# Laparoscopic Biliopancreatic Diversion

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## Introduction

In March 1991, the National Institutes of Health (NIH) organized a Consensus Conference on Bariatric Surgery, in which it was determined that because of their efficacy and low surgical risk, vertical banded gastroplasty (VBG) and gastric bypass (GBP) constituted the therapies of choice. (1) Since then, these procedures have been widely used in the United States, and several authors have reported favorably on them.(2-8) More recently, Brolin (9) criticized the criteria that led the NIH in 1991 to support the routine use of VBG and GBP, stressing the relative efficacy regarding long-term weight loss obtained with these procedures, and asked for a reassessment of the possible applications of biliopancreatic diversion (BPD) and other laparoscopic techniques.

These contradictory conclusions demonstrate that so far a consensus has not been reached by the scientific community regarding the choice of surgical intervention. In contrast to the United States, the BPD has greater importance worldwide in the spectrum of bariatric procedures. The BPD procedure can be performed laparoscopically. After a learning curve of 50 cases, the average operative time is approximately 1 to 2 hours in our own series. After failed pure restrictive procedures, the BPD seems to be the only long-term solution for morbidly obese patients.

## History of BPD

Jejunoileal bypass (JIB) was the prototype of the malabsorptive approach procedures. There were several steps in the development of the JIB. In all instances, an extensive length of small intestine was bypassed, not excised, excluding it from the alimentary stream. By the late 1970s, surgeons had gained from the JIB experience and learned what not to do in order to achieve surgical weight loss. The next major bariatric surgical weight loss procedure to emerge came out of Italy in 1976. Dr. Nicola Scopinaro of the University of Genoa revised the JIB procedure so that most of the small intestine remained intact, thus reducing the chances of liver or kidney problems.

To achieve maximum weight loss, Scopinaro's procedure used two components instead of one. First, approximately ⅔ of the stomach was removed to moderately restrict the amount of food that could be consumed at one time. Then, the outlet to the stomach was connected to the final segment of the small intestine. By diverting food through this new "limb," the nutrients were effectively separated from the bile and pancreatic enzymes that would break them down. As a result, BPD greatly reduced nutrient absorption, mainly the assimilation of fat, and therefore caloric intake.

The first to combine the restriction of food intake and malabsorption, BPD is also the first procedure to remain in usage (albeit limited) more than 2 decades after its advent. In 1996, Scopinaro reported that after 18 years of follow-up, his patients maintained an excess weight loss of 72%.(10) According to the American Society of Metabolic and Bariatric Surgery (ASMBS), BPD has yielded the best long-term results published to date.

The BPD is also unique because it is the only current procedure that allows the patient to eat normal quantities of food and still achieve excellent weight loss. But there is a catch. The procedure still carries some of the malabsorptive complications of JIB,

including loose stools, malodorous gas, and serious deficiencies in protein and minerals such as calcium. Patients who undergo BPD must take vitamins and calcium supplements for the rest of their lives in order to avoid malnutrition and bone demineralization.

In 1993, a group of Canadian doctors published the first results of a modification of the BPD procedure, known as the biliopancreatic diversion with duodenal switch (BPD-DS). The BPD-DS preserves the pyloric valve that connects the stomach to the beginning portion of the small intestine. In addition, physicians increase the length of the intact small intestine up to 75 to 100 cm. The main effect seems to be related to the restriction of the gastric sleeve. The malabsorption is mild and plays a downgraded role in weight loss. The restriction by a sleeve gastrectomy alone can achieve nearly the same weight loss. Therefore, BPD and BPD-DS are completely different procedures.

Nonetheless, BPD and BPD-DS are still the most extreme bariatric surgical weight loss procedures in use. Although BPD and BPD-DS produce profound weight loss, both also carry high risks of nutritional and metabolic problems if the supplementation is missed or insufficient. This has lead researchers to continue searching for an even safer approach for surgical weight loss. Presently, the BPD has increased use in Europe and South America, but is less in practice in the United States. The BPD is not currently covered by US insurers.

In the United States, the biliopancreatic diversion with duodenal switch (DS) has gained more interest, however, the operation is completely different than the original BPD in the Scopinaro technique. The number of surgeons performing DS in the United States has increased in the past few years, and its use continues to expand based on patient demand and growing awareness of the advantages of established hybrid procedures. Currently, RYGB is the most widely used bariatric operation in the United States; however, the number of centers offering DS is increasing. The ASMBS 2002 membership roster listed approximately 50 surgeons who offer DS, and the 2003 roster listed 104 surgeons offering the procedure. Most bariatric surgeons already have substantial experience with RYGB before beginning to perform DS, and the fact that the already large number of ASMBS members offering DS doubled in 1 year reflects widening recognition and acceptance of the superior weight loss and quality of life. The absence of any risk for dumping syndrome plays an important role in choosing the type of procedure. The sleeve gastrectomy as a part of the DS plays an important role for initial weight loss. The restriction is the main effect in the DS, with a common channel of 100 cm. These patients can have weight regain after several years like with all other mainly restrictive procedures. The original BPD in the Scopinaro technique is the only procedure that warranted lifelong weight loss. There are fundamental differences between the DS and the BPD. First, it is necessary to classify the procedures.

