Laparoscopic Biliopancreatic Diversion with Duodenal Switch (BPD-DS) Surgery

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Abstract

Biliopancreatic diversion with duodenal switch (BPD-DS) produces unmatched weight loss and superb resolution of comorbidities, particularly type 2 diabetes. However, BPD-DS remains a controversial procedure that polarizes opinion in both surgeons and patients. It combines surgical bypass of the majority of small intestine with a sleeve gastrectomy to produce greater weight loss and improved remission of comorbidities compared to that seen after Roux-en-Y gastric bypass. Moreover, it reduces the incidence of common side effects of a standard BPD such as marginal ulceration and dumping syndrome. With careful patient selection, meticulous technique, and attentive follow-up, BPD-DS offers outstanding long-term clinical results, a surprisingly good quality of life, and an effective revisional option when other procedures have failed. If performed badly, it is a recipe for protein-calorie malabsorption and a return to the bad old days of bariatric surgery from the 1970s. In this chapter, we explore the essentials of how to use this powerful tool – the nuclear option in the bariatric surgeon's armamentarium – safely and effectively.

Keywords

Biliopancreatic diversion · BPD · Biliopancreatic diversion with duodenal switch · Duodenal Switch · DS · RYGB · Type 2 diabetes

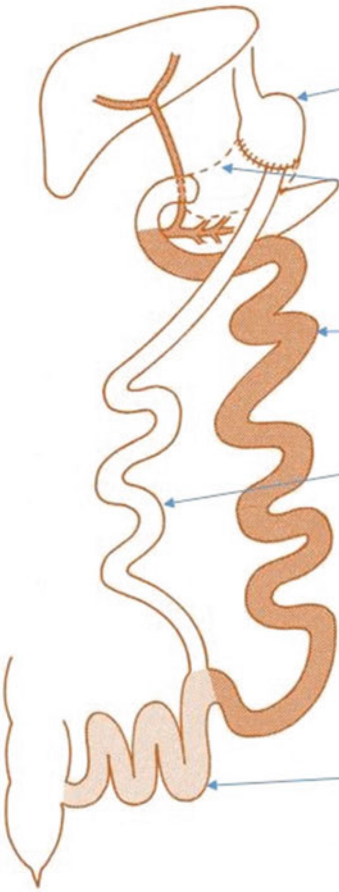
Introduction

Despite producing unmatched weight loss and superb resolution of comorbidities such as type 2 diabetes, the biliopancreatic diversion with duodenal switch (BPD-DS) is like an unloved child in the bariatric community that polarizes opinion in both surgeons and patients. This article attempts to explore this enigma, dispel some of the myths that surround the operation, and take a critical look at its role (if any) in the bariatric armamentarium. To begin, we need to understand what the procedure is and where it came from.

Biliopancreatic Diversion (BPD)

The BPD was originally described as an open operation by Nicola Scopinaro and his team in Genoa almost 40 years ago [1]. It combined surgical bypass of the majority of small intestine with a subtotal gastrectomy (Fig. 1). It was based on the rationale that greater weight loss following BPD would result in improved remission of comorbidities than that is seen after more established procedures such as the Roux-en-Y gastric bypass (RYGB) [2]. However, concerns related to the partial gastrectomy (such as marginal ulceration and dumping syndrome) together with the real risk of troublesome symptoms of malabsorption and the potential for surgically induced malnutrition hampered widespread adoption of the BPD. Marginal ulcers occurred in about 10–15% of BPD patients [3–5], although

Fig. 1 Biliopancreatic diversion



Scopinaro himself managed to reduce the incidence in his unit from 12.5% to 3.2% through modifications such as resecting more of the stomach and using prophylactic H2-receptor antagonists [6].

In 1998, almost 20 years after the introduction of the BPD, Douglas Hess (United states of America) [7] and Picard Marceau (Quebec) [8] independently published their experience of treating morbid obesity with a hybrid procedure called BPD-DS, often abbreviated to just duodenal switch (DS). The DS was originally developed by Tom DeMeester as a surgical solution for chronic duodenogastric reflux [9] and combines the small intestinal bypass of a BPD with a vertical "sleeve" gastrectomy (SG), resulting in a narrow banana-shaped gastric pouch based on the lesser curvature. The duodenum is transected a few centimeters beyond the pylorus and an ileoduodenal anastomosis is formed to divert food into the alimentary limb of the intestinal bypass (Fig. 2). Unlike a standard BPD, the DS preserves more normal physiological function by retaining the pylorus and most of the antrum.

BPD Versus BPD-DS

This BPD-DS resulted in a dramatic reduction in the incidence of marginal ulceration, and preservation of the pylorus virtually eliminated dumping syndrome. The exceptionally low rate of marginal ulceration is thought to result from a combination of alkaline mucus production by Brunner's glands in the duodenum and lower acid production (due to less residual parietal cell mass after SG), protecting the otherwise vulnerable ileal mucosa from acid attack. Marceau

