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Biliopancreatic Diversion with Duodenal Switch

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Abstract. In 1990 Scopinaro's technique of biliopancreatic diversion with distal gastrectomy (DG) and gastroileostomy was modified. A sleeve gastrectomy with duodenal switch (DS) was used instead of the distal gastrectomy; and the length of the common channel was made 100 cm instead of 50 cm. A questionnaire and a prescription for blood work were sent to 252 patients who underwent DG a mean 8.3 years ago (range 6–13 years) and 465 patients who underwent DS 4.1 years ago (range 1.7–6.0 years). The questionnaire response rate was 93%, and laboratory work was completed for 65% of both groups. The mean weight loss after DG was 37 ± 21 kg and after DS 46 ± 20 kg. There were fewer side effects after DS: The number of daily stools was lower ($p < 0.0002$), as was the prevalence of diarrhea ($p < 0.01$), vomiting ($p < 0.001$), and bone pain ($p < 0.001$). Greater benefits related to several aspects of life were reported after DS than DG ($p < 0.0001$). The mean serum levels of ferritin, calcium, and vitamin A were higher ($p < 0.001$), and parathyroid hormone was lower. The yearly revision rate for excessive malabsorption was 1.7% per year after DG and 0.1% per year after DS. The two procedures were equally efficient for treating co-morbid conditions such as diabetes, hypertension, and hypercholesterolemia. Biliopancreatic diversion with sleeve gastrectomy/duodenal switch and a 100-cm common limb was shown to produce greater weight loss with fewer side effects.

To obtain the weight loss required to correct severe obesity and its co-morbidity, it is necessary to counteract the physiologic mechanisms that maintain excess weight. Until effective medical treatment becomes available, surgery remains the only viable option. Surgically, food intake can be restricted or food absorption decreased. Scopinaro et al [1–4] showed that it was possible to decrease nutrient absorption by shortening the functional intestinal length and decrease fat absorption further by diverting biliopancreatic juices. The procedure was followed by large weight loss. Disturbing physiology seemed a reasonable price to pay when justified by the loss of large amounts of excess weight. The major advantage of this bariatric procedure was the preservation of normal eating behavior. Modifying absorptive mechanisms entails the possibility of late sequelae; therefore legitimate concerns with the possible consequences of fat-soluble vitamin and calcium malabsorption have delayed wider use until longer follow-up is available.

From 1984 to 1990, biliopancreatic diversion (BPD), as described by Scopinaro, was our procedure of choice for treatment of morbid obesity [5]. In 1990 two modifications were adopted with the hope of decreasing side effects while preserving the efficient weight loss [6]. One modification was the use of a sleeve gastrectomy with duodenal switch instead of a distal gastrectomy and gastroileostomy. The duodenoileal switch, described by De-Meester et al. [7, 8], preserved the antropyloric pump, left the vagal innervation undisturbed, and contributed a short segment of duodenum to the alimentary path. The sleeve gastrectomy decreased the volume of the gastric reservoir and diminished the parietal cell mass to minimize the ulcerogenicity of the duodenoileal switch. A second modification was placement of an ileoileal anastomosis along the alimentary limb 100 cm from the ileocecal junction (instead of 50 cm), thereby doubling the length of the common channel while maintaining a total alimentary intestinal limb of 250 cm. The decision to double the length of the common channel was based on our experience with the often successful treatment of excessive diarrhea and malnutrition by surgical relocation of the ileoileal anastomosis from the initial site 50 cm proximal to the ileocecal junction to a new site 100 cm from the ileocecal junction.

After our initial experience with BPD with duodenal switch and a 100-cm common channel, a better clinical outcome was immediately apparent, making us reluctant to do a randomized series. Since 1990 this has been our procedure of choice. Seven years later, we now report a cross-sectional study of the clinical outcome after both procedures, comparing BPD with distal gastrectomy (DG) to BPD with duodenal switch (DS).

Materials and Methods

Patients

In January 1997 patients who underwent BPD 18 months ago or more were chosen as the subjects of this study. Between January 1984 and July 1995 a total of 747 patients underwent BPD as a primary or secondary procedure for morbid obesity. The selection criteria for bariatric surgery was 100 lb excess weight; there were no exclusion criteria. There were 13 (1.7%) perioperative deaths. Fifteen patients (2%) died over the years, and three were reoperated to restore normal intestinal continuity. Most of these patients were followed yearly by ourselves or their family physicians, who were asked to send their patients' yearly laboratory

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Table 1. Initial characteristics of patients before BPD with distal gastrectomy or duodenal switch.