## Categorization of Bariatric Operations

1. **Purely malabsorptive procedures.** The most well-known and widely used purely malabsorptive procedure, JIB, involves bypassing all but 45 cm of small bowel. It has been associated with up to 8% mortality from hepatic and renal failure, and has largely been abandoned.(11-14)
2. **Purely restrictive operations.** Laparoscopic gastric banding (adjustable and nonadjustable), VBG, and the sleeve gastrectomy are purely restrictive procedures. As originally developed, the Roux-en-Y gastric bypass (RYGB) is also primarily and mainly restrictive, as weight loss results from constructing a very small (15–20 cc) proximal gastric pouch to limit the capacity of oral intake. But there is malabsorption of micronutrients (iron, calcium), maldigestion of proteins (lack of gastric acid to break muscle fibers of red meat), and some other

hormonal effects (hormonal diversion of [GLP-1], GLP-6), and other gastrointestinal hormones as well; therefore, it should be classified as a hybrid procedure.

3. **Hybrid Procedures.** Operations that incorporate both restriction and malabsorption may be classified as "hybrid" procedures:

   3.1. Mainly malabsorptive procedure with mild restriction: BPD (gastric volume 200–250 cc).

   3.2. Mainly restrictive procedure with mild malabsorption of micronutrients (iron, calcium): proximal gastric bypass (RYGB, one-anastomosis gastric bypass), with its reliance on restriction alone, has yielded inadequate long-term maintenance of weight loss in many surgeons' experience. Accordingly, surgeons who offer RYGB operations have more recently included variable amounts of small bowel bypass, and revisionary surgery for RYGB failure may include lengthening of the bypassed limb. The latter procedures may be termed "distal" RYGB. There are severe, long-term nutritional complications, especially protein deficiency, if restriction and malabsorption are combined.

   3.3. Restritive procedure with (mild) malabsorption: DS (gastric volume 50–90 cc; common channel 75–100 cm).

   The operation known as duodenal switch, or DS, was developed in 1988 by Hess of Bowling Green, Ohio, and was first published by Marceau et al. in 1993. (15) Hess (16) incorporated three main components into the DS:

   1) Vertical gastrectomy with excision of the greater curvature significantly reduces gastric volume and thus provides restriction.

   2) Division of the duodenum between the pyloric valve and the sphincter of Oddi allows for a normally functioning but smaller capacity stomach. Food empties into the small intestine under control of normal pyloric innervation and relaxation.

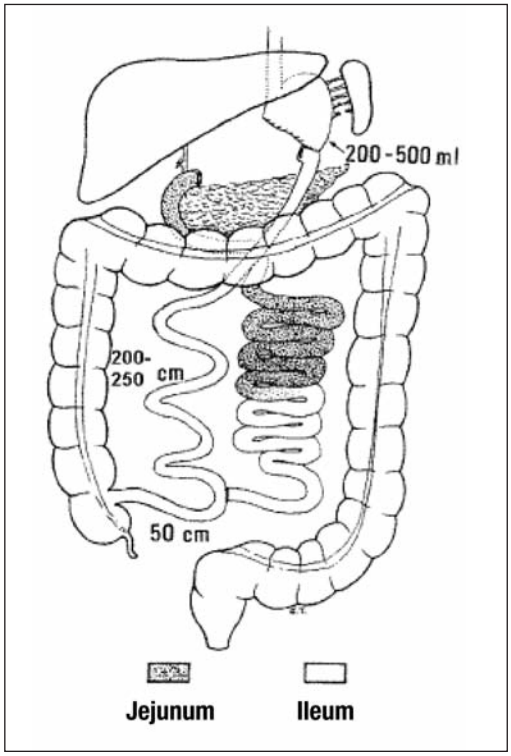
   3) Bypass of proximal small bowel produces malabsorption and was derived from experience with BPD. The first laparoscopic DS was performed by Gagner in 1999.(17)

   3.4. Malabsorptive and restrictive: Distal RYGB is constructed similar to RYGB, with a shorter common limb and extended length of bypassed small bowel. After an excellent initial weight loss, severe metabolic long-term complications will occur. The main problem is protein deficiency.

## Principles of BPD (Scopinaro)

Biliopancreatic diversion consists of a distal gastrectomy with long Roux-en-Y recontruction, where the enteroenterostomy is placed 50 cm proximal to the ileocecal valve (Figure 1). Both the volume of the gastric remnant and the length of the so-called alimentary limb, which are partly responsible for the level of weight stabilization, are adapted to patients' individual characteristics (ad hoc stomach, ad hoc alimentary limb BPD, in use since September 1992). The mechanism of action of BPD essentially consists of limiting fat, starch, and thus energy absorption while preserving the intestinal absorption of protein and noncaloric essential aliments. A constant maximum energy absorption capacity exists after BPD, which guarantees both weight loss and indefinite weight maintenance (10).

FIGURE 1.




Biliopancreatic Diversion

## Open Laparotomy vs. Laparoscopy

Long, conventional, abdominal incisions have been superseded in many centers by small incisions, made possible by technical advances in video equipment and surgical instrumentation. Patient preference for laparoscopic approaches is based on consistently decreased perioperative discomfort, shortened hospital stay, and smaller scars. An important principle of laparoscopic surgery is that the procedure performed within the abdomen should remain identical whether conventional laparotomy or laparoscopy is used. A principle enunciated at the time that laparoscopy was adapted to Nissen fundoplication—that only the access route will differ—has remained a guiding tenet. Other than measures specific to the wound, intermediate and long-term indicators should be the same when comparing laparoscopic with open laparotomy groups. In the author's facility, open BPD after previous gastric surgeries and laparoscopic BPD technique are consistent with this tenet, using identical suture material, staplers, and volume and length measurements regardless of whether long midline or laparoscopic incisions are employed. We started with laparoscopic BPD in 2001 along with other groups in Italy, Belgium, and Spain.(18)

## Technique

The patient is placed in the reverse Trendelenburg position on an operating table approved for the patient's body weight. Video monitors are positioned on the right and left side, above the patient's shoulders. The right arm is placed in a stretched-out position. A transurethral urinary catheter is placed, and the surgical site is disinfected repeatedly. Cephalosporin is given for antibiotic prophylaxis.