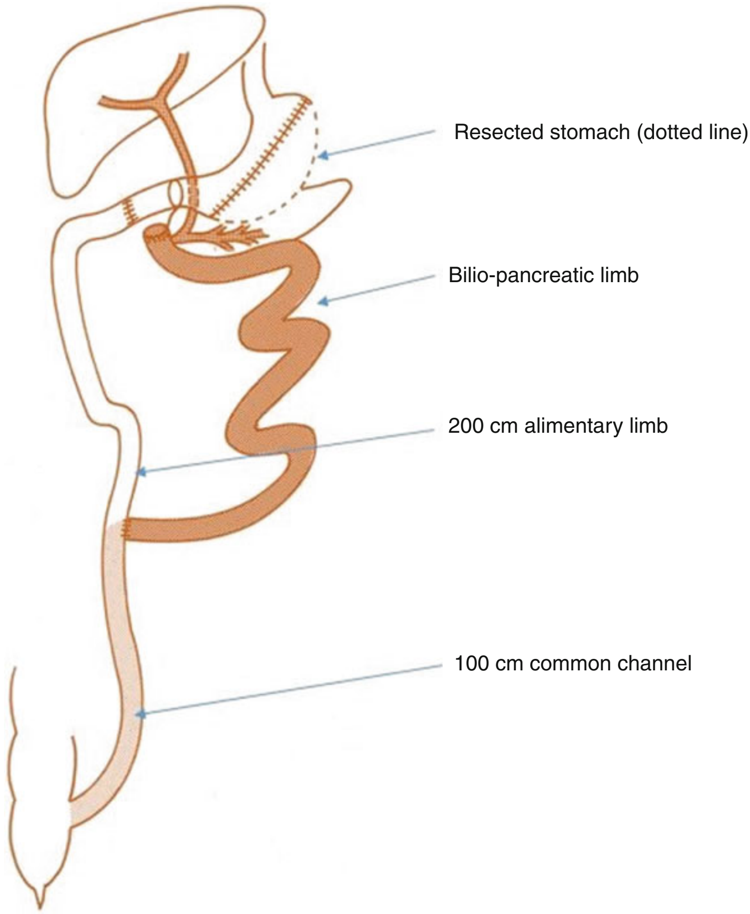


Fig. 2 Duodenal switch

reported just one case of marginal ulceration in a 15-year audit of 1000 patients [10], similar to the 0.3% incidence of marginal ulceration reported by Hess after more than 10 years of follow-up [11]. Preservation of more normal gastric physiology and a short segment of duodenum also reduced the severity of vitamin and mineral deficiencies compared with standard BPD, particularly calcium [12–14], iron [15–17], zinc [12, 13, 17], magnesium [12], and vitamin B12 [15, 17]. By avoiding a conventional subtotal gastrectomy after DS, the vagus nerves are spared; consequently, there is less disturbance of bowel motility and less disruption to the physiologic splanchnic signaling to the pancreas that regulates insulin release [18, 19]. Short-term weight loss after the two procedures is similar [12, 20] although long-term results favor the DS with 25% greater mean weight loss than BPD and with fewer patients (1.3%) failing to lose <25% of their excess weight [10, 21].

Patient Selection

Rigorous patient selection is crucial; more so than with any other bariatric procedure. The potential adverse consequences of a failure to adhere to a strict postoperative protocol involving a high daily intake of protein, minerals, and vitamins are potentially severe. Therefore, it is imperative that all patients undergo a trial of this dietary protocol as part of their preoperative assessment; only then can both physician and patient take a reasoned view on the likely ability of the patient to successfully adapt to life after a DS. It is an operation that mandates an exceptionally high degree of patient compliance, which in turn limits

its widespread applicability in patients who for economic, psychological, intellectual, or occupational reasons are unable to meet these requirements. This major drawback, along with the DS's technical complexity and the perceived severity and frequency of side effects are among the reasons why, along with the BPD, the DS has not being widely adopted. A recent review of the American Society for Bariatric and Metabolic Surgery patient registry reported that up to 2016, 0.6% of 216,000 registered patients had undergone either a BPD or a DS, mostly as open surgery [22]. The main indications for DS are based on the degree of weight loss it can induce (particularly in the very heaviest patients in whom other operations may fail) and its remarkable effect on diabetes remission.

Weight Loss

It is often claimed that super-obesity, a body mass index (BMI) more than 50 kg/m^2, is the main clinical indication for DS, but this should not be the only consideration as many super-obese patients would be unable to adhere to the postoperative regime. However, it is true that RYGB is less effective in the super-obese with one in five patients failing to reach or maintain the expected target weight loss [23]. The weight loss after DS compared favorably than that after RYGB in a randomized controlled trial of super-obese patients, with a percentage excess weight loss (% EWL) of 75% versus 54% respectively, after 12 months [24]. Others have reported similar superior results at 2 years in a study of super-obese patients undergoing DS or RYGB (%EWL of 72% and 60% respectively) [25]. A long-term follow-up cohort study of super-obese patients in the Scandinavian Obesity Surgery Registry matched each DS patient (n = 333) with four patients who had undergone RYGB (n = 1332). At 5 years out %EWL was 76.4% in the DS group compared with 57.4% in RYGB group (total body weight loss of 41.3% vs. 31% respectively, $p<0.001$) [26].

Late weight regain is also uncommon because the malabsorptive element of the DS provides a more durable long-term result [25] with 90% EWL maintained between 2 and 5 years postoperatively in the authors' own series [17].

The unrivaled weight loss of DS in the heaviest of patients has led some to propose it as the treatment of choice for the super-super-obese (BMI more than 60 kg/m^2), but the same limitations in patient selection must apply. Furthermore, there are several studies highlighting a significantly increased mortality in this particularly heavy subgroup (see mortality section below) if they undergo a lengthy and technically difficult laparoscopic operation as a single-stage procedure. Therefore, it is generally acceptable to recommend two-stage surgery for patients with a BMI more than 60 kg/m^2, carrying out the sleeve as an initial step, followed by completion of the DS 12 months later [27].

Remission of Comorbidities

Diabetes remission and correction of hyperlipidemia are more likely to occur after DS than after any other type of bariatric surgery. Therefore, some consideration should be given to the potential of the DS to benefit patients with these metabolic complications of obesity when discussing surgical options with them [17, 21, 27]. In the authors' practice, no fewer than 90% of type 2 diabetics were rendered euglycemic after surgery [17], a finding echoed by others [27, 28]. In a comparison of matched patients with a mean BMI of 50 kg/m^2 undergoing either RYGB or DS, Dorman et al. [28] reported 82% of diabetes remission after DS compared with just 64% after RYGB. The same study noted 69% resolution of hypertension and 81% resolution of hyperlipidemia in the DS group whereas 39% resolution of hypertension and 51% resolution of hyperlipidemia in RYGB group [28]. A randomized trial comparing relatively small numbers of diabetic patients undergoing DS or RYGB confirmed significantly lower HbA1c levels at 1 and 3 years postoperatively in the DS group, in addition to superior weight loss [29].

