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ORIGINAL CONTRIBUTIONS

Long-Term Metabolic Outcomes 5 to 20 Years After Biliopancreatic Diversion

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Abstract
Background Biliopancreatic diversion (BPD) is a complex bariatric operation requiring meticulous surveillance which has impeded its broad adoption. Improvements in surgical care and technique, better teaching programs, and stringent norms for follow-up have contributed to increased safety of BPD for patients with BMI <50, achieving better long-term results than other bariatric operations. Here we report 20-year outcomes of 2615 consecutive patients (median 8) having open BPD with duodenal switch (DS) between 1992 and 2010.
Methods Chart of 92 % of patients with complete clinical, biochemical, and physical examinations completed before 2013 was reviewed. The research was conducted at Academic Medical Center, Quebec City.
Results There was total mortality of 4.7 %, equivalent to that of the general population of Quebec. Incident diabetes (38.8 %) was cured in 93.4 % (blood glucose <6 mmol/l; HbA1c <6.5 %) with 4 % relapse rate after mean 9.6 years with no new cases. Dyslipidemia (24.2 %) was cured in 80 %. Hypertension (60 %) was cured in 64 % and improved in 31 %. Mean weight loss of 55.3 kg (71 % excess weight loss (EWL); 20 BMI units) was maintained for 5 to 20 years. Operative mortality was reduced from 1.3 % in 1992 to 0.2 % during 2005–2010, with cumulated rate surgical mortality of 0.5, revision rate 3, and reoperations in 13 %. Nutritional deficiencies were present in 2 % for calcium, iron, and vitamin A. Side effects were considered minor by the great majority of patients, rating global satisfaction as 4.5/5 (91 % "satisfied").
Conclusions BPD deserves more consideration as a primary procedure for eligible patients in experienced centers with sufficient resources for delivering high-quality care and long-term follow-up.

Keywords Duodenal switch · Bariatric surgery · Metabolic surgery · Outcomes · "Health care delivery"

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Introduction

Over 30 years ago, Nicola Scopinaro and his group in Genoa [1] introduced biliopancreatic diversion (BPD), consisting of distal gastrectomy and Roux-en-Y gastro-ileostomy for the treatment of morbid obesity continuously adding publications demonstrating and explaining its efficiency [2–5]. However, the worldwide use of this operation is still limited. Buchwald et al. [6] in a review of all opened bariatric operations (1990–2006) with results on weight and diabetes reported BPD as representing only 17 %. Its relative technical difficulty and requirement of demanding follow-up may explain this limitation. There are different methods for performing BPD with or without duodenal switch (BPD-DS) that share the same principal mechanism: decreasing lipid absorption.

We used the original Scopinaro procedure for 8 years [7] until 1992 when we introduced a modification aimed to decrease side effects without compromising weight loss, replacing distal gastrectomy with pylorus-preserving sleeve gastrectomy lengthening the common channel from 50 to 100 cm

(BPD-DS) (Fig. 1) [8]. This procedure has ever since been our procedure of choice. In 2005, Hess [9] reported his 10-year experience and we followed in 2007 with our own 15-year experience [10, 11]. Here we extend our prior study by providing data on the metabolic syndrome and adding another 5 years of observation for 2615 consecutive patients having open primary BPD-DS between June 1992 and January 2010 before we adopted routine laparoscopy.

Methods

Source of Data

Since 1982, our University Hospital has kept a prospective data bank for all bariatric surgery patients for quality assurance for this new type of surgery. The bank was designed to be extensive with preoperative evaluation and long-term follow-up including office visits, lab work, phone calls, etc. Clinical nurses diligently maintain contact with patients and family doctors ensuring annual office visits. In 2012, thanks to the Canadian Health Care System subsidizing medical care and the help of "*La Régie de l'Assurance maladie du Québec*" we were able to see 92 % of living patients and to obtain the vital status for those lost to follow-up (*n*, 218). Table 1 gives initial anthropometric characteristics and comorbidities for the whole group before surgery, and Fig. 1 allows the reader to grasp precisely the number being presented.

The cohort consists of 2615 consecutive patients operated following recommendations similar to those of the 1991 NIH Consensus Conference [12]. All patients signed a consent form allowing their data to be kept for clinical follow-up and for research. Every 5 years, we mailed a short written questionnaire to all patients, validated by the medical records. The latest short questionnaire was sent in 2012 to 2474 patients operated before 2010 and was completed by 1312 (53 %). Questions explored frequency of stools, prevalence of vomiting, diarrhea, heartburn, indigestion, bloating, and malodorous gas, and patients were asked to grade the severity of side effects and global satisfaction with weight loss considering side effects on a scale of 1–5.