The pneumoperitoneum is established in the left supraumbilical region until intra-abdominal pressure is at 15 mm Hg. The port placement is more distal than in standard gastric bypass surgery. It is essential that there be sufficient free space in the cranial position to permit free access to the gastroileal anastomosis. Accordingly, the initial port should be placed at an approximate distance of more than 18 cm from the xiphoid. The 15-cm (extra-long) trocar is especially well suited for use in patients with a body mass index (BMI) >50 kg/m$^2$.

The other trocars are then placed successively. Once the camera trocar port is established, a 10-mm trocar for insertion of the liver retractor is placed below the right costal arch. The liver retractor is then securely attached to an instrument holder and can also be used to elevate the greater omentum. Subsequently, a 10-mm trocar is placed at the lateral abdominal wall below the left costal arch. The two epigastric working trocars (10 mm) are inserted such that they provide an optimal working angle for surgical maneuvers in the area of the gastric angulus. The distance between the working trocars should be large enough to avoid any obstructions. Usually, HOPKINS rod-lens telescopes with 30° and 45° directions of view are inserted. The use of extra-long telescopes (42 cm) and extra-long instruments (43 cm) can be an advantage, particularly in obese men.

The left subhepatic region is exposed using the liver retractor, which is securely attached to the instrument

holder. Due to the frequent presence of hepatic steatosis, sturdy and extra-long retractors must be used in this step. The authors prefer the use of retractor 30623 UR (Karl Storz, Tuttlingen, Germany) because of its large and atraumatic contact surface.

Once inspection of the abdomen is completed, the antrum and corpus of the stomach are exposed. If there were severe adhesions in the pelvis after previous gynecological or other procedures, the surgery should start in the cecal region. For this the patient will be placed in Trendelenburg position. The surgeon will stand at the left side of the patient. If there are no adhesions of the small intestine, the surgery can start with the dissection of the stomach. The anatomical landmarks, such as the antrum, angulus (crowfoot), and lower margin of the spleen are then identified. Dissection starts at the greater curvature using a Harmonic scalpel. After entry into the lesser sac, the stomach has to be mobilized.The lower vasa brevia are transsected using an ultrasonic dissector. The dissection of the greater curvature leads to a mobilization of the proximal stomach. The stomach can be pulled down and the tension on the gastroileostomy can be avoided. The lesser curvature is then exposed.

Next, the lesser gastric curvature is dissected approximately 3 to 4 cm distal from the gastro-esophageal junction and extended into the omental bursa using the ultrasonic dissector under constant endoscopic vision. Usually, the adequate dissection site is located distal to the sinistral gastric artery. The stomach is completely transected using multiple cartridges of a linear cutter-stapler (length 45 or 60 mm, green or gold cartridges, Figure 6), creating a proximal gastric pouch of 200 to 250 cc. After a horizontal resection, starting at the greater curvature using a 60-mm stapler, the next staplers will be inserted into the direction of subcardial region at the lesser curvature. The resection of the lesser curvature plays an important role in reduction of gastric acid production. In 1934, Berger described the distribution of parietal cells in the human stomach.(19) While it is clear that the body of the stomach has a plentiful oxyntic cell count, it is equally apparent that the lesser curvature (the "Magenstrasse") of the stomach has a higher concentration of these cells than the cardia of the stomach, which has few parietal cells. Therefore, the resection of the angulus and the lesser curvature seems to be critical in reducing gastric acid production and the frequency of stomal ulcers.

Currently, the preferred gastric volume ranges between 200 and 250 mL. A nasogastric tube can be useful during this step in cases of massive intra-abdominal fat to protect the gastroesophageal junction. For calibration of the 200-mL pouch some surgeons using calibration balloons.(20)

Intraoperative hemorrhage from the staple line is frequent, but hemostasis must not be provided by electrocautery (ECT) since this may induce delayed necrosis. Clips can be applied for temporary management of spurting vessels. Oversewing of the staple line or clip application are more reliable methods.

Staple-line reinforcement is helpful in preventing staple-line bleeding.

Consequently, Scopinaro (in the original papers) and surgeons performing open BPD advise complete resection of the antrum with closure of the duodenum. This also prolongs the duration of the surgery, increases the complexity of the procedure, especially in the laparoscopic approach, and may occasionally entail the life-threatening duodenal stump insufficiency. Therefore, some surgeons start to lead the antrum in place (R. Steffen, F. Favretti, personal communications). We have done a series of 39 patients also without resection of the antrum. Under anti-acid medication we haven`t seen any complications in these patients during the last 5 years compared with the 84 patients in which the antrum was resected.

## Measuring the Common Channel and the Alimentary Limb

Next, the Bauhin valve is identified followed by measurement of the ileum (common channel) and

fixation of a marker-stitch of a 50-cm length from the Bauhin valve. The measurement can be done by using special instruments or by means of 25-cm or 50-cm long markers. The measurement is done in a "middle stretched" situation and at the mesentery side. It must be exactly 50 cm. In case of 40 cm and 60 cm, severe malnutrition and poor weight loss, respectively, will follow. Thereafter, the continuity of the small intestine will be divided 250 cm from the Bauhin valve by means of linear stapling device white cartridges. The oral end will be fixed to the marker of the common channel. The distal end of the small intestine will be fixed by a stay suture to the greater curvature of the stomach.

