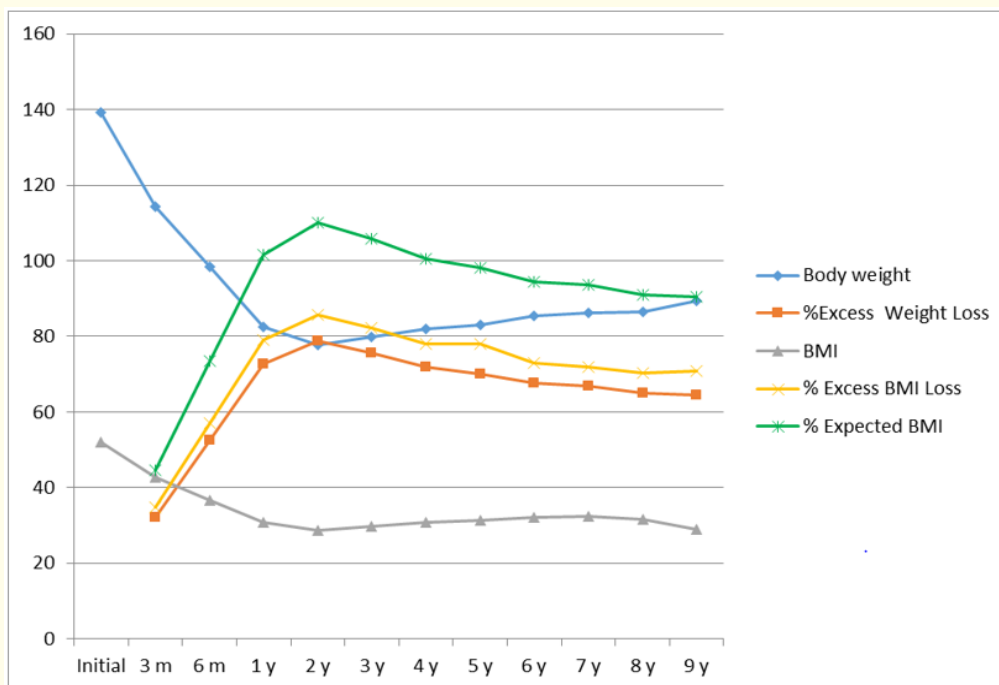


Figure 1: Body weight loss (Data in table 2).

On table 3 are shown chronologically evolution of diabetes, arterial hypertension, SOSA, arthropathy of major lower limb joints, and dyslipidemia, which were traced preoperatively, on 3<sup>rd</sup> month, 6<sup>th</sup> month, and annually from 1<sup>st</sup> to 9<sup>th</sup> year postoperatively.

	Initial (n = 141)	3m (n = 140)	6m (n = 140)	1y (n = 140)	2y (n = 137)	3y (n = 128)	4y (n = 114)	5y (n = 104)	6y (n = 91)	7y (n = 60)	8y (n = 32)	9y (n = 13)
DM2	19.1%	15%	6.4%	2.9%	3.7%	3.9%	3.5%	2.9%	3.6%	3.3%	6.3%	0%
AH	66.7%	52.9%	37.8%	18.7%	12.4%	13.3%	15.4%	15.4%	18.8%	19.7%	17.6%	23.1%
SOSA	78%	59.3%	31.4%	18.1%	6.6%	3.1%	1.7%	1.9%	2.4%	2.6%	0%	0%
Arthrop.	28.2%	28.1%	25.7%	14.4%	11.2%	13.4%	15.8%	15.5%	20.7%	23.7%	21.9%	21.7%
Chol	35.5%	2.1%	0.71%	0%	0%	0.78%	0%	1.90%	0%	0%	0%	0%
TG	38%	10.70%	2.90%	1.43%	1.47%	1.56%	1.72%	1%	2.45%	3.30%	6.30%	0%

Table 3: Evolution of obesity major comorbidities after BPD-DS.