Table 1 Characteristics (A) and comorbidities (B) of 2 615 patients having open biliopancreatic diversion-duodenal switch between 1992 and 2010

A. Characteristics (means±SD except as noted)

	Mean	Range
Sex m/f (% f)	804/1811(69.3)	–
Age (years)	42±30.8	(15–70)
Weight (kg)	142±30.8	79-325
Excess (weight %)	126±40.4	45-346
BMI	52±9.3	33-103
Height	165±9.4	119-201

B. Comorbidities (numbers and percentages)

	n	%
Hypertension[e]	1789	68.4
Diabetes[a]	1015	38.8
Dyslipidemia[d]	633	24.2
Sleep apnea CPAP[b]	497	19.0
Asthma[c]	495	18.9

[a] Treated or with fasting blood glucose >5.7 mmol/l or HbA1c >6.5 %

[b] Continuous positive ambulatory pressure treatment

[c] Treated

[d] On medication or with plasma HDL <0.7 mmol/l or triglycerides >2.3 mmol/l

[e] On medication or with SBP >140 mmHg and/or DBP >90 mmHg

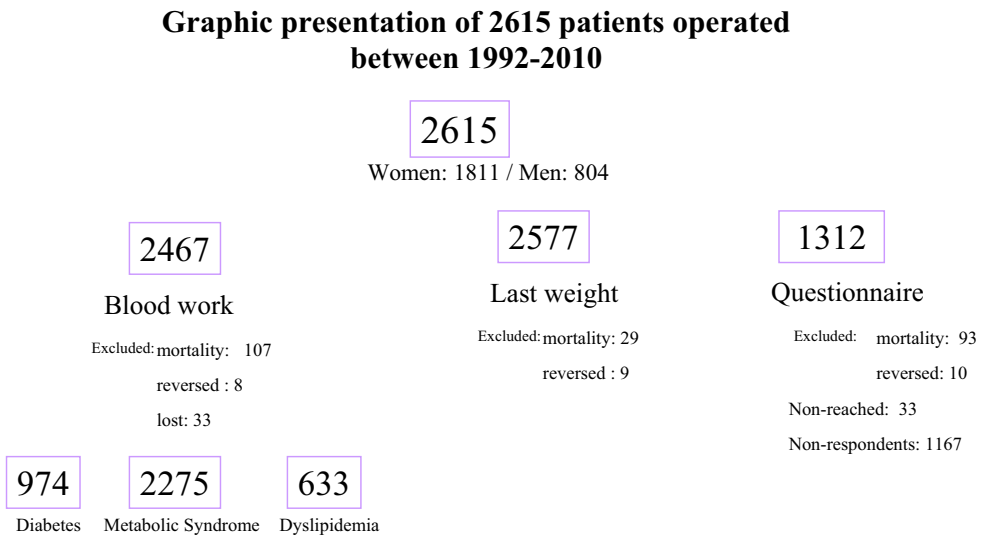

Fig. 1 Graphic presentation of 2615 patients operated between 1992 and 2010

Surgical Procedure

All surgical procedures were done open, by laparotomy, as previously described [8, 10]. In brief, it consisted in a 65 % sleeve gastrectomy starting 7–8 cm from the pylorus up to the angle of His. The biliopancreatic diversion consisted of a 250-cm alimentary "food" tract including 100 cm of a common digestive tract. Duodeno-ileal anastomosis was done laterally or terminally 4–5 cm distal to the pylorus and ileo-ileostomy and 100 cm from the ileocecal valve. Gall bladder and appendix were routinely excised. All these operations were done before our routine use of laparoscopy and represent 88 % of all primary bariatric operations. Post operative care has remained the same over the years (Fig. 2).

Follow-up

Mean long-term follow-up for the whole group (2615) was 9.8±4.8 years (median 8.1 years), median 8 years 2 months (range 3–21 years) comprising 2118 patients with greater than 5 years and 915 greater than 10 years. Figure 3 gives the number of patients each year. Long-term follow-up consisted of an annual office visit with blood analysis conducted through our clinic or by a collaborating family doctor participating in the national health insurance program who sent us all results. Daily oral recommendations were ferrous sulfate 300 mg, calcium carbonate 500 mg, vitamin D-forte 50,000 units, vitamin A 10, 000 units, and a multivitamin (Rx Centrum forte®). These were frequently adjusted according to monitored blood levels. Common prescriptions were probiotics, metronidazole, and H2 blockers or protein pump inhibitor (PPI) as needed, covered by insurance.

Statistical Analysis

Results were expressed as a mean±SD or percentage for continuous or categorical variables and were analyzed using Fischer's exact test or chi-square test. Unpaired observations of continuous variables were analyzed using Student's *t* test. Patient surveys were scored on a 5-point Likert scale; a parametric mean per survey category was calculated to estimate centricity of the population response, while contingency chi-square probabilities were calculated to assess statistical