The striking efficacy of DS to induce remission of obesity-related comorbidity is also maintained long-term. The Swedish Registry looked at a long-term comparison of comorbidity resolution after DS versus RYGB [26]. Diabetes remission was superior but not statistically significant at 2-year follow-up (91% DS vs. 72% RYGB, $p = 0.09$); however, by 6 years, the difference was more obvious (95% vs. 64%) as patients with RYGB began to relapse. After 10 years, all DS patients were off diabetes medication (100% remission) whereas only 46% of RYGB patients were off diabetes medication. Similar outcomes were observed for hypertension (6-year resolution rate 40% vs 27%). The rates of hypertension and cardiovascular disease naturally increase with age, but the Swedish study showed that the rate of increase was much less after DS compared with RYGB (41% vs. 105% in comparison with baseline prevalence, $p = 0.03$). Comparable outcomes were also noted with resolution of dyslipidemia, although it took 10 years for these differences to be truly marked (0% DS vs. 58% RYGB).

A meta-analysis looking at 10-year outcomes after DS and RYGB revealed 75% EWL (range 61–94%) after DS in comparison with 55% EWL (range 27–69%) after RYGB. The re-operation rate 10 years after surgery ranged from 3–37% after DS and 8–64% after RYGB [30].

Quality of Life (QoL)

However,, in practice, the main indication for DS in is patient preference. Prospective DS patients tend to be very well informed; they have a clear idea as to why they think the DS is the best operation for them, particularly in terms of QoL after surgery and have balanced the potential advantages of a DS against its drawbacks. A common perception among patients is that they will be able to eat “normally” after a DS compared with RYGB, but this has not always been borne out in several studies [31–33]. The rate limiting factor for portion size (at least in the early years) will of course be the sleeve; therefore, there is no reason why DS patients would be at any advantage here. What is true is that unlike RYGB, the absence of dumping allows unfettered carbohydrate consumption and a more ‘normal’ food intake.

In a small randomized controlled comparison of DS versus gastric bypass patients from a low-volume unit, QoL was actually slightly worse in the DS group with only five out of eight SF36 domains showing significant improvement at 2 years (compared with seven out of eight after RYGB) [34]. This is in contrast to the authors’ experience in which 98% of respondents to a bariatric surgery-specific QoL score reported improvement with 85% reporting “very good” or “excellent” outcomes [17].

BPD-DS as a Revisional Surgery

As detailed in other chapters of this book, there is strong evidence supporting the remarkable weight loss results of primary bariatric surgeries. However, not all patients who undergo bariatric surgery achieve significant weight loss or maintain the weight they lose on the long term [35]. The cause of failing to achieve or maintain weight loss after bariatric surgery is complex and could be due to a mix of anatomical and technical causes as well as inability to adopt a healthy lifestyle. Careful assessment of the surgical anatomy is required when considering revisional options. A textured barium X-ray (using a mixture of Carbex®, barium, and an absorbent thickening agent such as Weetabix®) and endoscopy are very helpful in this context. BPD-DS is a very effective primary procedure for weight loss, and evidence suggests that it could also be an effective revisional surgery option for patients with inadequate weight loss after primary bariatric surgery. Here, we summarize the main evidence of using BPD-DS as a revisional option after the two most popular bariatric operations now: SG and RYGB.

BPD-DS after SG

SG was developed as the first stage of a two-stage BPD-DS. Later, it established itself as a standalone procedure after it was demonstrated to be so effective that many patients did not require the second stage procedure. Revising SG to BPD-DS is achieved by performing the second stage (switch stage) of the standard BPD-DS. Biertho et al. [36] compared the results of BPD-DS as a revisional surgery in patients who had SG (n = 59) with a matched cohort of patients who had primary BPD-DS (n = 59). Second stage BPD-DS was found to be an effective option for the management of suboptimal outcomes of SG, with an additional 41% EWL and 35% remission rate for type 2 diabetes. At 3 years, the global outcomes of the staged approach did not significantly differ from single-stage BPD-DS [36]. A recently published systematic review compared the efficacy and safety of single anastomosis duodenal-ileal bypass with sleeve gastrectomy (SADI-S) or BPD-DS versus RYGB as a revisional procedure for SG [37]. Six retrospective cohort studies (n = 377) were included. While both SADI-S/BPD-DS and RYGB were found to be efficacious in lowering initial BMI, SADI/BPD-DS group achieved a significantly higher percentage of total weight loss compared with RYGB by 10% ($p = 0.006$). There were no significant differences in adverse events or improvement of comorbidities between the two groups [37].

BPD-DS after RYGB

Managing poor weight loss or weight regain after RYGB is challenging. Anatomical causes of RYGB technical failure include a loss of restriction with gastric pouch enlargement, dilation of the gastrojejunostomy, and fistula formation between the gastric pouch and the remnant stomach. So far, there is no one standardized approach to the revision of RYGB. Revision to BPD-DS is a feasible but technically challenging option. It involves three discrete steps, starting with restoration of 'normal' gastric anatomy by transecting the gastric pouch proximal to the gastrojejunostomy, resecting the Roux limb back to the level of the jejuno-jejunostomy, and finally reestablishing gastric continuity by re-anastomosing the gastric pouch to the remnant stomach. A SG is then performed taking great care not to allow the vertical staple line to encroach close to the newly created gastro-gastric anastomosis. Finally, the duodenal diversion is constructed in a standard fashion [38, 39]. Other RYGB revisional options include band on bypass, endoscopic procedures such as overstitch, gastric pouch reduction with anastomosis revision, or conversion to distal gastric bypass.

In 2016, Tran et al. [40] published their systematic review which reviewed all evidence for revisional surgery following RYGB. Twenty-four studies with 866 patients investigated the results of different revisional approaches (two studies on BPD-DS, 59 patients). At one- and 3-years after the revision, the weighted mean of the percent excess body mass index loss (%EBMIL) were: 64% and 76% following BPD-DS, 54% and 52% following distal gastric bypass groups, 48% and 47% following band on bypass, 43% and 14% following pouch/anastomosis revision, and 32% following endoluminal procedures (no data at 3-years following endoluminal procedures). Gastric pouch/anastomosis revision resulted in the lowest major complication rate at 3.5%, and distal gastric bypass with the highest at 11.9% when compared with the other revisional procedures. Revision to BPD-DS carried a modest complication rate of 4.0%.