Characteristic	Distal gastrectomy (n = 233)	Duodenal switch (n = 457)
Age (years)	37 ± 9 (18–59)	37 ± 10 (15–66)
Female (%)	80	80
Height (cm)	163 ± 9	163 ± 9
Weight (kg)	122 ± 26	126 ± 28
Body mass index	46 ± 9	47 ± 9
Excess weight (%)[a]	101 ± 37	105 ± 39

Results are the means ± SD.

Nineteen patients who underwent secondary BPD/DG and 8 patients who underwent secondary BPD/DS were excluded.

[a]Using the Metropolitan Life Table, 1980.

results. The patients are advised to take five supplements a day (multivitamin, iron, calcium, vitamin D, and vitamin A).

In January 1997 there were 717 patients still alive following BPD. Among them, 259 patients underwent BPD with DG between 1984 and 1990, and 465 patients underwent BPD with DS after 1990. These two groups of patients were comparable for age, sex, and preoperative weight; but the mean duration of follow-up after DG was 8.3 years (range 6–13 years) and after DS 4.1 years (range 1.7–6.0 years) (Table 1).

Procedure

When a biliopancreatic diversion was performed, the alimentary limb was a segment of ileum measured from the ileocecal junction to a constant length of 250 cm, where the gut was divided. The intestinal segment proximal to this division was termed the biliopancreatic limb, and its length accounted for the remainder of the small intestine. The biliopancreatic limb was isolated proximally from the path of ingested nutrients and thus carried digestive juices only. The distal cut end of the biliopancreatic limb was anastomosed to the alimentary limb at a site either 50 or 100 cm from the ileocecal junction. The segment of the alimentary limb distal to this anastomosis where nutrients and digestive juices mixed was termed the common limb. The cut end of the alimentary limb was brought up to receive the ingested nutrient stream by the creation of either a gastroileal anastomosis or a duodenoileal anastomosis (Fig. 1).

From 1984 to 1990 a distal gastrectomy with gastroileal anastomosis was used. This extended antrectomy reduced the gastric reservoir by two-thirds and acted as an acid-reducing procedure. Scopinaro suggested creating smaller gastric reservoirs for heavier patients, but we performed the distal gastrectomy to the extent necessary for an antiulcer result in all patients without regard to the patient's degree of obesity. The volume of the fundic reservoir was not measured, and the anastomosis was widely patent. In these patients, the ileoileal anastomosis was placed 50 cm proximal to the ileocecal junction, resulting in a 50-cm common limb. This procedure is referred to as biliopancreatic diversion with distal gastrectomy.

Since 1990 a sleeve gastrectomy with a duodenoileostomy was performed. The duodenal switch preserved vagal integrity as well as the antrum and pylorus, and it added a short segment of duodenum in the alimentary tract. Resection of the greater curvature of the stomach to create a lesser curvature gastric sleeve reduced the gastric volume to an extent judged similar to that achieved by the distal gastrectomy. The reduction of the parietal cell mass may have reduced acid production. In these patients, the ileoileal anastomosis was placed 100 cm proximal to the ileocecal junction, resulting in a 100-cm common limb. This procedure is referred to as biliopancreatic diversion with duodenal switch.

From 1990 to 1992 (226 patients) the duodenal switch was performed using a surgical stapling instrument across the duodenum to occlude the lumen, and a duodenoileal side-to-end anastomosis was created proximal to the staple line. After 1992 (239 patients) the duodenum was divided instead of stapled, and a duodenoileal end-to-end anastomosis was created proximal to the staple line (Fig. 2).

The technical difficulty was comparable for the two procedures. The appendix was removed when present in all patients. Prior to 1992 cholecystectomy was performed if gallstones were present or at the surgeon's discretion. Since 1992 cholecystectomy has been performed in all patients. Perioperative mortality, operative complication rates, and delayed mortality (related or not) were comparable (Table 2).

Questionnaire

A questionnaire and a prescription for blood work was sent to all patients, with a postcard reminder 3 weeks later. Phone calls were made to verify delivery of the study materials and encourage participation.

A structured written questionnaire with mostly multiple choice questions was used to obtain data on the present and nadir weight, the prevalence of side effects, and the patient's own evaluation of results. Questions assessed patient's evaluation of their eating behavior and specifically how their diet was restricted. Patients were asked about the frequency and severity of vomiting and if their appetite had changed following surgery. Questions also assessed bowel habits, specifically the frequency of bowel movements and the consistency of the stools. Other questions were intended to obtain the patients' own assessment of the severity of the problem caused by the frequency and odor of their stools and flatus. Patients were asked questions about the frequency and severity of heartburn, abdominal pain, abdominal bloating, and bone pain.