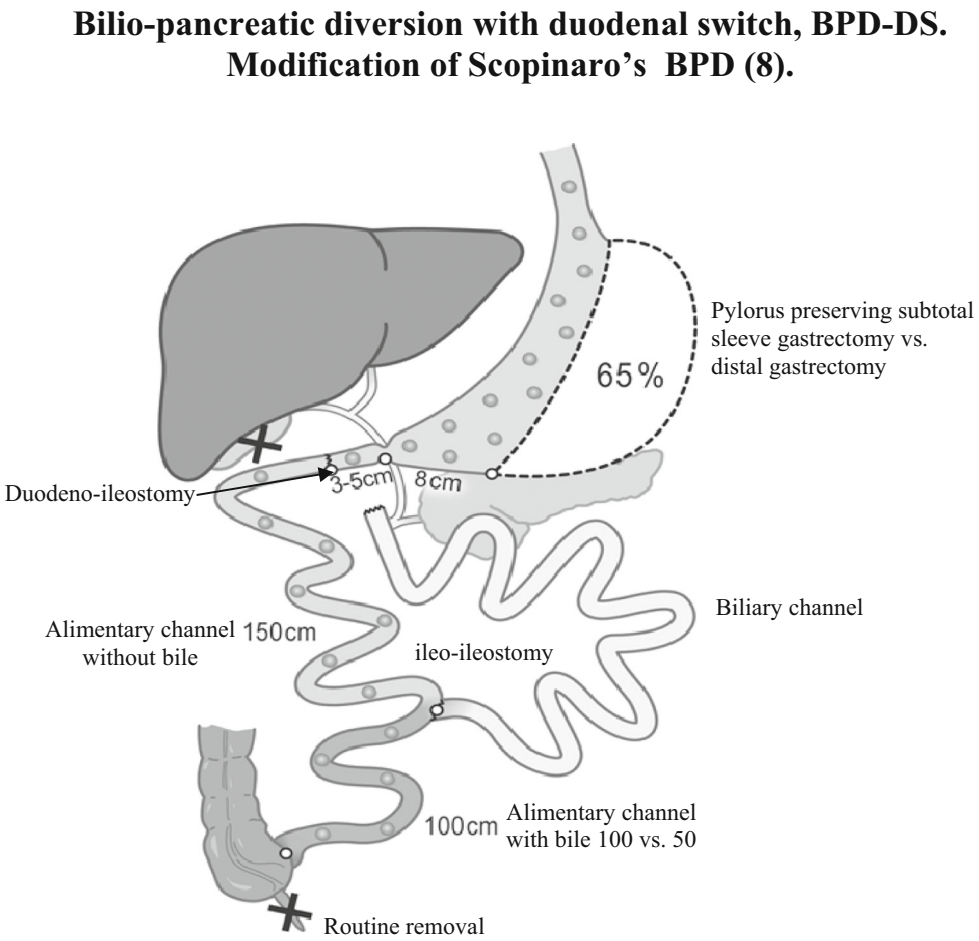

Fig. 2 Biliopancreatic diversion with duodenal switch, BPD-DS. Modification of Scopinaro's BPD (8). 1. Pylorus-preserving subtotal sleeve gastrectomy replacing the original distal gastrectomy. 2. Common "absorptive" channel lengthened from 50 to 100 cm. 3. Ileo-duodenal anastomosis 3–5 cm distal to the pylorus. 4. Incidental appendectomy and cholecystectomy

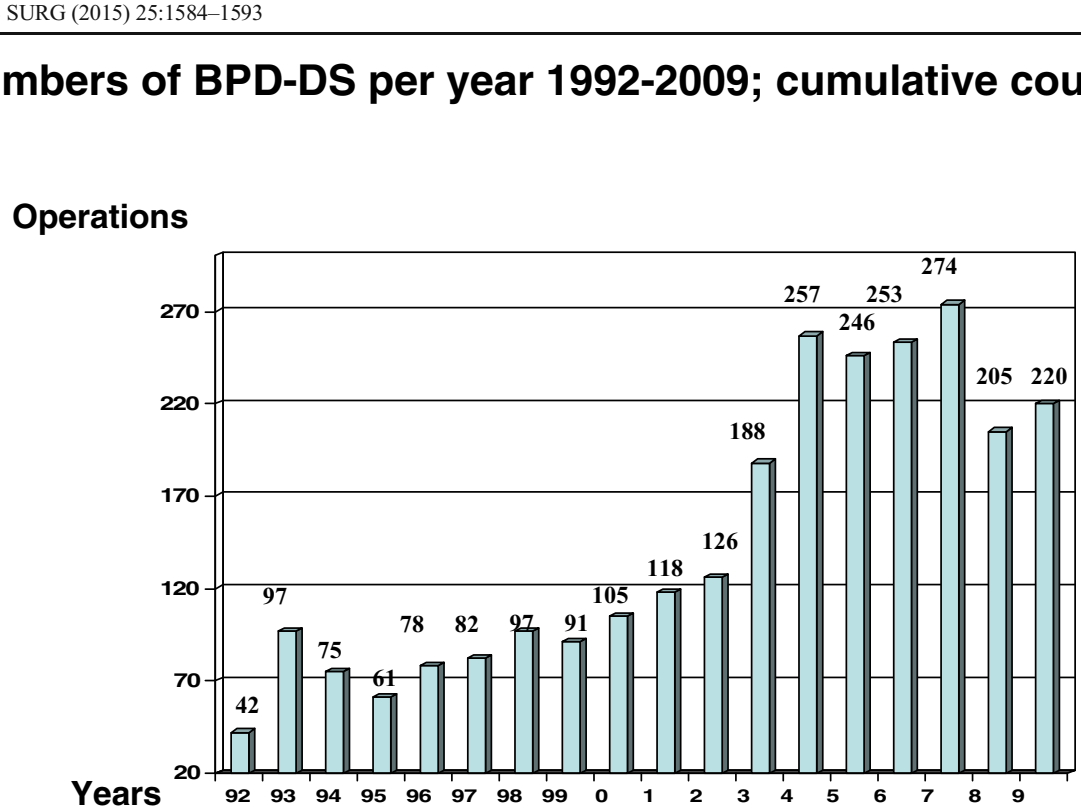

Fig. 3 Numbers of BPD-DS per year 1992–2009; cumulative count, 2615

significance of between-group differences. To adjust for secular trends, we used length of time as a covariate. The survival function was obtained from the Nelson-Aalen estimator of the cumulative hazard rate. Excess mortality was estimated using the relative mortality model, where the hazard rate at time T is a multiple of the reference hazard rate. The 2009 Quebec population census provided reference survival data [10]. Results were considered significant with p values ≤0.05. Data analysis used version 9.1.3 of SAS (SAS Institute Inc. Cary NC).