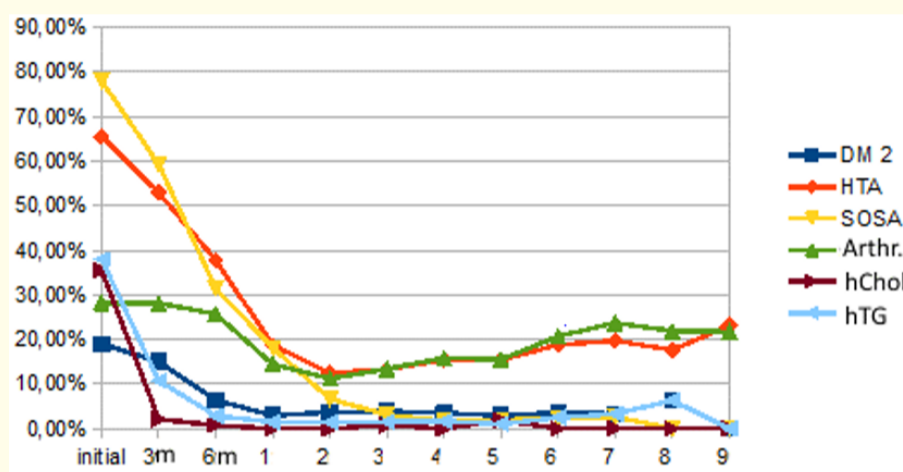


Figure 2: Evolution of obesity major comorbidities after BPD DS.

Resolution of T2DM was 79.6% on the 3<sup>rd</sup>, 81.2% on the 6<sup>th</sup> and 69.6% on the 8<sup>th</sup> year. Preoperatively we found a statistically significant difference in the rate of T2DM in the groups by age (p = 0.001), which shows that in older patients frequency of T2DM increases; in the 46 to 65 years group it reached 70%. There was also a statistically significant difference between the gender groups (p = 0.009), having distribution 4 men to 23 women with T2DM. Such statistically significant difference between the BMI groups was not to be found (p = 0.736).