The questionnaire included a series of questions to assess the effect of surgery on self-confidence, acceptance by others, social life, marital relations, sexual relations, and ability to perform various activities of daily living, such as maintaining personal hygiene, walking, climbing steps, carrying grocery bags, running, and performing household chores. The choices given were (A) greatly improved; (B) improved; (C) unchanged; (D) worsened; (E) greatly worsened. Finally, two questions were intended to measure the patients' satisfaction with their weight loss and overall outcome. The choices given were (A) very much satisfied; (B) satisfied; (C) hesitate to answer, unsure; (D) not satisfied; (E) very much dissatisfied. Answers to multiple choice questions were assigned numerical values: (A) = 5, (B) = 4, (C) = 3, (D) = 2, (E) = 1 to obtain a mean score for each group on a scale of 1 to 5, with 5 the best result.

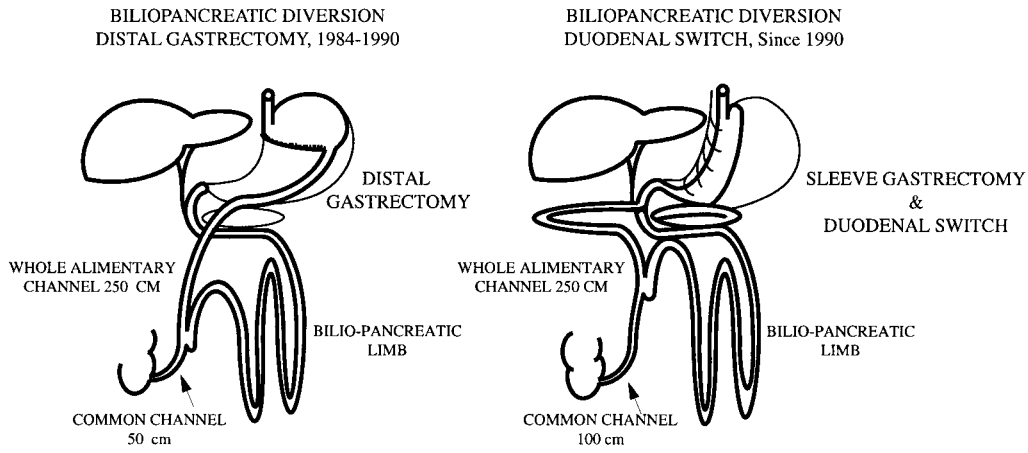

Fig. 1. Two types of biliopancreatic diversion: distal gastrectomy with a 50-cm common limb (DG, $n = 259$); and duodenal switch type with a 100-cm common limb (DS, $n = 465$). The total alimentary limb, including the common limb, was 250 cm in all patients.

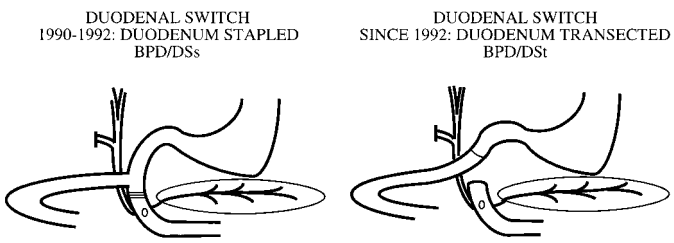

Fig. 2. Two surgical techniques for duodenal switch: duodenal occlusion with stapling alone (1990–1992) and duodenal occlusion with stapling and transection (since 1992).

Table 2. Operative mortality, operative morbidity, and delayed mortality (related or not) after BPD with distal gastrectomy or duodenal switch.

	Distal gastrectomy ($n = 252$)		Duodenal switch ($n = 465$)	
Parameter	No.	%	No.	%
Operative mortality	4	1.6	9	1.9
Anastomotic leak and sepsis	1		4	
Pancreatitis	2			
Pulmonary embolus	1		3	
Sleep apnea			1	
Malignant hyperthermia			1	
Operative morbidity	42	16.7	76	16.3
Gastric retention	23	9.1	29	6.2
Pulmonary (including emboli)	9	3.6	8	1.7
Abdominal abscess	1	0.4	11	2.4
Pancreatitis	2	0.8	8	1.7
Anastomotic fistula	2	0.8	8	1.7
Wound infection	2	0.8	5	1.0
Others	5	2.0	9	1.9
Delayed mortality	6	2.4	9	1.9
Cardiac	2		1	
Cancer	2		1	
Stroke			1	
Pulmonary embolism			1	
Septicemia			1	
Complications following reoperation	1		3	
Cirrhosis	1			
Suicide			1	

Blood Tests

The following blood tests were performed in clinical laboratories at the medical facilities closest to the patients' homes: complete blood count, calcium (Ca), iron (Fe), phosphorus (P), magnesium (Mg), albumin (Alb), prothrombin time (INR), aspartate aminotransferase (AST), alanine aminotransferase (ALT), γ-glutamyl transferase (GGT), alkaline phosphatase (AlkPh), glucose (FBS), cholesterol, triglycerides (TG), vitamins A and B_{12}, folate, and parathormone (PTH).