Definitions

"Excess weight" (EW)	Initial weight−ideal weight.
"Ideal weight"	Height (cm) squared divided by 10, 000 multiplied by 23 ("ideal BMI") [13].
"Percent excess weight loss" (%EWL)	Initial weight less current weight over excess weight×100.
"Annual weight"	The specific year±5 months.
"Follow-up"	Time between date of surgery and each of the following: death, last visit, last reported or measured weight, last lab analysis, or completed questionnaire. Deaths, reversals, and lost to follow-up were excluded from each calculation.

Results

Mortality

Thirty-day operative mortality was 0.76 % (20/2615). Over 20 years, it decreased significantly: 1992–1999=1.3 % (8/625), 2000–2005=0.96 % (10/1039), and 2005–2010=0.2 % (2/951) ($p<0.000$ for trend).

After 20 years of observation and a mean follow-up of 9.8 ±4.8 years, late mortality was 3.9 % (103/2615). Causes of late deaths are presented in Table 2. There were 81 deaths unrelated to surgery and 15 related to surgery. Five were unknown. Cirrhosis was present in two (In 1, the cirrhosis was present at surgery 12 years earlier, and in the other, death occurred 16 years after DS on a known continuous alcoholic). These deaths, more frequent in men ($p<0.04$), occurred at a mean 6.2±4.8 years postoperative. Survival during 20 years up to December 31, 2012, was 95.3 % including perioperative and delayed deaths, comparable to that of the Quebec general population [14].

Diabetes

Baseline A total of 1015 patients had known or newly diagnosed diabetes (38.8 %), 41 of whom were excluded: 15 early deaths, 21 with missing blood results, 1 reversal of operation, and 4 with type 1 diabetes, leaving a study group of 974 patients. Among them, 230

Table 2 Causes of late deaths, *n* 103

81 unrelated to BPD-DS	31	Cancer
	21	Trauma (9 suicide)
	18	Cardiac
	6	Pulmonary insufficiency
	5	Miscellaneous (cardiac surg, pneumonia, amyloidosis, enterocolitis, pancreatitis)
15 related to BPD-DS	5	Primary surgery (mean: 1 year)
	6	Revisions (mean: 3 years)
	4	Malnutrition (refusing revision) (mean 2 years)
2 cirrhosis	1	Cirr. and hep B before surgery (12 years after DS)
	1	Alcoholic (16 years after DS)
5 unknown		

were insulin dependent (24 %); 510 depended solely on hypoglycemic drugs (52 %) and 234 were treated by diet (*n*, 217) or were newly diagnosed having fasting blood glucose (FBG >6 mmol/l and/or HbA1c >6.5 %) (*n*, 17). Results are presented in Table 3.

Outcome For the whole group, 93.4 % of patients were able to discontinue all treatment and maintain FBG <5.7 mmol/l or HbA1c <6.5 %. Another 5.4 % decreased their medication. Insulin was discontinued in 97.4 %. Among the 93.4 % who discontinued all diabetic treatment, 10.8 % of the 230 insulin-treated patients recurred as did the 2.5 % of those on oral medication and 2.5 % of the diet-treated patients. Diabetic therapy was discontinued for 5 years or more in 93.2 % (778/835) and for 10 years or more in 92.7 % (293/316).

Metabolic Syndrome

We were among the first to describe the metabolic syndrome in severe obesity [15] subsequently demonstrating the beneficial effects of BPD on outcomes [16]. More than curing most diabetic patients, BPD-DS limits fat absorption, thus improving dyslipidemia, lowering blood pressure, and decreasing cardiometabolic risk. Preoperatively 633 patients were dyslipidemic (on medication or with plasma HDL <0.7 mmol/l and/or triglycerides >1.7 mmol/l). Postoperatively 80 % discontinued medication (413/518). There were significant decreases of 27 % in total cholesterol, 37 % in LDL cholesterol, and 35 % in triglycerides, and the cardiac risk index decreased by 29 %, whereas HDL cholesterol remained stable (Table 4).

At baseline, 1789 (68 %) patients were hypertensive: 1556 on treatment and 233 with systolic blood pressure (SBP) >140 and/or diastolic BP (DBP) >90 mmHg. Postoperative data were available in 1211 (78 %): 64 % (*n*=776) discontinued, whereas 31 % (*n*=381) decreased medication. Comparing 915 paired data before and 10 years after surgery, mean SBP had decreased from 138.9±17 to 130.7±18 ($p<0.000$) and DBP from 84.7±30.9 to 77.12±11.9 ($p<0.000$).