More evidence on the efficacy of revision of RYGB to BPD-DS came from two series by Surve et al. [41] and Halawani et al. [42]. Surve et al. [41] retrospectively reviewed the outcomes from 32 patients who underwent revision to BPD-DS (n = 9) or SADI-S (n = 23) for failed RYGB (EWL 16.2% from original RYGB). The %EWL was 54% and 56% at 1 and 2 years, respectively. Percentage total weight loss (%TWL) was 28% and 29% at 1 and 2 years respectively. No difference was found between revision to BPD-DS or SADI-S [41]. Halawani et al [42] performed one-stage conversion from RYGB to BPD-DS in nine patients. The operative time was 328–515 min (average 6.7 h). They reported no morbidities, reoperation, or readmission at 30 days postoperatively. At 3–42 months follow-up (16 ± 14 months), the BMI of the cohort decreased by a mean of 10 ± 5 kg/m^2 (46 ± 9 to 36 ± 8 kg/m^2) [42].

The Experts' View of the Role of BPD-DS as a Revisional Surgery

Merz et al [43] published an interesting article in 2019 which aimed to generate expert consensus on the appropriate use of BPD-DS as a revisional bariatric surgery for those with inadequate weight loss after their primary bariatric surgery. The opinion of an expert panel of 29 globally renowned bariatric surgeons was gathered during an international conference. The panel members were presented with an extensive literature review for each related topic proceeding the polling. As a revisional surgery, BPD/DS was seen as most appropriate after SG for the treatment of super-morbid obesity (96.7% agree) or as a subsequent operation for a reliable patient with insufficient weight loss after SG (88.5%). In patients with weight regain and reflux and/or enlarged fundus after SG, RYGB was the preferable option with recommendation to avoid BPD/DS in this setting. The panel thought that BPD-DS should not be used prophylactically in patients with a history of jejunoileal bypass who are otherwise doing well (80.8%). Due to the associated technical difficulties, the use of BPD/DS as a revisional surgery for failed gastric bypass is limited. The experts would routinely recommend or consider BPD/DS if it was more technically feasible after failed bypass (86.2%) [43].

In brief, although revision to BPD-DS has very good long-term weight loss with acceptable complication profile, the complexity of the procedure has not allowed for a wide practice rate as it requires extensive expertise and laparoscopic skills. Only few surgeons nowadays offer BPD-DS as a primary procedure and even fewer as a revisional surgery. When considering BPD-DS as a revisional surgery, careful selection of the suitable patients should follow the same principles for BPD-DS as a primary operation which is described above in the chapter.

Technical Tips and Operative Considerations

The laparoscopic approach is now the recommended method of performing a DS. It can be a very demanding and challenging operation for the surgeon as well as the patient. It is our practice to give a standard dose of both low molecular weight heparin and tranexamic acid at induction of anesthesia. A pneumoperitoneum is established with a left upper quadrant Veress needle (or through a direct vision cannulation technique) and sustained at 15–17 mmHg. Usually, seven trocars are necessary to perform the surgery. Their exact positions will vary with individual patients' abdominal shape (Figs. 3, 4, and 5).

The creation of the common channel is started using the active ports shown in Fig. 3. With the surgeon and camera holder standing on the patient's left, and the operating table in a neutral flat position with slight left tilt, the ileocecal valve is identified and from this point a 100 cm common channel of terminal ileum is carefully measured on the stretched anti-mesenteric border of the bowel. A suture is placed at this point to mark the site where the ileo-ileal anastomosis will be constructed. Measurements then continue proximally from the suture mark for a further 200 cm, at which point the ileum is transected with a linear stapler. An ileoileal anastomosis is then constructed using the bowel proximal to the point of transection (the biliopancreatic limb) and the point at which the terminal ileum had been marked with the suture, 100 cm from the ileocecal valve. Care must be taken not to twist the mesentery of the small bowel when aligning the bowel limbs in preparation for this anastomosis. It can be done using a hand sewn technique, or using a totally stapled method. This involves bidirectional linear stapler firings with transverse stapled closure of the enterotomy. Finally, the ileoileal mesenteric defect is closed with a non-absorbable running suture.

The patient is then positioned in reverse Trendelenburg and with the surgeon now standing between the patient's legs. Using the active ports shown in Fig. 4, careful dissection along the inferior border of the duodenal bulb is commenced

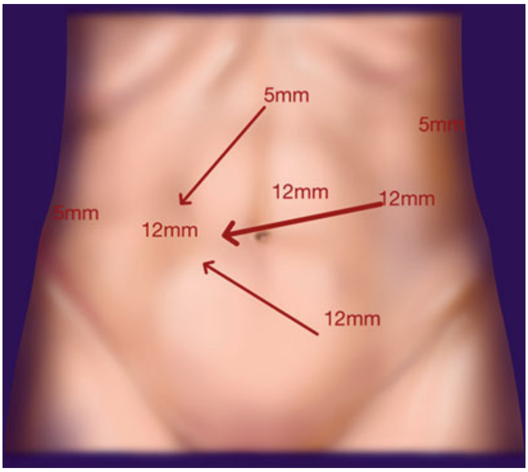


Fig. 3 Ports used in creating the common channel

approximately 4–5 cm distal to the pylorus by gently coagulating the very fine connecting vessels between the head of the pancreas and the posterior wall of the duodenum. The aim is to create a small window between the duodenum and pancreatic head wide enough to admit a linear stapler cartridge. Care should be taken not to damage the gastroduodenal artery as it passes behind the duodenal bulb; otherwise, significant bleeding can occur. A flexible angulating instrument can be useful when completing this posterior tunnel, which should result in a second window at the superior edge of the duodenal bulb, lateral to the hepatoduodenal ligament. The first part of the duodenum is then transected with the stapler. An alternative technique is to mobilize the posterior wall of the antrum, pylorus, and first part of the duodenum as described by Cottam [44], although this can sometimes result in a short length of duodenum beyond the pylorus if the gastroduodenal artery lies more proximally.