Chart Review

All charts of 747 patients were reviewed for preoperative data, postoperative complications, rehospitalizations, and reoperations.

Statistical Analysis

Results were expressed as the mean ± SD. Variables were analyzed using Fisher's exact test and Student's tests as appropriate. Correlations between variables and time were studied using regression analysis and Pearson correlation coefficients. All reported p values are two-sided and significant at a level of $p \leq 0.05$.

Anthropometry

Body mass index (BMI) was calculated as weight (kilograms) over height (meters). Percent excess weight (% EW) was defined as actual weight less ideal weight divided by ideal weight times 100, where ideal weight = 45.5 kg at a height of 152 cm adding or subtracting 0.9 kg for each centimeter of height above or below 152 cm [9].

Results

We have received 666 (93%) completed questionnaires; in only a few cases were they completed over the phone. Altogether 36 patients (5%) failed to complete and return the questionnaire as promised over the phone, 4 (0.6%) refused to complete it for personal reasons, and 11 patients (1.5%) were not reached. The response rate was similar for the two procedures. At the time of

Table 3. Weight loss after BPD with distal gastrectomy or duodenal switch.

Parameter	Distal gastrectomy (n = 233)	Duodenal switch (n = 457)
Mean follow-up (months)	100 ± 20	51 ± 25
Present weight (kg)	85 ± 18	80 ± 18
Obesity (%)	40 ± 27	31 ± 30
BMI (kg/m^2)	32 ± 6	30 ± 7
Weight loss (%)	30 ± 12	36 ± 10
Initial excess weight loss (%)	61 ± 22	73 ± 21
Weight loss (kg)	37 ± 21	46 ± 20
Maximum weight loss (kg)	48 ± 21	53 ± 20*

Results are means ± SD.
*$p < 0.001$, Student's t-test (applied to maximum weight loss only).

the present analysis, partial or complete blood test results were available in 67% of the DG group and in 64% of the DS group.

Weight Loss

Following DG the initial excess weight loss (IEWL) was 61% ± 22% after 100 ± 20 months; following DS, the IEWL was 73% ± 21% after 51 ± 25 months (Table 3). About 74% of the patients after DG and 87% of patients after DS had lost more than 50% of their initial excess weight. A BMI < 35 was achieved in 72% of patients after DG and in 81% after DS, whereas the BMI was > 40 in 13% of patients after DG and in 6% after DS.

Statistical comparisons were not applied to the above data because of the difference in duration of follow-up and the cumulative weight regain over the years. Nadir weight obtained by questionnaire from all patients showed a maximum postoperative weight loss of 48 ± 21 kg after DG and 53 ± 20 kg after DS ($p < 0.001$). Weight regain following maximal weight loss was revealed by the difference between the nadir weight and the present weight: 11 kg following DG and 7 kg following DS.

To minimize the difference in duration of follow-up, weight loss after DG and DS were compared in the subgroup of patients who underwent the surgical procedure during the year immediately preceding and the year immediately following the change of surgical technique (January 1990). The DG group (108 patients, follow-up 85 ± 3 months) obtained a 63% ± 21% IEWL and the DS group (52 patients without duodenal staple line dehiscence, follow-up 74 ± 4 months) obtained a 70% ± 21% IEWL ($p < 0.001$).

Eating Habits

Most patients eat without impediment after the biliopancreatic procedure (Table 4). Eating habits were not modified after surgery in 46% of patients after DG and in 58% after DS ($p < 0.0001$). The prevalence of vomiting was small: After DG 73% of patients and after DS 89% of patients reported no vomiting during the last months; 8% (DG) versus 2% (DS) reported vomiting more than once a week ($p < 0.0001$).

The BPD afforded some relief from unrelenting appetite. When asked if a change in appetite had occurred after surgery, a large percentage of patients noted a decrease: 41% after DG and 63% after DS ($p < 0.0001$).

Table 4. Responses to questionnaire concerning eating habits after BPD with distal gastrectomy and duodenal switch.

Questions	Distal gastrectomy (n = 252) (%)	Duodenal switch (n = 465) (%)
Food ingestion		
A I eat whatever I want	46	58
B I avoid some foods	39	32
C I avoid many foods	9	7
D I tolerate few different foods	2	2
E I'm severely restricted	3	0
Mean score	4.25	4.47*
Vomiting		
A Almost never	73	89
B Once a month	12	5
C Once a week	7	4
D More than once a week	6	1
E Daily	2	1
Mean score	4.48	4.78*
Appetite compared to preoperation		
A Greatly decreased	11	27
B Slightly decreased	30	36
C Unchanged	32	16
D Slightly increased	15	12
E Greatly increased	11	8
Mean score	3.16	3.64*

*$p < 0.05$ comparing DS and DG, Fisher exact test.