Using World Health Organization criteria [17, 18] for defining the metabolic syndrome at baseline, in aggregate 2275 patients (87 %) met the criteria by having BMI >30 and diabetes, and/or dyslipidemia and/or hypertension defined as in the preceding text. Since severely obese patients postoperatively often have persistent BMI >30 in the absence of metabolic obesity comorbidities [19], we calculated the reduction in the prevalence of the metabolic syndrome from a baseline prevalence of 57 % based on "other-than-BMI" comorbidities, demonstrating a prevalence of 6.5 % at 10 years, an 89 % reduction. Figure 4

Table 3 Diabetes treatment before and mean 9.6±4.8 years after BPD-DS (*n*=974)

Preoperative treatment	Insulin dependent *n*=230 (%)	Hypoglycemics *n*=510 (%)	Diet or Lab[d] *n*=234 (%)	Total *n*=974 (%)
Total remission[a]	187 (81)	489 (96)	234 (100)	910 (93.4)
Improved[b]	37 (16)	16 (3)	–	53 (5.4)
Unchanged	6 (2.6)	5 (1)	–	11 (1.1)
Recurrence[c]	25 (13)	12	6 (2.6)	43 (4.4)
Presently on insulin	4	1		
Oral medication	7	1		
No treatment	14	10		

Exclusions: 15 first year death, 4 type 1 diabetes, 1 operation being reversed, 21 missing blood values

[a] Total remission: treatment discontinued and HbA1c <6.5 % and FBS <5.7 mmol/l

[b] Improved: off insulin, oral medication continued or decreased

[c] Recurrence: HbA1c >6.5 %

[d] FBS ≥5.7 mmol/l

Table 4 Plasma lipids before and mean 7.9±4.6 years after BPD-DS n=2467

	Before		After		% decrease
	n	Mean	n	Mean	
CTO mmol/l	1992	4.77±0.96	1974	3.49±0.76	27
LDL mmol/l	1992	2.75±0.85	1974	1.72±0.58	37
TRI mmol/l	1992	1.81±0.93	1974	1.17±0.62	35
HDL mmol/l	1992	1.21±0.30	1974	1.23±0.36	–
CTO/HDL ratio	2148	4.21±1.38	2119	3.01±0.93	29

CTO total cholesterol, *LDL* low-density lipoprotein cholesterol, *TRI* triglycerides, *HDL* high-density lipoprotein, *CTO*/*HDL* cardiac risk index

shows the improvement of each component of the metabolic syndrome.

Weight Loss

To study long-term weight loss, we excluded 38 patients (29 early deaths and 9 patients with reversal operations). Thus there were 2577 (88.6 %) with recent postoperative weights. Weight loss was 55.3±22.8 kg representing excess weight loss (EWL) percent of 70.9±20 and a decrease in BMI of 20.2±7.7 units, 73.6 % of patients achieving BMI <35. As shown on Fig. 5, weight loss was maintained for the whole 20 years. To validate self-reported versus measured weight loss, we compared measured weight loss at 5 years of 281 randomly selected patients and their self-reports during the following 5-year interval and found no statistically significant differences between the two (85.7±18.1 vs 85.9±20.3 kg).

Operative Complications

The 30-day major complication rate was 10.2 % (n=269), defined as life threatening or causing hospitalization longer than twice the median length of stay (LOS) of 6.2 days (range 2–224 days) for the whole group. The minor complication rate was 8.8 % (n=229). Rehospitalization within 30 days had been necessary in 176 (6.7 %) and reoperation in 92 (3.5 %). As mentioned earlier, operative mortality decreased from 1.3 to 0.2 % during the 20 years.

Long-term mortality directly or indirectly related to surgery during the 20 years (mean 10.2±4.8 years) was 0.5 % (n=14 deaths); rehospitalization had been necessary in 8 % (n=211) and reoperation in 13 % (n=348) (Table 5).