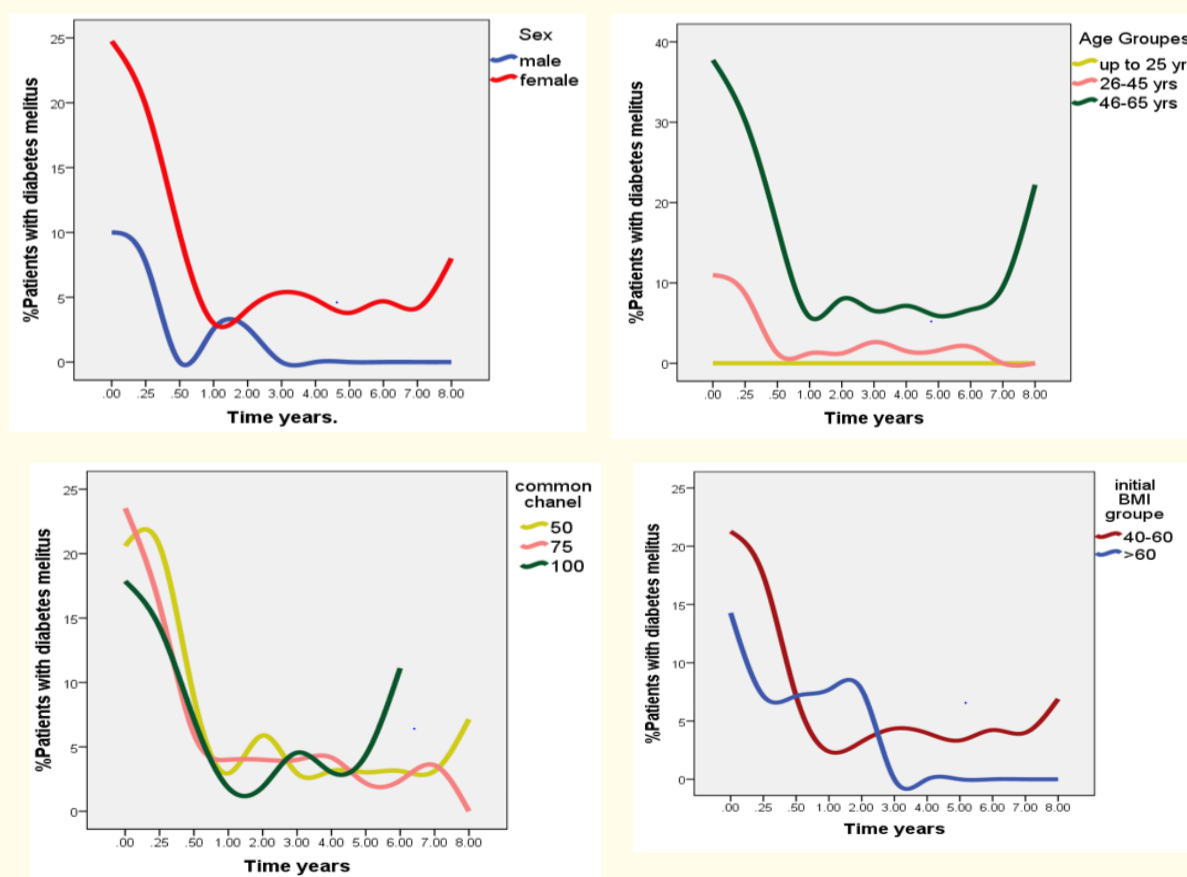


Figure 3: Evolution of T2DM in groups by age, gender, initial BMI, and common channel length.

After the operation there was not statistically significant difference in resolution of T2DM on the 6<sup>th</sup> year between the groups by age ( $p = 0.531$ ), gender ( $p = 0.694$ ), initial BMI ( $p = 0.536$ ) and common channel length ( $p = 0.727$ ). Therefore this pathology was equally influenced regardless of initial body weight, age, gender, and common channel length.

Arterial hypertension (AH) was observed in 93 patients (66.7%) before the bariatric intervention: 92 (65.9%) had mild or moderate form and 1 patient (0.71%) had a severe form of AH (antihypertensive therapy of more than 2 drugs). In half of the patients without improvement congenital form of AH was found. There was a 71.9% resolution of AH on the 6<sup>th</sup> year and 73.2% resolution of AH on the 8<sup>th</sup> year of the follow-up.

		Age group			Total
		Below 25 y	26 - 45 y	46 - 65 y	
AH	No AH	6	33	9	48
	AH	0	48	44	92
	Severe form of AH	0	1	0	1
Total		6	82	53	141

Table 4: Distribution of patients with AH by age.

There was no statistically significant correlation in resolution of AH postoperatively between the groups by age ( $p = 0.593$ ), gender ( $p = 0.964$ ) and initial BMI ( $p = 0.827$ ).

According to Kaplan-Mayer’s graphic (survival function), AH resolved the fastest in half of the patients in the 100 cm common channel group (on average 2 years and 4 months), next is the 75 cm group - 3 years and 6 months, and then the 50 cm group - 4 years and 7 months with a statistically significant difference ( $p < 0.001$ ).

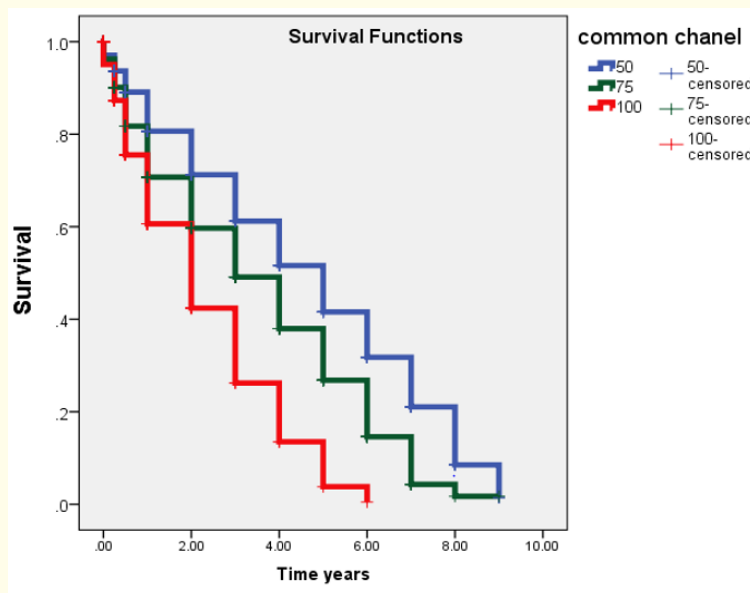


Figure 4: Evolution of arterial hypertension in the common channel group – survival function.