Table 5. Responses to questionnaire concerning consistency of stools after BPD with distal gastrectomy or duodenal switch.

Stool consistency*	Distal gastrectomy (n = 252) (%)	Duodenal switch (n = 465) (%)
A Firm	9	11
B Pasty, rarely liquid	35	39
C Occasionally liquid	26	31
D Frequently liquid	16	13
E Almost always liquid	13	7

*$p > 0.1$ comparing DG and DS, Fisher exact test.

Side Effects

After the biliopancreatic procedure, most patients have more than one bowel movement a day, and stools are seldom solid. The number of daily bowel movements reported was 3.7 ± 1.0 in the DG group and 3.0 ± 1.0 in the DS group ($p < 0.0002$). Diarrhea, defined as more than three stools a day and frequently liquid, was present in 14% after DG and 7% after DS ($p < 0.001$). Stool consistency was similar after both procedures and was reported as pasty and occasionally liquid in almost 60% of patients (Table 5).

After DG, 42% of patients did not consider the frequency of bowel movements to be a problem, and after DS this percentage was 60%. The unpleasant odor of stools and flatus was reported as a major problem by 43% of patients after DG and by 34% after DS (Table 6).

Abdominal bloating was the most frequent side effect reported. One-third of patients after either operation complained of abdominal bloating more than once a week. Heartburn and abdominal pains were experienced more than once a week in about 15% of patients after both procedures. There were no differences in the prevalence of abdominal pain, bloating, or heartburn when com-

Table 6. Patients' own assessment of the severity of problem caused by the frequency of bowel movements and by malodorous stool and flatus after BPD with distal gastrectomy ($n = 252$) or duodenal switch ($n = 465$).

	Frequency (%)		Odor (%)	
Severity of problem	DG	DS	DG	DS
A None	42	59	8	14
B Minor	19	22	17	19
C Annoyance	22	11	32	32
D Major	10	5	20	18
E Intolerable	6	3	23	16
Mean score	3.8	4.3*	2.7	2.9*

*$p < 0.01$ comparing DG and DS, Fisher exact test.

Table 7. Patients' rating of frequency of abdominal bloating after BPD with distal gastrectomy or duodenal switch.

Abdominal bloating	Distal gastrectomy (%) ($n = 252$)	Duodenal switch (%) ($n = 465$)
A Almost never	42	40
B Once a month	11	13
C Once a week	10	11
D More than once a week	23	21
E Daily	15	15
Mean score	3.4	3.4

paring the two procedures (Table 7). Bone pain was reported by 41% of patients after DG and by 29% after DS ($p < 0.003$).

Changes in Daily Life

Beneficial effects following biliopancreatic diversion were reported by most of the patients. Patients after DS reported greater benefits than patients after DG ($p < 0.0001$) for all measured aspects of life (Table 8).

Degree of Satisfaction

When patients were asked to grade their satisfaction specifically regarding their weight loss, 73% of patients in the DG group and 86% of those in the DS group were satisfied ($p < 0.0001$). When patients were asked for a global assessment of the consequence of their surgery, the satisfaction (A, very much satisfied; B, satisfied) was 67% after DG and 83% after DS. The percentage of patients who were not satisfied (D, unsatisfied; E, very much unsatisfied) was 11% after DG and 4% after DS. On a scale of 1 to 5, the mean score for global assessment was 3.76 after DG and 4.28 after DS ($p < 0.001$).

Blood Tests

Blood tests revealed that after both procedures there was a decrease of hemoglobin, serum iron, ferritin, calcium, and vitamin A and an increase of alkaline phosphatase and parathyroid hormone compared to preoperative values. These changes were slightly less pronounced after DS (Table 9).

The number of patients with abnormal results was also lower after DS compared to DG: Iron deficiency was found in 20% of DG patients versus 9% of DS patients; and low serum ferritin was found in 40% of DG patients versus 25% of DS patients. Serum calcium < 2.10 mmol/L was found in 16% of patients after DG versus 8% after DS, and PTH > 90 mg/L was found in 30% of patients after DG versus 17% after DS (Table 10). Similarly, vitamin A deficiency was found in 12% of DG patients versus 5% of DS patients. All these differences were significant ($p < 0.001$).

Table 8. Patients' evaluation of the changes surgery brought to their lives 8 years after BPD with distal gastrectomy or 4 years after BPD with duodenal switch.