Usually, the duodenal stump of the biliopancreatic limbs is not oversewn. An alternative method of mobilizing the duodenal bulb involves lifting the antrum and approaching the gastroduodenal artery by dissecting posterior to the pylorus via the lesser sac. We share the view that prophylactic cholecystectomy at the time of DS is unnecessary [45]. Indeed, based on experience, the combination of DS and cholecystectomy may cause problems by exacerbating

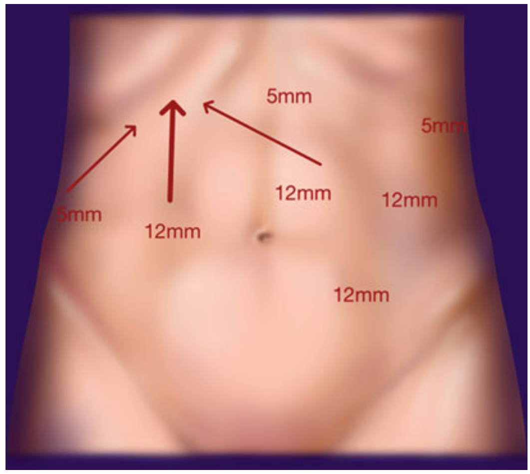


Fig. 4 Ports used in creating the ileo-duodenal anastomosis

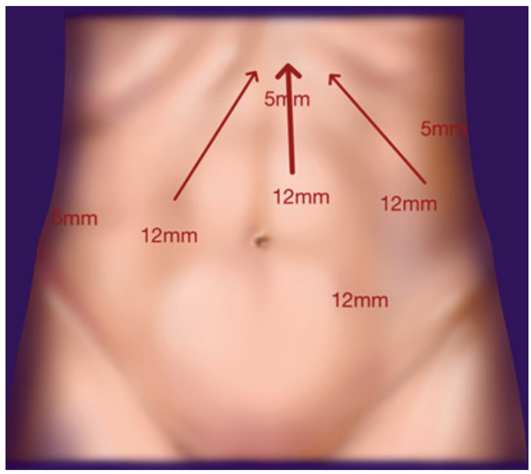


Fig. 5 Ports used in creating the sleeve gastrectomy

postoperative diarrhea. Hence, it is not used routinely and instead delayed cholecystectomy is reserved for symptomatic individuals only.

Ursodeoxycholic acid 300 mg twice a day is effective in preventing gallstone formation in patients with dramatic weight loss [46], although this benefit has to be balanced with the increased cost and added inconvenience to the patient. Furthermore, the value of ursodeoxycholic acid in long-term gallstone prevention is questionable. The 10% late cholecystectomy rate is remarkably similar to the 8.7% late cholecystectomy rate reported by Bardaro and Gagner [45] in DS patients who had also been treated with 6 months of ursodeoxycholic acid.

After transection of the duodenal bulb, the alimentary limb is pulled upwards in an antecolic fashion (after division of the greater omentum if this is necessary to reduce tension on the transposed small bowel), and an ileoduodenal anastomosis is constructed 3–5 cm beyond the pylorus. There are several means of achieving this; some prefer a transoral circular stapled (Gagner) technique which has the advantage of speed and is less technically challenging than a totally hand sewn anastomosis [47]. However, it can be difficult to maneuver the tip of the nasogastric tube and/or the anvil of the stapler through the pylorus. Additional problems can arise if the narrow caliber alimentary limb cannot easily accommodate the staple gun; there is a risk of tearing the ileum at this point. Use of a smaller (21 mm) anvil can help circumvent these problems, albeit with a higher risk of anastomotic stricture. An alternative is to perform a single layer ileoduodenal anastomosis by hand, using a continuous seromuscular posterior suture. This will approximate the sealed ends of the duodenal bulb and alimentary limb, before creating an enterotomy in each and closing the corners and anterior wall of the anastomosis with a second continuous serosubmucosal stitch. Since the alimentary and biliopancreatic limbs are much longer than in a gastric bypass, it is possible to inadvertently perform a duodenoileal anastomosis with the wrong limb (loop bypass) or to twist the mesentery of the alimentary limb. This can be avoided by marking and carefully checking the position of the limbs prior to performing the anastomosis. Early symptoms of small bowel obstruction suggest the need for an oral water-soluble contrast study and/or a diagnostic laparoscopy.

Now that the more challenging parts of the procedure are complete, it is usually a relatively straightforward matter to complete the DS by carrying out a standard SG (using the ports indicated in Fig. 5). The lesser sac is easier to enter at the midpoint of the greater curvature (less experienced surgeons tend to start too distally). After creating a window in the greater omentum (close to the stomach wall) with an energy device, dissection is continued proximally, dividing the short gastric vessels and the phrenosplenic ligament until the left crus is reached. The crurae are dissected and exposed to rule out the presence of a hiatus hernia, which must be repaired if present [48]. After taking down any posterior lesser sac adhesions, the greater curvature is then mobilized distally in a similar fashion until the mid-antrum is reached, several centimeters distal to the incisura. It is important not to be over-zealous in this distal dissection as the right gastroepiploic vessels must be preserved; they form part of the blood supply to the duodenal bulb. Division of posterior adhesions is an important technical point; otherwise, they could prevent the stapling device being applied close enough to the lesser curvature posteriorly, risking an unduly wide sleeve or excess fundus being inadvertently included within the proximal portion of the sleeve, both of which could result in sleeve failure.

The sleeve is fashioned using a linear stapler placed lateral to a 36–40 French bougie, starting about 4–6 cm from the pylorus and progressing cranially snug with the bougie, ensuring that each staple firing slightly crosses the last. The choice of the staple cartridges depends upon the thickness of the gastric wall. A thicker 4.5 mm or greater cartridge is advised in the gastric antrum to prevent serosal splitting, bleeding, or leakage, while in the absence of staple-line reinforcement, a 3.5–4.5 mm cartridge is usually sufficient when progressing across the gastric body and fundus. Counter-traction with instruments accurately placed on the greater curvature of a properly mobilized stomach reduces the risk of creating a spiral effect in the cylindrical sleeve during the stapling process, a well-recognized cause of postoperative functional obstruction [49, 50]. It is particularly important that the last firing of stapler does not sit too close to the gastroesophageal junction and that any thick fat pad at this site is reflected medially to reduce the depth of tissue the stapler has to fire through. Anastomotic leakage at the proximal end of the sleeve is the most feared and most common perioperative complication of DS. The value of staple line buttressing with bovine pericardium or other bioabsorbable material, while effective in reducing staple line bleeding, is still debatable with respect to the prevention of early postoperative leaks [48, 51, 52].