SOSA was observed in 78% of the patients in the beginning of the study with necessary night-time oxygen supply with a CPAP device. From them 29.2% had a mild form, 34.3% - moderate form, and 14.6% - severe form of SOSA. The resolution of this comorbidity was as follows: 97,8% on the 4<sup>th</sup>, 96.9% on the 6<sup>th</sup> and 100% resolution on the 8<sup>th</sup> year respectively.

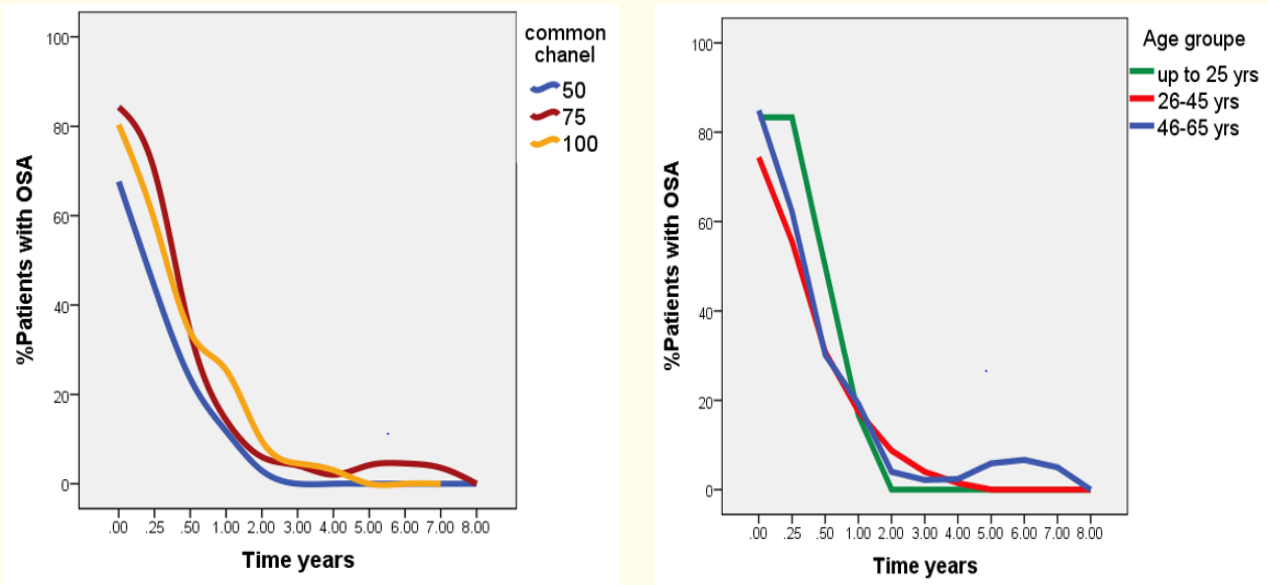


Figure 5: Evolution of SOSA in groups by common channel length and age.

There was no statistically significant difference in the resolution of SOSA on the 6<sup>th</sup> year of follow-up (n = 91) in the groups by age (p = 0.45), gender (p = 0.741), initial BMI (p = 0.06), and CC (p = 0.761). Therefore this pathology was also equally well treated by the bariatric intervention regardless of initial body weight, age, gender, and common channel length.

Arthropathy of lower extremities major joints was one of the diseases, which was hardest to influence by the bariatric intervention. Improvement of the symptoms was observed only in 26.6% on the 6<sup>th</sup> and 22.1% the 8<sup>th</sup> year respectively. After the bariatric surgery 2 patients underwent bilateral, 2 pts - unilateral knee arthroplasty, and 1 pt - hip arthroplasty. The arthroplasty was done on average on the 6<sup>th</sup> postoperative year. We found a strong, statistically significant correlation between initial rates of arthropathy and age groups (p = 0.002).

A statistically significant difference in evolution of arthropathy in groups by gender (p = 0.925) and initial BMI (p = 0.996) was not found. There was no such correlation in the different age groups (p = 0.998), but the tendency for a difference in the initial arthropathy rates between the age groups remained postoperatively (p < 0.001).