## Enteroenterostomy

The enteroenteral anastomosis is created by applying the side-to-side technique using a 45-mm linear stapler. For this purpose, an incision must first be placed in the antimesenteric aspect of the jejunum. Once the jejunal limbs are aligned parallel, the linear stapler is then inserted into each limb, and a continuous suture is applied to close the remaining enterotomy. At this site, it is difficult to perform a leak test by use of methylene blue solution. As such, profound proficiency in laparoscopic technique is mandatory. It is important to check for any hemorrhage from the staple line prior to closure of the enterostomy. Any hemorrhage must be stopped by placement of a suture. It is also important not to generate a dead end to avoid manifestation of symptoms of blind limb syndrome. The completed anastomosis should be free of any signs of leakage when pressure is exerted on it.

## Changing the Surgeon's Position

After changing the patient's position from Trendelenburg to reverse Trendelenburg, the surgeon positions him/herself between the patient`s legs with the assistant on the left side and the scrub nurse on the right side of the patient.

## Gastroileostomy

The oral and the aboral limbs must be identified unambiguously. After correct identification, the aboral limb is fixed by a stay suture to the stomach to ensure that the surgeon does not lose orientation in the further course of the procedure.

The consequences of any mishaps would be disastrous.

There are two general types of gastroileostomy:

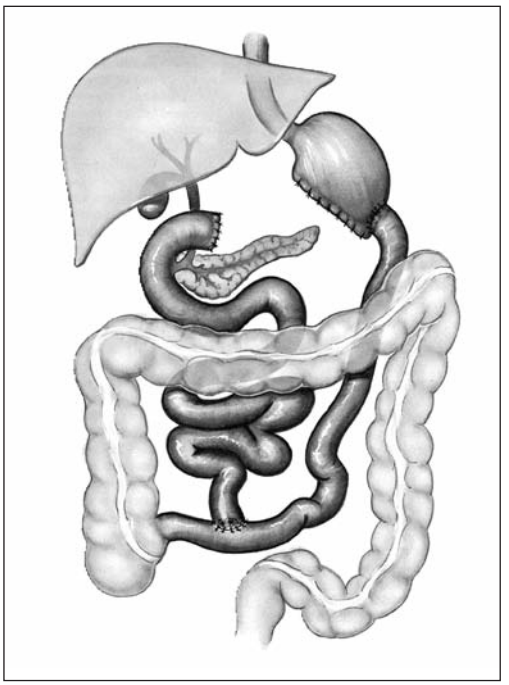
1. Antecolic (preferred by the author)
2. Retrocolic

In terms of technique, the following types of anastomoses can be distinguished:

1. Linear side-to-side anastomosis stapling technique (Figure 2)
2. Hand-sewn anastomosis

The circular stapling technique is very difficult because the ileum is very small for insertion of an anvil.

**FIGURE 2**



Gastroilesotomy linear side-to-side anastomosis stapling technique

The opening in the intestinal limb must be created far enough on the mesenteric side to facilitate insertion of the stapler. The stapler is inserted while the limb is secured in position with forceps. A gentle, twisting motion may facilitate passage of the stapler.

Preliminary placement of fixation sutures can be helpful, ensuring that no undue tension is produced while the stapler is introduced (Figure 2).

After completion of the anastomosis, the stapler must be removed very carefully since tactile sensitivity may be attenuated at this point. The diameter of the anastomosis should be at least 8 mm. In the course of more than 100 successive procedures, the authors have inserted an 8-mm nasogastric jejunal probe for determination of the anastomotic size only. After completion of the anastomotic suture and laparoscopically controlled removal of the probe, the authors dispensed with postoperative reinsertion.

To an increasing degree, surgeons dispense with internal drainage of the anastomosis. In this case, the anesthetist verifies mobility of the tube. To achieve adequate decompression, it is advantageous to place the lateral openings of the nasogastric tube inside the ileum. The nasogastric tube is fixed to the patient's nose.

Since postoperative anastomotic insufficiencies are associated with high rates of morbidity and mortality, a leak test with methylene blue solution is performed during the operation. For this purpose, clips are applied to briefly exert pressure on the ileum at the distal end of the nasogastric tube. At least 250 mL of methylene blue solution are injected under pressure through the nasogastric tube. Any leakage detected requires immediate repair by manual seromuscular suture.

As an alternative leak-test method, air may be insufflated while the area of anastomosis is submerged under water. In general, fixation sutures should be placed between the descending ileal limb and the gastric pouch to ensure that traction on the anastomosis from the weight of the mesentery is reduced when the patient is mobilized early.

Superior mastery of suture skills and sturdy needle holders are fundamental to ensure that the suture is safely placed, even under extreme working angles. In the hands of the authors, the 26173 KC KOH Macro Needle Holder (Karl Storz) produces outstandingly good results.

## Additional Cholecystectomy

If not previously performed, the last step is a routine cholecystectomy, clipping the cystic duct and artery after confirming the anatomy with an intraoperative cholangiogram.

## Additional Appendectomy

If not previously performed, the appendix vermiformis is resected by means of linear stapler. Performing an appendectomy at a later time will be more difficult due to adhesions and pain in the right lower quadrant of the abdominal cavity as a result of the previous surgery.

## Closure of Mesenteric Windows

All mesenteric windows were then closed with non-absorbable sutures. We prefer silk 0.