Finally, Petersen's defect is closed from the patient's right, as this allows better exposure of the mesentery of the alimentary limb and transverse mesocolon. It is advisable to start the closure from the lower end of the defect and progress upwards so that the last bite incorporates the inferior taenia of the colonic wall.

Inpatient Care and Complications

An enhanced recovery protocol that eschews the routine use of urinary catheters, arterial and central venous lines, and nasogastric tubes is adopted, although patients do undergo close postoperative monitoring to detect hypoxia, unexplained tachycardia (which may indicate a leak), and hypotension. Two additional doses of tranexamic acid are prescribed 12 h apart during the first 24 h after surgery; this has been shown to reduce the requirement for blood transfusion after elective surgery without convincingly increasing the risk of venous thromboembolism (VTE)[53, 54].

Given the longer operative time associated with DS (and its suitability for heavier patients), it is important to be alert to the possibility of rhabdomyolysis and myoglobinuria, particularly if the patient complains of severe buttock pain. It is also vital that a VTE prevention protocol adequate for the needs of high BMI patients who have undergone prolonged surgery is in force. The authors have previously reported a 0% VTE rate in 735 bariatric patients treated using our extended low molecular weight heparin protocol [55].

An early (day one) water-soluble contrast study is unnecessary as it will not pick up a leak that develops the following day. Indeed, given the low sensitivity of this test in ruling out a leak [56], in the presence of symptoms and signs of sepsis, a very low threshold for diagnostic relaparoscopy is adopted in those with clinically suspicious findings.

In patients who have an uneventful postoperative course, a liquid diet can be commenced within hours of surgery and patients are discharged on postoperative day three, after appropriate dietetic counseling. Normal solids can usually be started 4–6 weeks postoperatively. Sometimes supplementation with liquid protein shakes is recommended to prevent protein malnourishment until the patients achieve their target protein intake of 100–140 g/day.

Operative Mortality

Laparoscopic DS is perceived by some as a high-risk procedure, but this has not been borne out in several large cohort and individual institution studies that have reported a 30 day mortality of 0–0.7% [17, 24, 57–59], closely matching that of laparoscopic gastric bypass. A nationwide study based on the Swedish Registry included 63,469 patients; the 90-day mortality rates among the studied procedures did not differ significantly between gastric bypass (33/54,026, 0.06%), SG (1/7919, 0.01%), and duodenal switch (1/513, 0.19%) [60]. However, an all-cause mortality (that is including deaths unrelated to surgical complications) of 7.2% was noted in a report from the University of Southern California [57].

What is clear from the literature is that the super-super-obese (BMI more than 60 kg/m^2) represent a subgroup with high perioperative mortality. Fazylov's group reported a 0% mortality in patients with BMI <60 kg/m^2, but a 7.8% mortality in the super-super-obese [61]. Ren et al. [62] also reported a similar higher mortality in this group as did Kim et al. (7.6%) [63]. Therefore, in patients with BMI more than 60 kg/m^2, the DS is performed as a two-stage procedure [27, 64].

Data on longer term mortality is more difficult to come by but Marceau's group [10] reported 4.7% mortality (67 out of 1423 patients) at 15 years. A breakdown of these data showed a 1.1% perioperative mortality with a further 0.7% of patients dying from late surgical complications such as malnutrition, obstruction, and delayed operative deaths. The remainder died of seemingly unrelated causes such as cancer (0.9%), suicide (0.4%), and trauma. Less than 1% of the patients in this study died of late medical complications such as cardiopulmonary disease or a cerebral vascular accident [10].

Staple Line/Anastomotic Leak

Anastomotic leakage is the most feared complication of bariatric surgery. Once again, there is a perception that leak rates are higher after DS than other procedures, but in fact, majority of leaks come not from the malabsorptive part of the operation but from the construction of the gastric sleeve. Small intestinal leaks are relatively rare in most series. The risk of leak arising from the long gastric staple line has progressively reduced with increasing awareness of the technical details of performing SG (Chap. 26). In a comprehensive analysis from Mason's group [57] in California, there was no evidence of a higher rate of serious perioperative complications (including anastomotic leakage) in matched groups of patients undergoing laparoscopic DS and laparoscopic gastric bypass. There is undoubtedly a steep learning curve that surgeons undertaking DS have to negotiate which probably explains the high leak rates reported in some early studies of open and laparoscopic duodenal switches performed 10 or more years ago (0–6.6% leak rate) [12, 59, 62, 65, 66], and more recent low-volume studies (6.8–8% leak rate) [24, 67]. Recent high-volume studies consistently report leak rates of 0–3.5% [28, 68, 69]. In 2011, the authors reported their learning curve with the laparoscopic DS [17]. At that time, the sleeve leak rate was 1.6% (two out of 121 patients), with one duodenal stump leak and another patient with an ileoduodenal leak. These serious complications occurred in the first 50 cases and the overall leak rate fell to 1.4% (a sleeve leak) in the next 71 patients treated [17].

Leaks can be managed conservatively with surgical or radiological drainage of any collections and intravenous antibiotics. However, management of the catabolic state resulting from this complication is more difficult because of the presence of significant surgically-induced malabsorption. Enhanced nutritional supplementation is usually required and this is best achieved by inserting a laparoscopic feeding jejunostomy into the proximal part of the bypassed jejunum (the biliopancreatic limb), thus making most of the length of the small bowel available for nutrient absorption. An alternative would be total parenteral nutrition (TPN), but the preference is always to use the enteral route if feasible.

Possible risk factors for anastomotic leakage include high BMI, use of a circular stapled ileoduodenal anastomosis [70], and cases performed at the beginning of surgeon's learning curves [17, 24, 62, 67].

Outpatient Care and Complications

This is perhaps the most critical part of the patient's management. It must be thorough, frequent, and carried out to an uncompromisingly high standard for the patient's lifetime with involvement of a comprehensive multidisciplinary team of bariatric surgeons, dieticians, physicians, and psychologists. Failure to closely monitor and manage a DS patient is a recipe for disaster, but when properly cared for, majority of patients achieve a safe, durable, and highly effective outcome.

