Chapter 1
A Brief History of the Duodenal Switch

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1.1 History

The history of duodenal switch dates back to the initial work of Tom DeMeester who conceived a rerouting of bile and pancreatic secretions, to avoid duodenogastric reflux, a condition that is resistant to pharmaceutical treatment [1].

The term duodenal switch refers to the separation of the distal duodenum from the stomach and the proximal duodenum. The consequence is that bile and pancreatic secretions are indeed prevented from refluxing into the stomach, hence addressing pathologic duodenogastric reflux [2] and biliary gastro-esophageal reflux [3] (Fig. 1.1). Thus, in its initial embodiment, the DS was not a bariatric operation and did not involve a gastrectomy. The purpose of the current chapter is to discuss the advent and expansion of DS in metabolic-bariatric surgery (MBS), which typically does include a gastrectomy.

When looking at the history of MBS, the first attempts aimed at simply inducing substantial weight loss, without much attention paid to what the actual physiologic implications were. (The term "metabolic" in conjunction with "bariatric" (weight loss) surgery was introduced by Buchwald [4]). Bariatric surgery initially did not analyze the mechanisms through which surgical manipulations achieved weight loss. The first pioneers focused on bowel length and resected (Henriksen, 1952) or—in an attempt to make the procedure less invasive—bypassed part of the small bowel (Payne, 1963), leaving behind a long blind ending part of the jejunum and ileum. Interestingly, when faced with the ill consequences of the iatrogenic short bowel induced by his technique, Payne did not hesitate to reverse the anatomy when sufficient weight loss had been achieved. Throughout the years, reversibility will continue to be an important asset in bariatric surgery.

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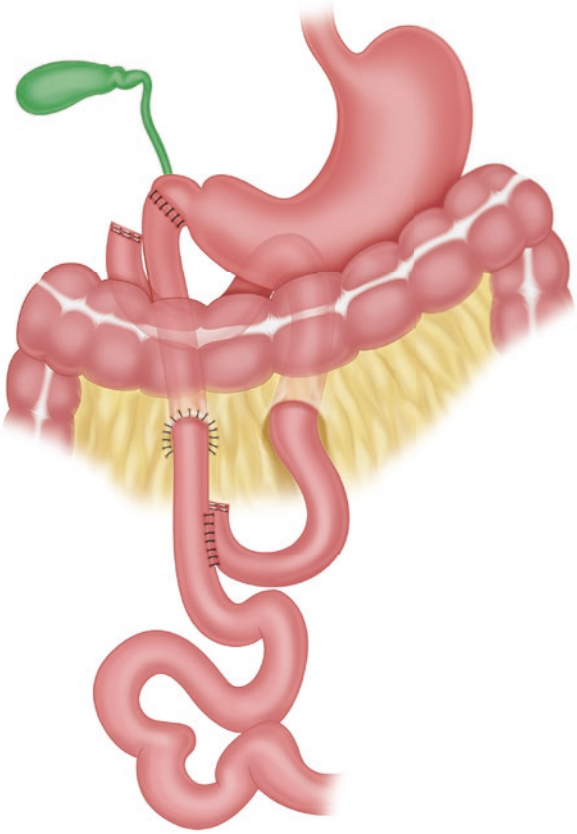

Fig. 1.1 The (open) duodenal switch procedure, designed by DeMeester (USA) in the 1980s. The stomach is left untouched, the duodenum is transected some 3–4 cm distal to the pylorus, and the proximal edge is anastomosed in end-to-end fashion to a Roux-en-Y limb going through the transverse mesocolon. The Roux limb is fashioned by transecting the jejunum some 25 cm distal to the Treitz angle. The jejuno-jejunostomy that completes the Roux construction is located approximately 55 cm distal to the duodeno-ileostomy

Historically, after addressing (and subsequently abandoning) the aspect "bowel length," surgeons soon started focusing on the reservoir function of the stomach. Taking into account the potential of reversibility, they looked into procedures that transected the upper part of the stomach and reconstituted gastrointestinal continuity by connecting the proximal transected stomach to a loop of the small bowel. Thus, Mason [5] transected the stomach horizontally, leaving a rather large pouch. However, because he reconnected the stomach with a loop of jejunum, gastric reflux of bile and digestive juices often created a situation. This inconvenience was approached by Griffen [6] who replaced the loop construction with a Roux-en-Y, thereby completing what became known as the Roux-en-Y gastric bypass.