One or two drains are placed, one near the gastroileal anastomosis and the other near the entero-enteroanastomosis.

## BPD as Revisional Surgery After Failed Restrictive Procedures

Revisional bariatric surgery is technically demanding. The most commonly performed revision operation following failed VBG or gastric banding was gastric bypass. There are a number of reports for BPD-DS as a revisional surgery as well.

The incidence of complications in these revision surgeries was high, especially if the staple lines were crossing old staple lines and areas of band migrations. Therefore, the BPD seems to be the safest and easiest version of a revisional surgery. Far away from severe adhesions and staple lines, the surgery can be performed in a region of native stomach. In the past, VBG and adjustable gastric banding have frequently converted to a RYGB followed by effective weight loss

in the short term.(21) But all restrictive procedures, including gastric bypass, are followed by weight gain after several years. It is known that BPD to date is the most effective bariatric operation in terms of excess weight loss (EWL) and long-term weight maintenance. Therefore, it makes sense that revision to a BPD can be offered to patients who have had failure of previous restrictive surgery. This idea is not new. Fox and Fox(22) used this option in the 1980s and published the experiences in 1991. In our experiences, 14 of 21 cases after VBG were performed totally laparoscopically.

## Postoperative Period

Postoperative care of the patients was conducted in the ICU for the next 16 hours. Since tachycardia occasionally is the only sign of significant problems, postoperative monitoring in the ICU is of particular importance. The patient should be mobilized on the evening of the day of surgery. The high incidence of atelectasis and low oxygen saturation often makes breathing exercises (e.g., Triflow) necessary for tachycardia patients. All patients should be given thrombosis prophylaxis and low-molecular–weight heparin (at a dose adjusted to body weight).

The nasogastric tube was not used in all cases but it is removed ≤24 hours after surgery and liquid alimentation can be given on day 2 without x-ray contrast imaging. The drainage is removed 36 hours after the operation. Postoperative alimentation must be restricted to fluids (e.g., soups). On postoperative days 14 through 21, a bland diet can be initiated (white meat, cooked fish; easily digestible, low-fiber foods; and no raw vegetables or fruit).

Wound infections at the trocar site after laparoscopic surgeries are very rare (<1 %).

Serious disturbances of the wound-healing process after open revisional surgeries are rare, but the occurrence of hematomas and seromas is quite common. For this reason, we normally continue draining the subcutis after open revisional surgery in most patients for 1 to 2 days to reduce the incidence of wound-healing disturbances.

In the event of subcutaneous fluid collection, we attempt drainage by slightly spreading the wound margins.

Occasionally, stenosis of the gastrojejunostomy is encountered in the early postoperative phase. Balloon dilation of the stenosis under endoscopic control may be indicated in some patients.

All patients received anti-acid medication during hospital stay and for the next 3 months. In cases with antrum in place, the anti-acid medications were continued at least 18 months after surgery.

The mean hospital stay in our practice is 5 days.

## Results

Biliopancreatic diversion operation outcomes with respect to weight loss and improvement of quality of life are convincing, provided the operation is performed at centers with a sufficiently large patient

**TABLE 1.** PERSONAL EXPERIENCES WITH LAPAROSCOPIC ADJUSTABLE GASTRIC BANDING, GASTRIC BYPASS, BPD, AND BPD-DS

| | Band | RYGB | BPD | BPD-DS |
|---|---|---|---|---|
| **N** | 1,498 | 1,088 | 102 | 186 |
| **Age in y** | 37.9 (15-76) | 38.2 (15-83) | 43.2 (19-62) | 39.5 (19-63) |
| **Mortality 30 days (%)** | 0 | 0 | 0 | 1.1 |
| **Mortality 1 year (%)** | 0.1 | 0.3 | 0 | 0.5 |
| **Hospital morbidity (%)** | 4.5 | 16.7 | 15.3 | 24.5 |

population. The general rate of complications (e.g., thrombosis, embolism, postoperative hernia) after laparoscopic procedures is clearly lower compared with the patient population subjected to laparotomy. The laparoscopic approach requires the surgeon to have special expertise and practical skills, and the learning phase is quite long. In our experience, the mortality and morbidity is at the same level as the RYGB and lower than the BPD-DS (Table 1).

Weight loss outcomes for the BPD are impressive. Laparoscopic conversion surgery after BPD rarely occurs.

The extremely long duration of the surgery with the patient in the reverse Trendelenburg position accounts for the relatively high rate of complications and lethality, aside from the challenging nature of the procedure. If the duration of surgery is allowed to extend for a very long period, deep vein thrombosis and other thromboembolic complications must be anticipated.

The rate of complications is in the range of 6.7% to 15%, as far as the laparoscopic approach is concerned.

## Morbidity and Mortality

The risk of complication is a factor of great concern in bariatric surgery. In our experience, early complications are practically confined to the BPD group, including two early reinterventions. Most of our early complications concern our initial experience, in particular the cases of postoperative gastric bleeding, which were due to incomplete hemostasis on the gastrointestinal stapled anastomosis line, as previously reported.(23)

Thromboembolic complications, recorded throughout the literature for all types of interventions, are known to be the most common cause of mortality in bariatric surgery.(24,25) Recently (26) increased fibrin synthesis, interaction between fibrin and platelets, and platelet activity has been demonstrated during the postoperative period in obese patients versus nonobese control patients.