	Answered A or B (%)		Answered D or E (%)		Mean score	
Parameters	DG	DS	DG	DS	DG	DS
Self-confidence	67	82	8	4	4.0	4.4*
Acceptance by others	66	78	5	3	4.0	4.3*
Social life	58	77	7	3	3.8	4.3*
Marital relations	36	53	11	8	3.0	3.5*
Sexual relations	40	57	17	11	3.1	3.6*
Ten daily activities	49	71	20	9	3.4	4.1*

Choice of responses: A, greatly improved; B, improved; C, unchanged; D, worsened; E, greatly worsened.
*$p < 0.001$, Student's *t*-test.

Revision Rate

The number of patients who underwent surgical revision for malabsorption or diarrhea after biliopancreatic diversion was less in the DS group. The yearly revision rate during the first 6 years was 1.7% in the DG group and 0.1% in the DS group. The yearly hospitalization rate (without surgery) for malabsorption or diarrhea during the first 5 years decreased from 1.72% after DG to 0.93% after DS.

Other Long-term Morbidity

Prior to 1992 gallbladders that had been left in situ were later removed in 50% of patients after either type of procedure. Pancreatitis was diagnosed in 0.4% of patients after DG and in 1.7% of patients after DS. Duodenal staple line disruption occurred in one-half of patients who underwent duodenal switch with duodenal stapling without duodenal transection (1990–1992). Duodenal recanalization resulted in cessation of weight loss and subsequent weight gain; and these patients underwent reoperation to staple and transect the duodenum, thereby restoring the duodenal switch.

The prevalence of kidney stones was the same for both procedures. It was found to be 7% preoperatively and 9% postoperatively. The prevalence of bone fracture, at 2% per year, was the same for both procedures.

Outcome of Co-morbid Conditions

The two procedures were equally efficient in treating co-morbid conditions. After the procedures, 69 of 72 diabetic patients no longer required medical treatment. Among the three patients still requiring treatment, two are now on oral medication instead of insulin. Preoperatively, fasting blood sugar > 6 mmol/L was present in 35% of patients, and postoperatively in only 3%. Preoperatively, medical therapy of hypertension was required in

Table 9. Biochemical changes after BPD.

Test	Lab normal	Preoperation		Post-DG		Post-DS	
		No.	Result	No.	Result	No.	Result
Hemoglobin (g/L)	140 ± 20	592	138 ± 14	168	125 ± 14	298	131 ± 14
Ferritin (μg/L)	120 ± 100	56	93 ± 136	159	36 ± 54	286	67 ± 94*
Fe (μmol/L)	22 ± 13	32	14 ± 7	163	11 ± 5	293	13 ± 6
Vitamin B_{12} (pmol/L)	350 ± 100	473	284 ± 115	148	280 ± 144	251	294 ± 147
Ca (mmol/L)	2.30 ± 0.15	536	2.28 ± 0.71	167	2.16 ± 0.14	295	2.22 ± 0.12*
P (mmol/L)	1.18 ± 0.31	55	1.0 ± 0.4	161	1.03 ± 0.2	279	1.13 ± 0.2
Alk Ph (U/L)	60 ± 30	545	77 ± 47	167	101 ± 51	285	105 ± 51
PTH (mg/L)	35 ± 25	0	—	147	108 ± 83	228	78 ± 65*

Preoperation: the whole group; the others are means obtained 8 years after BPD with DG and 4 years after BPD with DS. Results are the means ± SD.

*$p < 0.001$ comparing DS to DG, Student's *t*-test.

Table 10. Prevalence of patients with abnormal laboratory results before and after BPD with distal gastrectomy or duodenal switch.

Test	Abnormal levels	Preop (%)	Post-DG (%)	Post-DS (%)
Hemoglobin (g/L)	< 100	2	9	6
Ferritin (μg/L)	< 20	4	40	25*
Fe (μmol/L)	< 6	13	20	9*
Vitamin B_{12} (pmol/L)	< 110	3	3	3
Ca (mmol/L)	< 2.10	4	16	8*
P (mmol/L)	< 0.8	0	4	2
AlkPh (U/L)	> 200	2	3	3
PTH (mg/L)	> 90	—	30	17*

*$p < 0.001$ between the two groups, Fisher exact test.

91 patients and postoperatively in only 38 patients. Preoperatively, hypercholesterolemia (> 6 mmol/L) was present in 23% of patients, and postoperatively in only 0.7%. Preoperatively, 51 patients required medications for respiratory conditions, whereas postoperatively only 26 patients still used them.

Correlations with Duration of Follow-up

Correlations were sought between the time elapsed since surgery and the responses to the questionnaire. Within each surgical group (DG, DS) the elapsed time since surgery exerted no detectable influence on the intensity or frequency of benefits and side effects.