Vitamin and Micronutrient Deficiency

After DS, the need for closely monitored vitamin and mineral supplementation is paramount because of the degree of malabsorption, particularly with respect to fat soluble vitamins (A, D, E, and K). Therefore, they must be supplemented in high doses, the exact dosage being adjusted according to the results of regular serum assays including vitamin D3 and vitamin A. Vitamin E levels have not been shown to differ from levels in RYGB patients during the first 12 months after surgery [71], and therefore we do not routinely assay vitamin E. An indirect measure of vitamin K activity can be deduced by checking the patient's international normalized ratio (INR).

Our current baseline maintenance regime is Vitamin D3 10,000 IU daily, together with vitamin A 10–25,000 IU daily in non-pregnant individuals. Unabsorbed fatty acids may form complexes with minerals such as calcium, thus inhibiting absorption and increasing the risk of long-term deficiency. Ingestion of medium chain triglycerides that are easily assimilated by the body (for example coconut oil) can ameliorate this effect, enhancing absorption of minerals and fat-soluble vitamins [72]. Nevertheless, calcium supplements (at least 2 g per day) are mandatory, preferably given in the citrate form. Calcium citrate is better absorbed than carbonate preparations in the more alkaline milieu that follows SG. Because citrate is an inhibitor of calcium salt renal stone formation, it has the added advantage of lowering the risk of troublesome calcium or oxalate calculi [73, 74]. Careful dosing of calcium and vitamin D levels is necessary to prevent bone demineralization (a rare but serious complication of malabsorptive procedures). We do not routinely perform dual-energy X-ray absorptiometry (DEXA) scans (indeed these are often abnormal preoperatively in the morbidly obese), but a good indication for a DEXA scan is persistent elevation of alkaline phosphatase and parathormone levels, despite appropriate supplementation.

Most other trace elements such as copper, zinc, magnesium, and selenium can be maintained by taking a good quality complete multivitamin and mineral preparation twice daily, but it is common to require additional iron (particularly in premenopausal women) [12, 15]. Some patients fail to respond to oral iron and require iron infusions from time to time. There is a clear interaction (either synergistic or antagonistic) between different trace metals and minerals that can influence effective absorption of supplements after DS, particularly in the relationship between iron, zinc, and calcium [75] and similarly between copper and iron absorption [76]. Therefore, it is unusual for a single nutrient deficiency to develop exclusively; other deficiencies or excesses are often involved.

The combination of a subtotal SG and the short terminal ileal common channel of a DS clearly poses a risk of vitamin B12 deficiency, and close monitoring is required. Having said that, the authors do not routinely supplement with parenteral vitamin B12 after DS as an incidence of deficiency of just 5% was noted in each of the first two postoperative years, thereafter falling to 1% [17]. Although vitamin B2 and B6 levels are similar after DS and RYGB [71], within the first few months after DS, there is a greater risk of thiamine (B1) deficiency compared with the gastric bypass, but this difference seems to correct spontaneously within 6 months [71]. In a review published in 2008, of the 84 cases reported with Wernike's encephalopathy (WE) after bariatric surgery, 80 were associated with gastric bypass or other restrictive procedures (95%), and this was almost always associated with vomiting [77]. A rare but concerning incidence of WE (0.18%) was reported within 3–5 months of surgery in a large historical series of 1,663 BPD patients [78]; however, this finding has not been confirmed after DS, suggesting that it may be more related to the high incidence of stomal ulceration (and thus vomiting) after BPD than to any malabsorption.

The importance of close and meticulous outpatient follow-up after DS cannot be over emphasized. Patients are seen with an up-to-date nutritional blood screen at least four times a year for the first 2 years; the frequency of appointments can be reduced to twice a year if all is well. In addition to a full blood count, liver function tests, urea & electrolytes, and a bone profile, regular blood screens include magnesium, zinc, serum iron, vitamin B12, red cell folate, vitamin A, INR (as a marker of Vitamin K status), vitamin D, and parathormone. A good review of practice guidelines for postoperative bariatric vitamin and mineral replacement endorsed by the British Obesity and Metabolic Surgery Society was recently published [79].

Protein Calorie Malnutrition

The short common channel of a DS reduces the opportunity for pancreatic enzymes to digest food. Older malabsorptive operations affect absorption of fat, protein, and carbohydrate equally. What is different about the DS is that it selectively protects protein absorption to a degree. Pepsinogen and acid are still produced in the sleeve and trituration can occur in the near-intact antrum. Therefore, it is likely that a degree of protein predigestion occurs in the stomach, which would allow peptide absorption not just in the common channel but also in the 200 cm alimentary limb. Nevertheless, as the rate of protein loss from the gut is five times greater than normal after the very short 50 cm common channel of a BPD [2]; it is prudent that DS patients adhere to a high protein intake indefinitely [12]. Given the careful preoperative selection and counseling for DS patients, it is unusual to see severe protein calorie malnutrition in the course of follow-up, with a peak 3–5% incidence of hypoalbuminemia (less than 30 g/L) about a year postoperatively, decreasing to 1–3.7% at 2 years and 0–1% thereafter [17, 59].

Majority of DS patients can easily maintain serum albumin with diet alone, but they have reduced reserve should they develop a severe intercurrent or diarrheal illness. Therefore, it is usually recommended for DS patients to consume more than 100 g of protein daily choosing high biologically valued proteins such as meat, fish, nuts, eggs, milk, cheese, yogurts, and oral protein supplements such as bars or food additives. If a decrease in albumin levels is identified, protein shakes and/or high protein (semi-elemental) prescription nutritional supplements should also be used with the addition of pancreatic enzyme replacement (Creon® 10–40,000 units two to four times a day) if required. Another key to managing hypoalbuminemia after DS is to control any diarrhea by vigorous and prompt treatment of underlying causes such as infection, bacterial overgrowth, and bile salt irritation of the colon.