## Excess Weight Loss

Our experiences in 5 years and all published data show BPD produces consistent weight loss (Tables 2, 3); BPD has maintained this result even at several years postoperative, while all restrictive procedures were followed by weight gain after 5 to 10 years. Regarding weight loss, our data are similar to those reported in the literature. Concerning BPD, we refer to the findings of Scopinaro et al.(10), who in 1996, published a 15-year follow-up study showing a mean EWL >70% in their 1976 patient group. Other authors with shorter follow-up periods of 5 (12-14) and 2 years (29) report similar results. Bajardi et al.(41) presented the 7-year data (Figure 3).

## Late Complications

The only late common complication between the two groups was incisional hernia, occurring in 24% of patients who underwent BPD and in 15% of those treated by RYGB. These data emphasize the concept of obesity as a risk factor for incisional hernias and surgical incision infections, as previously reported.(25) No differences were encountered regarding suture technique of the abdominal wall or the presence of other possible common risk factors, as reported by other investigators.(42-44) The higher incidence after open BPD can be explained by the longer follow-up period and by nutritional deficiencies that may have contributed to incomplete fascial healing.

The laparoscopic approach reduces morbidity due to parietal disease and results in a more comfortable postoperative course. It should be stated that in any case following laparoscopic procedure, no difference in weight loss is observed from the results following open surgery (Tables 2, 3). A more consistent follow-up is needed to evaluate the specific complications associated with the laparoscopic approach.

**TABLE 2.** RESULTS OF OPEN BPD AND BPD-DS

| Author | Procedure | N | Preop BMI | Complications | Mortality | Follow-up (y) | EWL |
|---|---|---|---|---|---|---|---|
| Lemmens (1993) (28) | BPD | 170 | NR | NR | 0.5 | 3 | 64% |
| Scopinaro (1998) (29) | BPD | 1,356 | 47 | 2.8 | 0.6 | 12 | 75% |
| Doldi (1998) (30) | BPD | 70 | 53 | 16 | 0 | 6 | 78% |
| Totte (1999) (31) | BPD | 180 | 48.8 | 31.2 | 0 | 3 | 55% |
| Baltasar (2001) (32) | DS | 125 | 50 | 5.6 | 1.6 | 5 | 81% |
| Anthone (2003) (33) | DS | 701 | 53 | 2.9 | 1.4 | 5 | 66% |
| Biron, Marceau (2004) (34) | BPD=220 DS= 962 | 1,271 | 48.4 | NR | 1 | 7.9 | 68.6% |
| Hess (2005) (35) | DS | 1,454 | 50 | 5.6 | 0.57 | 10 | 75% |

**TABLE 3.** RESULTS OF LAPAROSCOPIC BPD AND BPD-DS

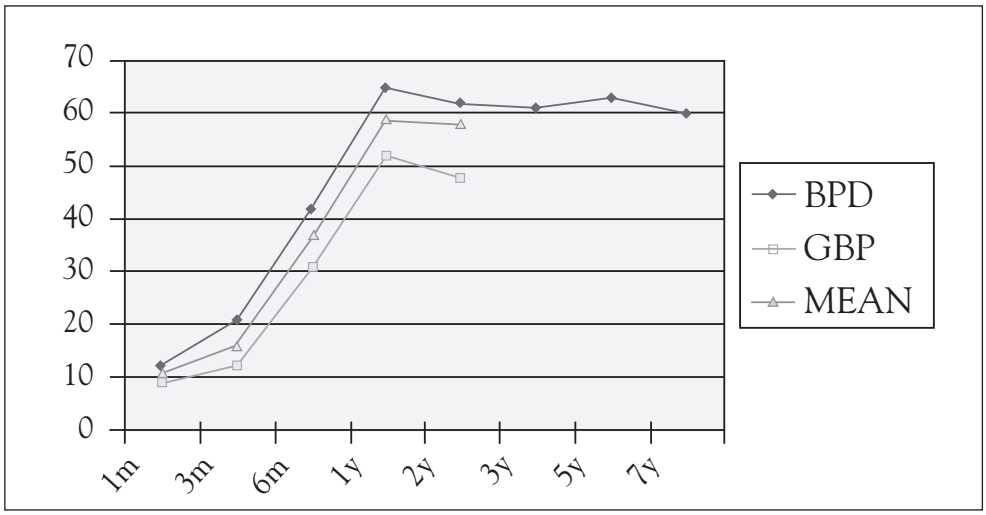
| Author | OP | N | BMI | OR time (min) | Conversion (%) | Complications (%) | Mortality (%) | Follow-up (mo) | EWL |
|---|---|---|---|---|---|---|---|---|---|
| Ren, Gagner (2000) (17) | DS | 40 | 60 | 210 | 2.5 | 15 | 2.5 | 9 | 58% |
| Paiva (2002) (18) | BPD | 40 | 43 | 210 | 0 | 25 | 2.5 | NR | NR |
| Scopinaro (2002) (36) | BPD | 26 | 43 | 240 | 26 | 15 | 0 | 12 | 68% |
| Baltasar (2002) (37) | DS | 16 | 43–56 | 232 | 0 | NR | 0 | NR | NR% |
| Rabkin (2003) (38) | DS | 345 | 50 | 201 | 2 | 10 | 0 | 12 | 72% |
| Resa (2004) (39) | BPD | 65 | 48 | 176 | NR | 7.6 | 1.5 | 36 | 81% |
| Weiner (2004) (40) | DS | 63 | 56 | 207 | 0 | 25.3 | 0 | NR | NR |

Late follow-up showed 3.5% mortality in the BPD group in the study by Bajardi et al.(45) Complications leading to death (colonic adenocarcinoma, cardiac failure) were not in any instance linked to nutritional deficiencies, but specific nutritional requirements resulted in particular problems regarding the therapeutical approach toward these patients.