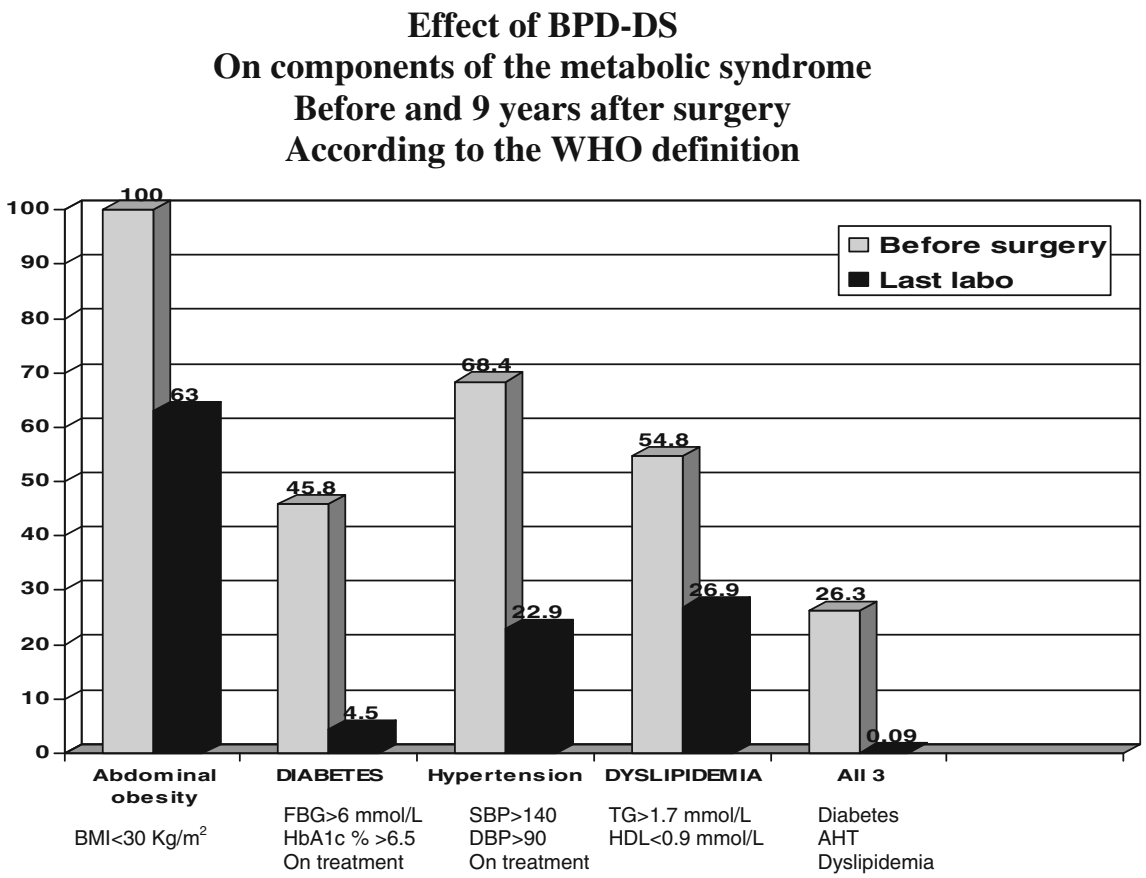

Fig. 4 Effect of BPD-DS on components of the metabolic syndrome before and 9 years after surgery according to the WHO definition. *FBG* fasting blood glucose, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *TG* triglycerides, *HDL* high-density cholesterol, *AHT* arterial hypertension

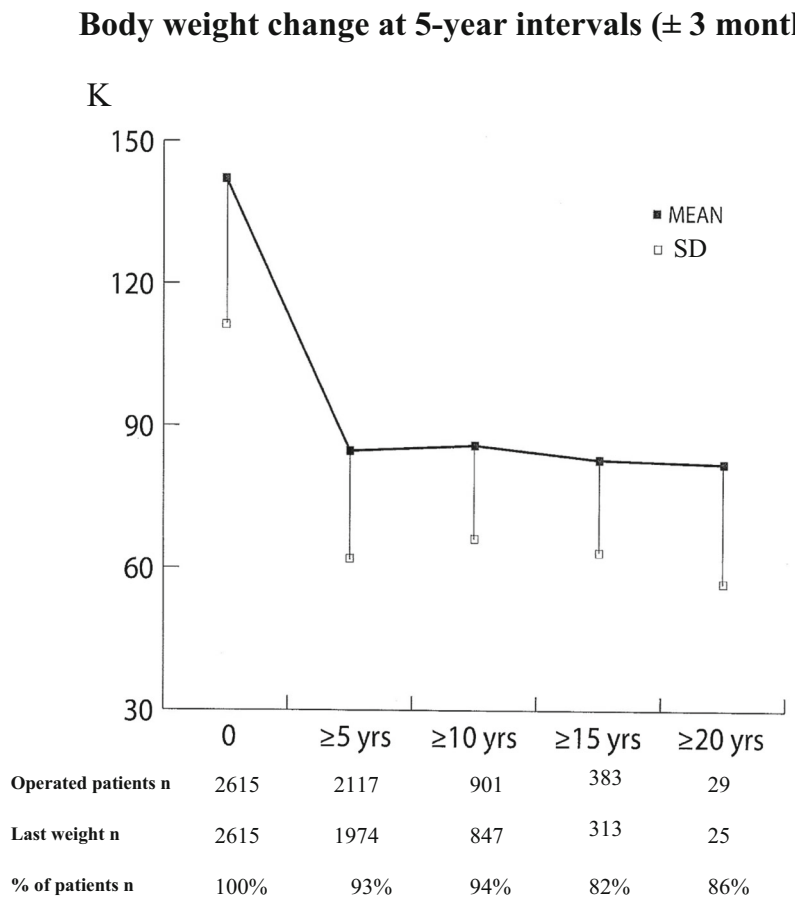

Fig. 5 Body weight change at 5-year intervals (±3 months)

Revision surgery Reoperation for insufficient weight loss was done in 41 patients (1.6 %) and consisted of shortening the functional small intestine in 23 and resecting stomach wall in 18 (Table 4). Rehospitalization was needed in 211 patients (8 %): 37 requiring reoperation for malabsorption (1.4 %), reversing bypass in 9, and lengthening the alimentary limb in 28 patients. Temporary perioperative feeding jejunostomy was done at surgery in 79 (3 %), during hospitalization in 46 (1.7 %), and as a delayed procedure in 47 (1.8 %).

Nutritional Markers

After 20 years (mean follow-up of 9.2±4.9 years, range 2–21 years), last blood levels were improved or unchanged from before surgery: B12, folic acid, vitamin D 1-25(OH), iron, ferritin, and albumin (Table 5). Only vitamin A, hemoglobin, and calcium levels were slightly decreased: (Vit A, 2.25 to 1.82; Hgb, 137.3 to 130.5; calcium, 2.29 to 2.22). Prevalence of deficiencies for all nutritional markers remained below 2 % with no increases over the last 5 years. The only measured significant persistent hormonal change was PTH above 100 ng/l in 22 % of patients (normal range 15–65 ng/l). This elevated PTH was correlated with lower calcium (*r,* 0.29; $p<0.0001$) but not with the level of vitamin D (*r,* 0.05; $p=0.32$) (Table 6).