The principle of transecting the small bowel, anastomosing the distal part to a viscus (often the stomach) and restoring continuity by reconnecting the proximal part with the distal part of the transected bowel at some distance from the anastomosis with the viscus was first described in the late nineteenth century by César Roux, a Swiss surgeon [7] (Fig. 1.2). Initially, the thus created "Roux" limb was a mere 12 cm long. Of note, the Roux-en-Y technique was soon abandoned by its inventor,

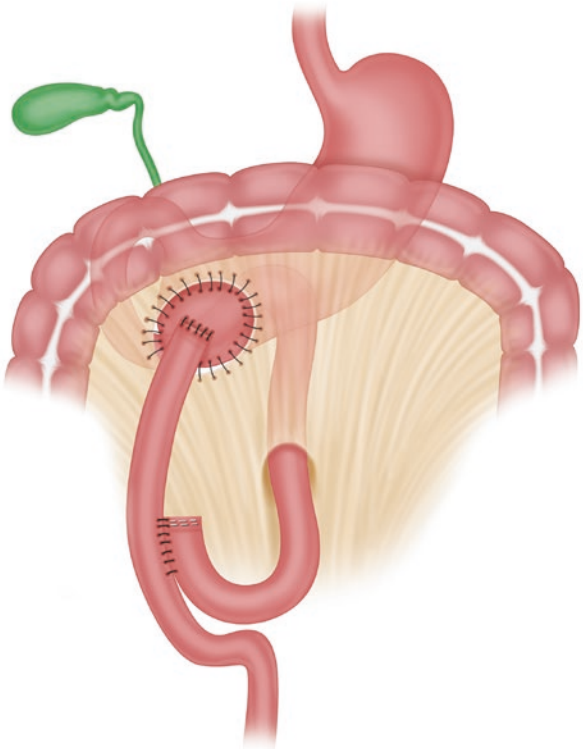

Fig. 1.2 The original Roux-en-Y procedure, invented by the Swiss surgeon César Roux in the 1880s. After opening the mesocolon, portion of the greater curvature of the stomach is pulled in an infra-mesocolic position. The proximal jejunum is transected, and the distal edge is anastomosed to the thus prepared stomach. The intestinal continuity is restored by suturing the proximal end of transected jejunum to the mounted jejunal loop, about 12 cm distal to the gastroenterostomy

because of complications at the gastro-enterostomy. Nevertheless, the principle of mounting a small bowel limb where no digestive juices flow was widely implemented in different domains, including MBS.

1.2 The Initiator: Scopinaro

As of 1977, Nicola Scopinaro finetuned the intestinal bypass procedure—bypassing duodenum and jejunum—and combined it with an antrectomy with Roux-en-Y reconstruction including a Roux-limb of some 200 cm [8] (Fig. 1.3).

Scopinaro called his procedure the biliopancreatic diversion (BPD) because bile and pancreatic juices were diverted away from the flow of nutrients and only allowed to mix with the latter some 50 cm proximal to the ileocecal valve, site of the jejuno-ileal anastomosis. The biliopancreatic "passive" limb length was not routinely measured in BPD, but the relatively short "active" limb (i.e., Roux limb + common limb, together 250 cm long) implied that the passive limb was predominant in length. As a consequence, in clinical practice, because of the large re-absorptive surface of the biliopancreatic limb, pancreatic enzymes are almost undetectable at