## Late Metabolic Complications

A larger overview shows that 19% of BPD patients develop postoperative anemia, multivitamin shortage, hypoproteinemia, and various degrees of hepatic dysfunction sufficient to require hospitalization for nutritional support. In addition, in three cases, there was a surgical attempt to elongate the intestinal common limb. Patients were readmitted for nutritional deficiency when this was determined to be

**FIGURE 3.**




Excess Weight Loss % after Gastric Banding and BPD; Bajardi et al., 2000(45)

chronic at clinical or laboratory analysis (hemoglobin <8 g/dL, hemeralopy, mucosal phlogosis, relapsing infections, PT <35%, persistent leg edema or an anasarcatic condition, severe bone demineralization, proteinemia <4 g/dL, albumin <40%).

Apart from incisional hernia, BPD resulted in 11% reinterventions and 30% further hospitalizations. Comparison with Scopinaro's findings (10) shows that our data are similar regarding the incidence of malnutrition and reintervention rate for common limb elongation (21% vs. 17%). Differences are observed in the incidence of stomal ulcers (1.4% vs. 15%) and proctologic diseases (4.2% vs. <1%).

A particularly disappointing experience in our study was that of two cases of late mortality due to hepatic failure. Scopinaro et al.(10) reported three cases of liver cirrhosis with fatal evolution (0.1%), determined by the authors to be the result of alcohol abuse; however, no link was found with alcohol or with disease of viral etiology in our series.

Recent reports (46) have demonstrated that patients who have undergone VBG show, after consistent weight loss, reduction of liver steatosis, but also an increase in lobular phlogistic response. The cases progressing to cirrhosis required liver transplantation, which was successfully performed in patients submitted to jejunoileal bypass.(47)

## Therapeutic Effects on Comorbidities

Following bariatric surgery, a decrease in glycemic levels, a reduced need for antidiabetic medication, and an overall improvement of the metabolic conditions have been widely reported.(48-56) After gastric restriction procedures, the weight loss is accompanied by a normalization of the serum glucose concentration in 40% to 50% of cases(55-58), while gastric bypass surgery provides long-term glycemic control in >80% of obese subjects with type 2 diabetes. (48,51,53,54)

The proposed mechanisms that may explain the efficacy of bariatric surgery in the resolution of diabetes are the weight loss, decreased energy intake, and reduced intra-abdominal fat mass.(59) Furthermore, changes in gut hormone secretion (hormonal diversion) due to foregut bypass are thought to elicit a reduction of insulin levels and an improvement in insulin sensitivity.(49,60-62) This could specifically account for the far better results achieved following GBP surgery compared with pure restrictive procedures. The relationships between pro-insulin and ghrelin are under investigation.

Following BPD, in addition to the aforementioned specific action, an additional mechanism may lead to the normalization of serum glucose concentration.

Due to the rearrangement of the gastrointestinal tract in the post-BPD subjects, a profound limitation of fat absorption occurs that greatly contributes to the long-term maintenance of fully satisfactory weight loss results. The fundamental study by Scopinaro et al.(63) demonstrates the extraordinary benefits of BPD in the resolution of comorbidities, especially metabolic syndrome, and describes the pathophysiological mechanisms involved. According to Randle et al.(64,65), the increased free fatty acid oxidation that occurs in obese patients inhibits glucose oxidation, thus causing insulin resistance. Therefore, a reduced fat absorption should result in enhanced insulin sensitivity. Moreover, recent investigations showed that lipid deprivation selectively reduces intramyo-cellular lipid stores, thereby inducing an improvement of insulin action by acting on the insulin-mediated whole-body glucose disposal on the intracellular insulin signaling and circulating leptin levels.(66-69) Finally, the reduced beta-cell fat toxicity (70,71) certainly also plays a role in the improvement of glucose metabolism. It can then be postulated that the strongly reduced fat absorption might effectively contribute with other mechanisms to normalization of the metabolic status, thus explaining the complete resolution of type 2 diabetes in obese patients following BPD.

In addition to serum glucose level normalization, this study highlights other beneficial effects of BPD on some components of the metabolic syndrome. Gastric restrictive procedures or gastric bypass surgery induce an overall improvement of serum lipid profiles entailing a marked fall of serum triglyceride level with a relatively small decrease in serum total cholesterol. These effects most likely result merely from weight loss and decreased dietary cholesterol intake.(72-74) As far as serum triglyceride level is concerned, the same applies to BPD, the improvement being greater and longer lasting because of the better weight loss results. By contrast, in the obese patients with diabetes undergoing BPD in this study, the serum cholesterol level normalized in all cases and remained below the 200 mg/dL threshold at very long term. Therefore, since the simple reduction of cholesterol intestinal absorption alone cannot yield such an outcome, a specific action of BPD on cholesterol metabolism must also be postulated. In fact, the enterohepatic bile salt circulation is partly interrupted after BPD, with the consequent loss of bile salts causing enhancement of hepatic bile acid synthesis at the expense of the cholesterol pool.(75,76) Furthermore, a sharp reduction of endogenous cholesterol is likely to occur, along with other lipid absorption. The reduced availability of free cholesterol ultimately stimulates the synthesis of LDL receptors, thus resulting in an increased removal of LDL from the bloodstream.(77,78)

The normalization of serum total cholesterol at long term following BPD is accompanied by a rise of HDL cholesterol (52); unfortunately, since the initial findings of normal arterial pressure was observed after BPD, reaching 50% at 1 year. The percentage of normal values rose to 64% at 5 years and 74% at 10 years, despite aging and the absence of any further weight change. This phenomenon was also observed in the whole population of hypertensive patients undergoing BPD controlled up to the 10th year.