Side Effects

The response rate of the questionnaire was 53 % (1312/2479) with no difference between respondents (R) and non-respondents (NR) in terms of age, sex, initial BMI, initial

Table 5 Late complications requiring surgery

	Number	Percentage
A. Prevalence: 13.3 % (348/2615)		
Small bowel obstruction	156	6
Umbilical or incisional hernia	110	4.2
Delayed jejunostomy	42	1.6
Delayed fistula	15	0.6
Duodenal stricture	7	0.3
Hiatal hernia	7	0.3
Bleeding duodenal ulcer	4	0.2
Biliary complications	5	0.2
Peri-gastric abscess	2	0.07
B. Revisional operations. Prevalence 2.9 %, $n=78$		
Reversal	9	0.3
Functional intestine lengthened	28	1
Functional intestine shortened	23	0.8
Gastric resection	18	0.7

Table 6 Blood chemistry before and 15 and 20 years after BPD-DS with % prevalence of deficiencies (means±SD)

Analytes (reference values)	Number	Before surgery	Number	After 15 years[a]	Number	After 20 years[b]
Albumin (≥36 g/l) % deficiency <30	2033	41.4±3.10.2	1028	40.3±3.80.9	2352	40.4±3.70.7
Folic acid (≥9.5 mmol/l) % deficiency <4.5	1971	23.9±9.866.7	898	32.3±5.10.3	2174	33.9±11.51.1
Vit B12 (≥145 pmol/l) % deficiency <110	2004	265±1061.8	924	433±2051.0	2244	468±2180.4
Iron (≥10 mmol/l) % deficiency <4	1862	13.7±5.10	807	14.3±7.80.9	2305	14.3±5.21.2
Vit D (≥50 nmol/ml) % deficiency <40	468	57±21.421.6	531	81.2±47.415	1964	96.1±57.810.9
Hemoglobin (≥120 g/l) % deficiency <100	2159	137.3±12.30	1142	132.1±12.30.8	2377	130.5±13.31.7
Vit A (≥1.4 μmol/l) % deficiency <0.7	1851	2.25±0.70.5	807	1.89±0.71.9	1886	1.82±0.62.2
Calcium (≥2,15 g/l) % deficiency <2	2042	2.29±0.10.3	1000	2.23±0.121.3	2358	2.22±0.11.9
PTH (≤75 ng/l) % excess >100	1730	37.8±23.22.1	720	66.8±42.816.8	2135	78.5±41.622

We distinguish "insufficiency," level needing only adjustment of supplement, and "Deficiency," level susceptible to be detrimental

[a] Mean follow-up 7.3±3.7 years (range 2–15)

[b] Mean follow-up 9.2±4.7 years (range 2–21)

comorbidities, length of follow-up, or weight loss (54.3 ±21.7 vs 56.3±21.1 kg). The only difference was the greater prevalence of three deficiencies in NR (vitamin A 10.6 vs 3.2 %, $p<0.001$; vitamin D 6.7 vs 3.3 %, $p<0.001$; Iron 7.2 vs 3.9 %, $p<0.004$). Bloating (more than once a week) was present in 46 % (586/1282); malodorous gas was considered a major inconvenience in 36 % (469/1302); and epigastric pain (more than once a week) was present in 25 % (313/1272) requiring medication (alkali or PPI) in 36 %. Diarrhea (liquid stool for more than 3 days) was present in 12 % (158/1288). The number of stools per day was 3.0±1.9 and was not considered a problem for 92 % (1187/1292). Vomiting (once a week or more) was rare: 4 % (54/1288). Patients graded the inconvenience caused by their side effects as negligible in 24 %, minor in 42 %, moderate in 24 %, severe in 8 %, and very severe in 2 %.

Patient Satisfaction

Satisfaction with weight loss was graded 4.4 on a 5-point scale (62 % "highly satisfied," 26 % "satisfied," 8.8 % "more or less satisfied," 1.8 % "rather dissatisfied," and 1.7 % "frankly dissatisfied"). Mean "global satisfaction" considering side effects, change in quality of life, and weight loss was even better 4.5 ($p<0.01$). In aggregate, 90 % were satisfied and only 2 % dissatisfied.

Discussion

This is a unique exceptionally long-term single-center study of an open (laparotomic) bariatric gastrointestinal operation with a high follow-up rate. We demonstrate that BPD-DS is safe, with low mortality capable of extending longevity, reducing and even curing comorbidities and the metabolic syndrome, and providing great satisfaction over the very long term. Our results compare favorably to those of the paucity of published studies of laparoscopic bariatric surgery of less complexity. Earlier we have also shown that BPD-DS prevents intergenerational transmission of the dysmetabolic diathesis of obesity [20–23].