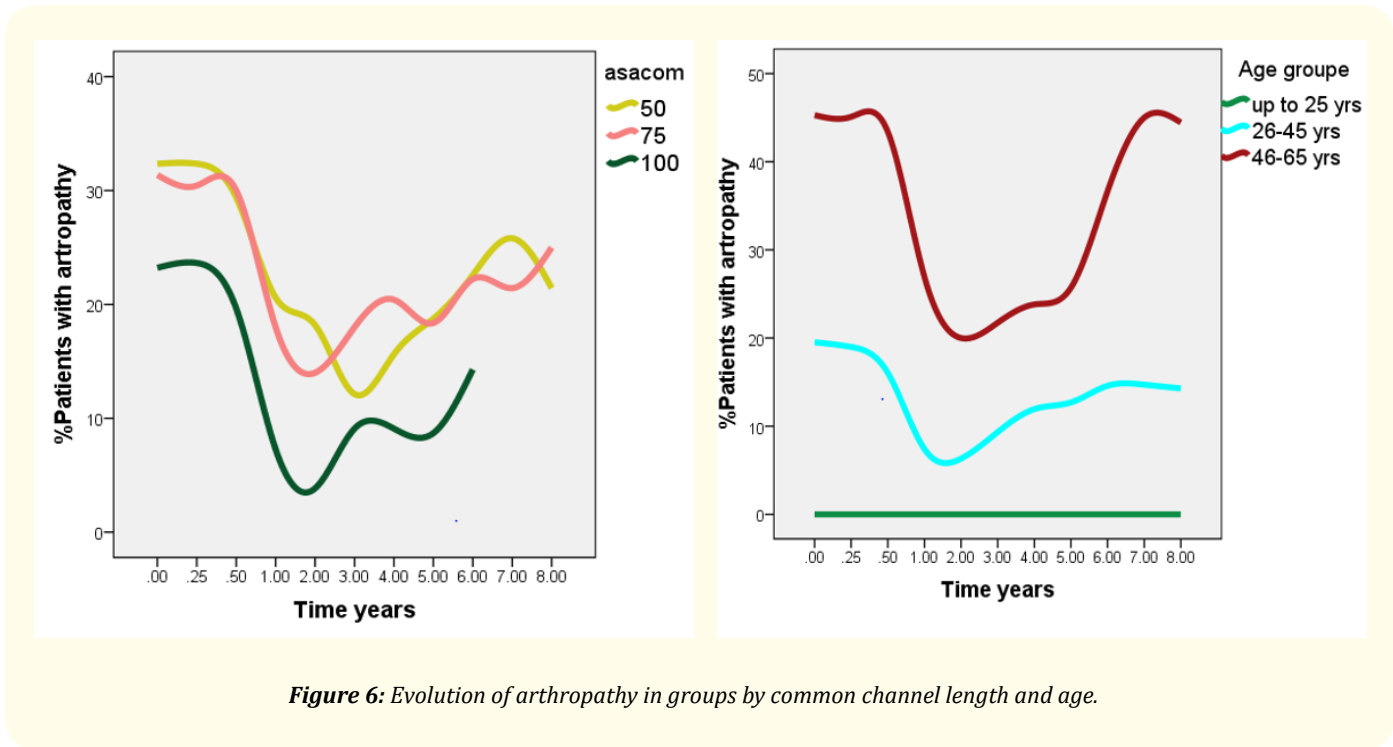


Figure 6: Evolution of arthropathy in groups by common channel length and age.

High serum cholesterol levels was one of the metabolic disorders, which was best influenced by the bariatric intervention. We can conclude that there was a 100% resolution of this metabolic disorder on the 6<sup>th</sup> year, which has a significant effect on cardiovascular diseases and a substantial social importance. There was a statistically significant difference in hypercholesterolemia between the age groups, which indicated that the highest rate of this disorder was in the 45 - 65 year group.

Hypertriglyceridemia was another metabolic disorder, on which BPD-DS had an excellent effect. On the 6<sup>th</sup> year 93,6% resolution of hypertriglyceridemia was accounted. There was no statistically significant difference in the resolution of this disorder between the groups by gender ( $p = 0.849$ ), initial BMI ( $p = 0.410$ ), age ( $p = 0.191$ ), and common channel length ( $p = 0.923$ ).