In the rare instance of protein calorie malnutrition that cannot be managed using the above conservative measures, ambulatory enteral feeding using a laparoscopically placed feeding jejunostomy tube (positioned in the proximal part of the biliopancreatic limb) is a useful technique. If, at all, possible, try to avoid the use of TPN. In cases of persistent protein malnutrition or if a lack of compliance is suspected, reversal or revision of the procedure must be considered. The reported incidence of this in early series of open DS procedures was quite high (2–12%) [7, 20, 80], but in more recent reports runs at about 1.5% [59].

Small Bowel Obstruction

In a study of 805 DS patients, Biertho et al. [59] reported a 2.4% incidence of intestinal obstruction with 1.6% requiring further surgery, findings that are similar to those reported after RYGB. Intestinal obstruction after laparoscopic DS can result from simple adhesions, port site hernia, incorrect anastomotic technique (twisting or narrowing), or ischemic stenosis. However, the most dangerous causes are internal herniation of the bowel and organo-axial rotation of the very long alimentary limb [81]. Meticulous attention must be paid to the closure of the ileoileal mesenteric and Petersen's defects. Several cases of infarction of the alimentary limb after organo-axial twisting and entrapment in Petersen's defect have been encountered [81]. Early relaparoscopy should be considered in any DS patient presenting with bouts of severe abdominal pain for which there is not an obvious alternative explanation.

Chronic Diarrhea/Steatorrhea

Contrary to common wisdom, chronic diarrhea is not typical after DS although steatorrhea (fatty, offensive stools) can be a notable problem, particularly if patients choose not to adhere to a low-fat diet. Most DS patients pass two to three semi-formed stools per day [8, 17] and less than 1% ever require hospitalization to manage severe diarrhea [59]. In a comparison between DS and RYGB patients, no significant difference was noted in stool frequency over a 14 day period (average of 23.5 movements after DS versus 16.5 after RYGB) [82]. A sudden increase in bowel frequency, loosening of stool, and flatulence is usually due to bacterial overgrowth (which often follows a course of antibiotics taken for an unconnected condition). A stool culture should be taken if possible (to exclude causes of infective gastroenteritis such as Campylobacter) and the patient started on empirical treatment with metronidazole 400 mg thrice daily for 10 days, followed by a further 10 days of ciprofloxacin 500 mg twice daily if the diarrhea has not cleared. During this time, patients are encouraged to consume probiotics or live natural yogurt products [83].

Loose stools that are steatorrheal in nature can be managed with pancreatic enzyme supplements such as Creon® (10.000 to 40,000 units with each meal), while simple antidiarrheals such as loperamide and codeine are also valuable in controlling frequent or loose bowel movements. Consideration should also be given to the possibility of bile salt malabsorption causing colonic irritation, particularly in patients who have also had a cholecystectomy in whom bile acids can be delivered into the short terminal ileum between mealtimes before passing unbound into the colon. This can be difficult to manage, but our current regime using colesevelam appears to be better tolerated than older products such as cholestyramine. Only rare refractory cases of severe diarrhea, usually related to poor dietary compliance, may require a reversal of the procedure or conversion to a gastric bypass.

Effect of BPD-DS on the Composition of Gut Microbiota

Evidence suggests changes in fecal bacterial communities and fermentation following bariatric surgery [84, 85]. Animal studies found marked alterations in the faucal and small intestinal microbiota following BPD-DS, resulting in reduced bacterial diversity and richness [86]. These alterations are mainly associated with the DS rather than the SG part of the procedure. The mechanisms through which BPD-DS affects the gut microbiota are not yet fully known. Although some authors speculate that the positive outcome of surgery may be enhanced by the modulation of gut microbiota; a causal relationship between the microbiota and the effects of the BPD-DS is yet to be established [86].

Single-Anastomosis Duodeno-Ileal Switch (SADI-S)

Since 2017, the SADI-S has been proposed as a modification of the traditional DS [87]. In SADI-S, the duodenum is anastomosed directly into an omega loop of ileum about 200–250 cm proximal to the ileocecal valve, eliminating the need for the Roux-en-Y jejuno-ileal anastomosis. The proposed advantages of SADI-S over DS are reducing the number of anastomoses (reduced risk of leak and making the operation technically easier) and avoiding a mesenteric defect that could be a site for future internal herniation.

It is beyond the remit of this chapter to discuss SADI-S in detail; however, SADI-S has now become a substitute for DS in the authors' practice. In 2018, the International Federation for the Surgery of Obesity and Metabolic Disorders published a position statement on SADI-S after the allocated Task Force reviewed all available evidence for its efficacy and safety [88]. Multiple studies indicate that SADI-S has comparable efficacy and safety to the DS in the short-term, although questions still remain about its long-term outcomes as this data is not yet available [88].

Summary

The DS offers patients, particularly very high BMI patients, a powerful option in the fight against diabetes and obesity. It is an operation that is much maligned, usually by those with little first-hand experience of the technique. In practice, as with most branches of bariatric surgery, DS can produce outstanding, long-term clinical results without having a major negative impact on patient safety or QoL if careful patient selection, meticulous surgical technique, good patient compliance, and excellent multi-disciplinary follow-up are practiced. Mortality, complication rates, and even the incidence of diarrhea are comparable to those seen after the more mainstream procedures such as SG and RYGB. The main obstacles to its widespread adoption are the shortage of surgeons with suitable training and the shortage of patients for whom the rigors of the postoperative protocol are suitable.

Key Learning Points

- The DS is the most effective bariatric procedure in terms of weight loss and diabetes remission. Unlike RYGB and sleeve gastrectomy, DS retains its efficacy even in patients with super-super-obesity (BMI > 60 kg/m^2).
- There is a common misconception that DS is associated with higher rates of perioperative and postoperative complications compared with RYGB, but this is not supported by the published literature.
- Rigorous patient selection is essential for a safe DS surgery – it is not a procedure that is widely applicable to the general bariatric patient population.
- The patient and the bariatric team must both commit to the lifelong follow-up if long-term nutritional sequelae are to be minimized.
- SADI-S is a modification of DS which involves one loop duodenoileal anastomosis instead of the Roux-en-Y structure. Though there is no evidence yet on long-term safety and efficacy, short-term data suggests comparable results with DS.

Cross-References

▶ Single-Anastomosis Duodeno-Ileal Bypass with Sleeve Gastrectomy (SADI-S) Surgery

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