Operative Mortality and Longevity As is the case for all bariatric operations, operative mortality after BPD has greatly decreased in the past 20 years generally ascribed to the wide introduction of the laparoscopic approach. It is 0.2 % in our last 1000 cases, all done open. We have already shown that DS had the same operative risk as gastric bypass (GBP) for similar preoperative risk factors [10]. Operative mortality should no longer be a major factor for choosing less effective operations. Life expectancy after BPD-DS is 97.3 % during follow-up of 9.8 years, equivalent to the general population of Quebec [14]. There are only two reported long-term survival after GBP: Adams [24], 97.1 % after 7 years, and Flum [25], 88.2 % after 15 years. These results are remarkable considering that severely obese people have a 2–3 times greater risk of dying than a

normal weight person [26–28] and a life shortened by 8 to 12 years depending on age, gender, and smoking habits [29, 30].

Comorbidity Reduction and Cure Improved survival after bariatric surgery is due to the prevention of "deaths from diseases" such as the prevalent comorbidities: cardiovascular disease, diabetes, and cancer, in contrast to deaths from accidents or trauma [24], which also are increased in obese patients. BPD has superior capacity to effectively treat and prevent the metabolic syndrome by durably curing components of the syndrome [4, 6, 31], likely attributable to its selective lipid sequestration [4] not present in banding or other bypass operations. Ten years after BPD, the prevalence of the metabolic syndrome (defined as three or more risk factors including "obesity") decreased from 85.7 to 30.9 %, the prevalence in the American general population [32]. If abdominal or visceral obesity is excluded in the setting of substantial weight loss, the metabolic syndrome is almost absent (0.09 %).

Our findings of diabetes and dyslipidemia confirm reports of others. Diabetes is cured in over 90 % for 10 years [4, 8, 31] after BPD compared to 45 % after GBP [33]; plasma triglycerides are normalized in 80 % [4] versus 63 % after GBP [34]; and total cholesterol decreased by 27 % in the present series and is reported to be increased by 8 % after GBP [34]. The beneficial effect of BPD on hypertension in the present series is in accordance with the findings of Adami et al., an improvement in 95 % of patients 10 years postoperative [5]. Sjostrom et al. [35] reported that the early improvement in hypertension seen after gastric bariatric operations including a small subset of GBP diminished with aging, being only temporary and independent of weight loss.

Patient Satisfaction BPD provides great patient satisfaction which remained above 95 % 5 years apart which is superior to the 79 % after GBP reported by Edholm [33]. This greater satisfaction may be explained by the greater weight loss produced after DS: an additional 6.2 BMI units [36] and 85 instead of 65 % of patients losing more than 50 % of excess weight after BPD [4, 9, 10]. Regarding side effects, 10 % of patients found them difficult.

Postoperative Care Early postoperative care after BPD is the same as for any major foregut surgery [10, 37, 38]. Deficiencies are the most prevalent of long-term complications but are preventable with assiduous monitoring and supplementation. Up to 20 years surveillance of iron, calcium, and vitamin A appears to be sufficient. No serious irreversible bone or liver damage was described [16, 39] although there are isolated case reports, inevitably linked to patient cooperation with recommended treatment plans. Just the same, it is easier and less risky to prevent and treat long-term complications in operated patients than to effectively manage severe obesity per se.

Limitations

This series has many of the inherent weaknesses of long-term studies: multiple laboratories, changes in lab norms, missing results, lack of severely obese controls, etc. However, this series is unique in presenting 20 years' results with a standardized intervention from a single institution with over 90 % follow-up. Comparisons with GBP are indirect in the absence of contemporaneous single-center studies. Our long experience with DS may in part explain our remarkable results. BPD remained our procedure of choice for so long because it met patients' and care providers' expectations leading to referrals and enabling follow-up. During the last 5 years, we have adopted the laparoscopic approach, for which the present series will serve as a benchmark.

It can be argued that our findings cannot be generalized owing to our racially and ethnically relatively homogeneous population, in a region with a highly developed national health insurance system and local financial support enabling access to care and necessary meticulous office follow-up monitoring and supplementing vitamins and minerals as needed. The results speak for themselves but serve to emphasize the need for adequate resources to provide quality assurance for severely ill patients with significant comorbidities.

Conclusions

The selective lipid malabsorption of BPD compared to other current bariatric operations likely explains much of its advantage. It abrogates systemic glucotoxicity and pancreatic lipotoxicity, improving glucose disposal, curing and preventing the insulin resistance, inflammatory metabolic diathesis of diabesity. Since more than half of patients in the present series had a BMI less than 50 and considering that surgical morbidity has been greatly reduced, we believe that DS should have a wider application. In a health-care system enabling access to care in the hands of an experienced team of surgeons and affiliated healthcare providers with resources to provide meticulous postoperative care, BPD with duodenal switch deserves serious consideration in the armamentarium combatting epidemic obesity.

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Authors' contributions Picard Marceau and Simon Marceau have full access to all of the data and take responsibility for the integrity and accuracy of the data. John G. Kral, co-writer supervisor, was participated in the conception, revision, and approval of the study. Biron S., Hould F.S., Lebel S., Lescelleur O., and Biertho L., bariatric surgeons, were participated in the revision and approval of the study. Simard S. was the research statistician from IUCPQ Research Center.

Conflict of Interest All authors have no financial relationships relevant to this article to disclose.

A Statement of Informed Consent Informed consent was obtained from all individual participants included in the study. Databank and its use for research have been accepted by the Laval University, University Institute of Cardiology and Pneumology of Quebec (IUCPQ).

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

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