## Discussion

Chronologically, in the 'length of common channel' group statistically significant correlation between body weight loss and the length of the common channel was not found ( $p = 0.752$ ). Neither in the age  $p = 0.947$  nor in the gender group ( $p = 0.933$ ) was such correlation discovered. Solely in the group by initial BMI there was a statistically significant difference in the bodyweight loss in time. Patients with higher initial BMI lost less body weight and lost it more slowly in time.

Every patient with morbid obesity could be considered ill because of comorbidities, which lead to a significant rise in mortality rate and to a deteriorated quality of life. In our study group 95% initially had one, and 79.5% of the patients had more than one major comorbidity. There was a direct correlation between body weight loss after the operation and improvement or resolution of most of comorbidities. In the 1<sup>st</sup> and 2<sup>nd</sup> years after the intervention when the loss of body weight was fastest and greatest a significant drop of comorbidities rates was found [8].

The results of our study confirmed the good resolution of T2DM, declared in other major clinical trials like Buchwald's meta-analysis [9,10]. We accounted for 81.2% resolution of T2DM on the 6<sup>th</sup> and 69.6% on the 8<sup>th</sup> year after the operation. There was no difference between the different CC groups ( $p = 0.727$ ). Furthermore, these excellent results were observed very early in the postoperative period, in some patients even during their hospital stay, when practically the body weight loss was minimal. Rubino considers that the reason for that is bypassing the bowel transit from the duodenum, which improves glucose tolerance by decreasing the secretion of a so-called anti-incretin factor [11].

Different authors report remission of arterial hypertension in patients, operated with BPDDS even during hospital stay and lowering blood pressure levels in normotonic patients [12]. They explain this fact with the exclusion of proximal jejunum from bowel transit, the stimulation of ileum, and the improvement of dyslipidemia after a few weeks [13,14].

Our clinical research confirmed the good results of this type of surgical techniques in their effect on arterial hypertension and its maintain for a long time postoperatively (73.2% resolution on the 8<sup>th</sup> year). A possible explanation for that is bypassing a major part of the small intestine and stimulating gut hormones that most likely have an effect of blood pressure [15].

According to the Swedish Obese Subjects study in patients with restrictive bariatric procedure the rate of new cases of hypertension rises with time and 10 years after the operation reaches average levels of general society despite the maintained significant body weight loss [16]. On the other hand with malabsorptive bariatric techniques the new cases of AH is much lower than the average for the society, and this tendency is preserved after 10 and even after 25 years [17,18]. Only in this disorder we found difference in resolution between different length of CC. AH resolved the fastest in half of the patients in the 100 cm common channel group (on average 2 years and 4 months), with a statistically significant difference ( $p < 0.001$ ).

SOSA is a disease that was profoundly improved by BPDDS in our study group with 97% resolution on the 6<sup>th</sup> and 100% on the 8<sup>th</sup> year. The fastest resolution of this comorbidity was observed in the first 6 months, when the body weight loss was most intensive. Thus, we can conclude that SOSA was directly related to obesity and after losing weight this pathology disappeared. This tendency could be explained with the decreased oropharyngeal adipose tissue and reduced pressure on the muscles, keeping open the upper respiratory tract [19]. There was no statistically significant difference in the resolution of SOSA on the 6<sup>th</sup> year of follow-up ( $n = 91$ ) between the different CC length groups ( $p = 0.761$ ).

In view of dyslipidemia, preoperatively there was a statistically significant difference in the rate of hypercholesterolemia in the group by age ( $p = 0.018$ ), which means levels of cholesterol and triglycerides increased with age. Dyslipidemia is one of the comorbidities that was also greatly improved by BPDDS [9]. This fact is explained with malabsorption of fat in distal ileum. Duodenal switch leads to universal reduction in levels of cholesterol and triglycerides, which was proven by several clinical trials that investigate these factors [20]. Our study confirmed this statement: resolution of hypercholesterolemia was observed in 100% of the patients after 6 years. Hypertriglyceridemia was improved in 93.6% on the 6<sup>th</sup> and in 83.5% of the patients on the 8<sup>th</sup> year after the operation.