On the other hand, a similar statistical test showed fewer metabolic disturbances with more time elapsed since surgery. In the DG group there was a significant correlation between time elapsed since surgery and higher hemoglobin ($n = 145, r = 0.31, p < 0.0001$) and albumin ($n = 145, r = 0.22, p < 0.009$) levels and lower values for alkaline phosphatase ($n = 144, r = -0.20; p < 0.02$). Similarly, in the DS group there was a correlation between higher serum levels of vitamin B_{12} ($n = 134, r = 021, p < 0.01$) and phosphate ($n = 123, r = 0.47, p < 0.02$) and the time elapsed since surgery.

Discussion

There is evidence that surgical treatment of morbid obesity not only improves quality of life [10] but also prevents death [11]. Although the role of surgery is being recognized, there are still insufficient data to establish the superiority of any one procedure over another. Biliopancreatic diversion became our procedure of choice because it offered a major advantage compared to restrictive surgical procedures in that it allowed patients to continue eating normally. Furthermore, restrictive procedures, although preventing normal eating habits, often did not result in successful weight loss for those in greater need of it (those with greater initial BMI) [12, 13]. Gastric bypass procedures, with or without long Roux-Y, although adding a degree of malabsorption to the restriction, also relied chiefly on restriction [14–16]. It remains difficult to assign a value to the ability to eat normally, and a comparison with another procedure based on a principle of severe restriction of oral intake may not be valid. Patients who chose between disabling diarrhea and a loss of normal eating habits and underwent surgical conversion of their jejunoileal bypass to a restrictive procedure have experienced both surgical approaches. Some have expressed dissatisfaction with the loss of unimpeded oral intake [17].

Despite the fact that patients were pleased with the results following BPD with distal gastrectomy, we sought to minimize the digestive symptoms that could be attributed to the gastric resection and the short gut. The sleeve gastrectomy with the duodenal switch and lengthening of the common channel were shown to cause less disturbance of eating habits and bowel habits. It was expected that weight loss would be less because the common limb was longer, but the loss of weight was greater after DS. Metabolic disturbances were slightly decreased, and the number of surgical revisions for malnutrition or diarrhea was greatly diminished. All of these factors contributed to a greater improvement in quality of life after duodenal switch, which in turn enhanced patient satisfaction.

The comparison of the evolving outcome of two bariatric procedures without randomization, particularly when successive modifications are added, is mitigated by the effect of time on patient evolution and on factors such as the expertise of the surgical team and the quality of medical care. Despite this limitation we interpret the present data as showing improved outcome, at least in part, as a result of the surgical modifications.

Because of the simultaneous modifications to the biliopancreatic diversion, it was not possible to ascribe the benefits specifically to the sleeve gastrectomy, the duodenal switch, or the longer common channel. That greater weight loss should be observed with a longer common limb suggests that the new gastric reservoir has been a significant factor. The sleeve gastrectomy decreased the volume of the gastric reservoir but preserved the antropyloric

pump. In the DS group we reported hastened gastric emptying of a radiolabeled solid meal compared to that in the controls and in the DG patients [18]. Vagal continuity was preserved, and the duodenal switch introduced a short segment of duodenum in the alimentary channel. All these factors may have contributed to enhanced satiety, or it may be that rapid gastric emptying reduced intestinal transit time and enhanced the malabsorptive effect of the biliopancreatic diversion. Thus many hypotheses may be proposed to explain the greater weight loss observed. Duodenal staple line failure, as seen in some of our patients, resulted in weight regain, which suggests that the basic mechanism responsible for weight loss remained diminished absorption of nutrients and fat.

Although patients with DS had fewer side effects overall than those with DG, the new technique did not improve the most annoying side effects of BPD: abdominal bloating and malodorous stool and flatus. These symptoms were thought to be a major problem by one-third of patients. Despite some improvement by avoidance of fat and high fiber food and by the occasional use of metronidazole, this problem may have had a negative impact on the quality of life.

The new technique improved but did not solve the problem of insufficient absorption of iron and calcium in some patients. Iron malabsorption is relatively easy to manage medically with oral and occasionally intramuscular iron. Malabsorption of calcium and vitamin D remains a major concern. From the present data it is evident that BPD presents a challenge to bone, as evidenced by lower serum calcium levels and increased alkaline phosphatase and parathyroid hormone. So far, the incidence of bone fracture has been 2% per year, which was within normal limits for the general population [19, 20]. Furthermore, the correlations of lower alkaline phosphatase levels and the higher phosphate levels with greater time elapsed after surgery may represent a positive trend. Continued follow-up is needed to measure the clinical impact.

The BPD is a major operation for a severely debilitating disease. It improves the health and well-being of most of these patients and results in a remarkable degree of patient satisfaction. The construction of a BPD with a sleeve gastrectomy and duodenal switch instead of a distal gastrectomy has improved the clinical outcome.