At short term, these findings are essentially similar to those observed in hypertensive obese and diabetic obese patients undergoing gastric restrictive procedures or gastric bypass (49,53,54,79-81).

However, in the Swedish Obese Subjects study, no difference in the frequency of hypertension between the operated patients and obese controls at long term was observed(82), due to long-term increase in hypertension prevalence irrespective of weight changes.

In the BPD subjects of this study, the exact opposite was found, the good outcomes being increased throughout the 10-year follow-up period, despite aging and no change in body weight. This suggests a specific action of BPD also on hypertension. In fact, the highly satisfactory effects on arterial hypertension can be accounted for on one hand by the excellent weight loss and long-term weight maintenance

occurring following BPD, and on the other hand by the complete and sustained disappearance of insulin resistance (83) with its key role in the metabolic syndrome (84-87).

This is further supported by the greater effects on blood pressure observed in the Swedish Obese Subjects study in the small subset (68 vs. 1,089 pure gastric restrictive procedures) of patients submitted to gastric bypass, which, in addition to yielding much better weight loss results, also has a specific beneficial action on insulin sensitivity.(82)

In addition to insulin resistance, dyslipidemia, and hypertension, central obesity, which is defined by excessive waist circumference (>40 in or 100 cm in men and >35 in or 87.5 cm in women), is a major component of the metabolic syndrome. The mean waist value 1 year following BPD was reduced from 138 cm to 105 cm in men, and from 131 cm to 99 cm in women; patients with abnormal values being decreased from 100% to 75%.

These figures remained substantially unchanged throughout the 10-year follow-up. The reason why these data were not considered in the present study is the lack of meaning of waist circumference value in severely obese patients. In fact, the visceral fat, which represents central obesity, is the actual risk factor in metabolic syndrome, while waist value also measures the peripheral subcutaneous fat. When body mass increases, the subcutaneous component of waist circumference increases much more than the visceral component, so that in severe obesity, which is the case of the present study population, waist value measures much more subcutaneous than visceral fat, thus losing its meaning.

However, the abnormal waist values in metabolically normalized subjects after BPD is a further demonstration of the specific effects of the operation. The operative mortality in this study was higher than that observed in the general BPD series (52) and closely resembles that observed in a population of obese patients with diabetes undergoing gastric bypass surgery.(51)

The overall mortality in a 10-year follow-up period was also comparable to that reported following gastric bypass surgery in the aforementioned study. This mortality rate was similar to that observed over 10 years in general populations of both US and Italian subjects in the same age range(88,89), and much lower than that reported in cohorts of patients with diabetes.(90)

Regretfully, matched comparisons with a group of nonoperated obese patients with diabetes were not available in the study by Scopinaro et al.(63) However, it is possible to compare our data with those of MacDonald et al., who provide a control group of obese patients with diabetes who did not undergo surgery because of either personal choice or insurance company's refusal to pay for the operation.(51) During a nearly 7-year follow-up period, the mortality rate in these nonoperated patients was 28%, which is sharply higher than that observed after BPD in the present investigation.

Moreover, there was a marked difference in the percentage of cardiovascular deaths, which accounted for 12 deaths among the 78 control subjects compared with the 4 deaths out of 264 subjects in the Scopinaro study.(63) In conclusion, this study demonstrates that BPD is very effective in normalizing serum glucose levels in obese patients with diabetes. The achievement of a good glycemic control is reflected in the reduction of the overall mortality rate compared with that of patients with diabetes and obese patients with diabetes, as well as in the very low frequency of death from cardiovascular events, thus implying a true clinical recovery. In terms of percentage of obese subjects with diabetes becoming euglycemic following the operation, BPD has proven to achieve better results than not only the restrictive operations but also the gastric bypass procedures. It can be postulated that the striking results obtained with BPD might be due to the foregut hormonal changes (a specific mechanism shared with the gastric bypass) and to the lipid deprivation, acting on insulin activity concurrently with the nonspecific mechanisms of bariatric surgery. Moreover, BPD is extremely

effective in reversing dyslipidemia, a condition that very often accompanies type 2 diabetes and represents a major component of the metabolic syndrome. Finally, arterial hypertension was also cured in the majority of cases by BPD, thus completing the reversal of the major components of metabolic syndrome. Prospective studies are needed to assess the possible use of BPD for the treatment of severe type 2 diabetes and hypercholesterolemia in mildly obese or simply overweight patients.

## Conclusions

Our findings lead us to conclude that the original BPD can be done by laparoscopy safely and quickly, and with a low morbidity. Biliopancreatic diversion is successful in bringing about adequate weight loss and long-term stability.

Despite these conclusions, each study shows that there is a variable group of patients in which the technique utilized is unsuccessful due to an insufficient weight loss or a high complication rate.

Given our findings, even if the complication rate is similar in the two groups, the severity of most of the ensuing BPD complications has led us to more selectively consider the use of this approach. We are of the opinion that BPD should be offered to all patients with complications and inadequate weight loss after restrictive procedures.

As an optimal approach is still lacking, future efforts must be made regarding preoperative selection of the surgical procedure, so that a bariatric surgical team should use both a restrictive and a malabsorptive approach. Surgery remains the primary treatment in a more complex therapeutic scheme, which should include both psychological and medical support.

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