Arthropathy was one of the morbidities with the worst results after BPD-DS. This could be explained by the progress of irreversible, osteo-articular degeneration in the major lower limb joints. This process was probably caused by the enormous pressure exerted on the joints for years. Preoperatively we found a statistically significant difference in the rate of arthropathy between the groups by age ( $p = 0.002$ ), and this rate was highest in the 46 - 65 years group, where it reached 44.2% of patients. This fact led us to believe that early treatment of obesity should prevent eventual arthropathy of major lower limb joints, which is later hard to treat by weight loss after bariatric intervention.

Surgical complication after BPDDS range from 2.9 to 16.3% and include anastomotic leak, hemorrhage, abscess, bowel obstruction etc [21,22]. The management of these disorders could be surgical or nonsurgical depending on timing, severity, and general condition of the patient. In our study surgical complications were observed in 18 patients (12.8%), and surgical treatment was necessary in 13 patients (9.2%).

Sleeve part of stomach resection may result in symptomatic GERD[23]. Resleeve gastrectomy or closure of diaphragmatic crura was reported to control the symptoms [24,25]. In patients who underwent BPD-DS and have chronic GERD symptoms with poor conservative control, we propose horizontal gastrectomy and removal of the gastric antrum with excellent postoperative results.

One of the main criticism to BPD-DS is the long-term risk of nutritional deficiencies [26]. The incidence of PCM after BPDDS ranges from 1 to 6% [27]. The surgical revision in general is very rare and most helpful in patients with CC < 100 cm [28]. According to many authors the safest CC is 100 cm, because of the fewest malnutritional complications [29]. In our study the rate of PCM was 4.99% and no cases were recorded in the 50 cm CC group. Such conditions requiring surgical adjustment of the CC were observed in the 75 and 100 cm groups, even though these differences were not statistically significant ( $p = 0.137$ ). Such difference in frequency of PCM was not found between the groups by initial BMI ( $p = 0.690$ ), gender ( $p = 0.658$ ), and age ( $p = 0.370$ ). In spite of the not too large number of patients included in this study, based on the results we conclude that there is no relationship between malnutritional conditions and different common channel length. Therefore we recommend all three common channel lengths as equally safe and effective.

BPD-DS is a technique that has a decreasing use worldwide and presently represents approximately 2% of bariatric procedures in USA [28]. Despite this fact the long term weight loss and adverse events of BPDDS are similar to Roux-en-Y-gastric bypass (RYGB) [30], but BPDDS is more effective in the resolution of T2DM. Dorman., *et al.* [31] in 8 years retrospective case matches study reported resolution of T2DM: 81.5% after BPDDS versus 48.1% after RYGB by the first year. The majority of the patients with T2DM on oral medicaments improve with any bariatric procedure because of the weight loss. For the patients on high insulin doses requirements BPDDS is a procedure of choice and give the best chance for resolution [32].

Our study confirms these good results and indicates that BPDDS is certainly valid operation at an experienced center in a patients with severe forms of T2DM, AH, SOSA and dyslipidemia.

Weaknesses of this study are the relatively small number of patients and the mainly retrospective nature of the study. Strengths are the high follow-up rate over a long period of time and full spectrum record of nutritional deficiencies and comorbidities resolution.

### Conclusion

Biliopancreatic derivation with duodenal switch is a bariatric technique with excellent and stable results in treating obesity comorbidities such as T2DM, arterial hypertension, obstructive sleep apnea syndrome, hypercholesterolemia, and hypertriglyceridemia. Poorer results were achieved in influencing arthropathy of major lower limb joints, probably because of irreversible degenerative processes.

We found no statistically significant difference in resolution of T2DM, SOSA, dyslipidemia, arthropathy of the major joints of lower extremities and malnutritional complications between the groups by common channel length. Only AH resolved fastest In the 100 cm CC. Thus all three lengths (50, 75, and 100 cm) should be considered equally safe and effective.

### Conflict of Interest

The authors declare that they have no conflict of interest. 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 from all individual participants was not obtained because of the retrospective nature of the study.

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