Much remains to be studied and understood, such as the optimal length of the alimentary and common limbs required for each patient and effective supplementation of fat-soluble vitamins, iron, and calcium. Long-term side effects, particularly with regard to bone metabolism, require continuous study and must be compared with those seen after other bariatric procedures. The potential late sequelae must then be weighed against the overall improvements in quality of life and the continued pleasure of eating normally.

Conclusions

Biliopancreatic diversion with a sleeve gastrectomy, a duodenal switch, and a 100-cm common channel was shown to produce better results than biliopancreatic diversion with a distal gastrectomy and a 50-cm common channel. Weight loss was greater, side effects were decreased, and malabsorption was less significant. Abdominal bloating and malodorous stools were not diminished and remained the most unpleasant side effects. Although less marked after DS, decreased calcium absorption remains the long-term concern after BPD.

Résumé

En 1990, nous avons modifié la technique de Scopinaro, c'est à dire, la diversion biliopancréatique avec gastrectomie distale et anastomose gastroiléale. La gastrectomie en manchon avec inversion duodénale («duodenal switch» = DS) a remplacé la gastrectomie distale; on a rallongé la longueur de l'anse en commun à 100 cm au lieu de 50 cm. Un questionnaire et une ordonnance pour effectuer un bilan sanguin ont été envoyés à 252 patients qui ont eu une gastrectomie distale 8.3 ans auparavant en moyenne (extrêmes 6 à 13 ans) et à 465 patients qui ont eu une inversion duodénale 4.1 ans auparavant en moyenne (extrêmes 1.7 à 6 ans). Le taux de réponse au questionnaire a été de 93% et les examens sanguins ont été réalisés chez 65% des patients dans chaque groupe, respectivement. La perte de poids (moyenne) a été de 37 ± 21 kg après gastrectomie distale et de 46 ± 20 kg après inversion duodénale. Les effets secondaires ont été moindres après inversion duodénale, le nombre de selles était plus bas ($p < 0.0002$), de même que la prévalance de diarrhée ($p < 0.01$), des vomissements ($p < 0.001$) et des douleurs osseuses ($p < 0.001$). La qualité de vie a été améliorée après inversion duodénale par rapport à la gastrectomie distale ($p < 0.0001$). Les niveaux sanguins de ferritine, de calcium, de vitamine A étaient plus élevés ($p < 0.001$) et les niveaux de parathormone plus bas. Le pourcentage de révisions chirurgicales précoces nécessitées par une malabsorption a été de 1.7%/an après gastrectomie distale et de 0.1%/an après inversion duodénale. Les deux procédés ont été aussi efficaces pour traiter les conditions pathologiques (de co-morbidité) comme le diabète, l'hypertension et l'hypercholestérolémie. On a observé plus de perte de poids et moins d'effets secondaires avec la diversion biliopancréatique avec gastrectomie en manchon et inversion duodénale.

Resumen

En 1990 se modificó la técnica de Scopinaro de desviación biliopancreática con gastrectomía distal (GD) y gastroileostomía, mediante un cambio a gastrectomía tubular y duodenal ("duodenal switch", DS) en vez de la GD con aumento de la longitud del canal común a 100 cm en vez de 50 cm. Un cuestionario acompañado de prescripción para exámenes de sangre fue enviado a 252 pacientes sometidos a GD 8.3 años antes (rango 6 a 13) y a 465 sometidos a DS 4.1 años antes (rango 1.7 a 6). La tasa de respuesta del cuestionario fue 93% y el 65% de los pacientes completaron los exámenes de laboratorio. La pérdida promedio de peso luego de GD fue 37 ± 21 kg y luego de DS fue de 46 ± 20 kg. Los efectos secundarios aparecieron menos pronunciados luego de DS: el número de deposiciones diarias fue menor ($p < 0.002$), como lo fue la prevalencia de diarrea ($p < 0.01$), vómito ($p < 0.001$) y dolor óseo ($p < 0.001$). Se registraron mayores beneficios pertinentes a diversos aspectos de la vida, luego de DS que de GD ($p < 0.0001$). Los niveles séricos promedios de ferritina, calcio y vitamina A aparecieron superiores ($p < 0.001$) y los de parathormona inferiores. En una revisión anual, la tasa de malabsorción excesiva fue 1.7%/año luego de GD y de 0.1%/año luego de DS. Los dos procedimientos probaron ser igualmente efectivos en el control de condiciones co-mórbidas tales como

diabetes, hipertensión e hipercolesterolemia. La desviación biliopancreática con gastrectomía tubular/"duodenal switch" y un canal común de 100 cm demostró mayor reducción de peso con menos efectos secundarios.

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