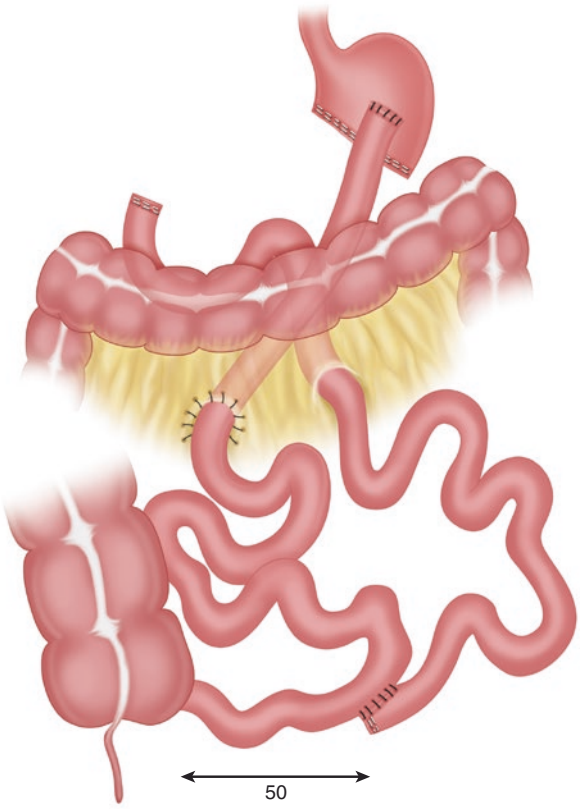

Fig. 1.3 Scopinaro's (open) biliopancreatic diversion (Italy, 1982). When present, the gall bladder is removed. The stomach is reduced in volume by a wide antrectomy, leaving 200–300 cc of fundus (the "ad hoc stomach"), depending on the patient's body mass index. A Roux limb is created at the distal jejunum, exactly 250 cm from the ileocecal valve, and brought through the transverse mesocolon for anastomosis with the lateral part of the distal edge of the stomach. The proximal cut edge of the distal jejunum is sutured to the distal ileum, 50 cm proximal to the ileocecal valve

the level of the jejunoileal anastomosis. The result is an imbalance between the pancreatic secretions and the bile when they mix with nutrients. Therefore, while weight loss is excellent, protein and micronutrient malnutrition constitute a true hazard and malodorous diarrheic stools often impair quality of life. It is these undesirable side effects that prevented the widespread adoption of the procedure, and actually caused its eventual disappearance [9].

1.3 The Pioneers: Hess and Marceau

Importantly, on top of the already mentioned downsides, the BPD construction appeared to predispose to (gastro-enteral) anastomotic ulcer. Anticipating on these side effects, and keeping the basic idea of separating the ingested food stuffs and the

biliopancreatic secretions, a number of surgeons, including Hess (in the USA) [10] and Marceau (in Canada) [11] came forward with a substantially altered version of BPD that they called the biliopancreatic diversion with duodenal switch (BPD-DS).

Both Hess and Marceau honored Scopinaro's principle of intestinal bypass but they addressed the distal stomach and proximal duodenum in a specific way. Their configuration was actually a hybrid of BPD and DeMeester's duodenal switch procedure performed for duodenogastric reflux as mentioned earlier.

A significant difference with the BPD Roux construction is that Hess and Marceau approached the problem of anastomotic ulcers by reducing the gastric parietal cell mass, rather than the gastrin producing cells, as performed by Scopinaro. They proceeded to resect the greater curvature of the stomach, that is, created a longitudinal gastrectomy, commonly called a "sleeve gastrectomy (SG)". Importantly, this new approach allowed to preserve the pylorus while the duodenum was transected some 3–4 cm distal to it. Besides avoiding proximal anastomotic ulceration, the new construction was meant to reduce the incidence of dumping [12] by better regulating gastric emptying.

The sleeve gastrectomy (SG) itself plays a significant functional role in the operation. As mentioned by Marceau, the sleeved stomach leaves a sufficiently large gastric remnant (in Picard Marceau's initial description greater than 250 cc [11]) so as to initiate protein digestion. Conversely, Hess leaves a smaller stomach (some 150 cc), which, however, is still substantially larger than in traditional RYGB. With both Marceau's and Hess' technique, the reduction in stomach size benefits early satiety without inducing food intolerance. The preservation of the different compartments of the stomach in continuity with the proximal duodenum likely avoids the ill consequences of a blind stomach as in classic BPD.

Unlike in Scopinaro's procedure, Hess measured the entire bowel length (from Treitz' angle to the ileocecal valve) and, rather than arbitrarily using 250 cm of distal small bowel as in classic BPD (see above), he used the distal 40% of small bowel to create the alimentary and common limb. After separation from the proximal small bowel, he connected the 40% of the distal bowel to the proximal end of transected duodenum, constituting the active limb that was in contact with nutrients. The proximal bowel was then anastomosed to the active channel between 50 and 100 cm proximal to the ileocecal valve, depending on the total bowel length and the patient's weight [13] (Fig. 1.4).

In 1990, Picard Marceau brought his own personal touch to the Scopinaro BPD. Quite as in Hess's technique he included a sleeve gastrectomy, preserved the proximal duodenum, and performed a duodeno-ileostomy, but he kept the bowel lengths as described by Scopinaro, except for the common channel that he lengthened to some 100 cm [11] (Fig. 1.5).

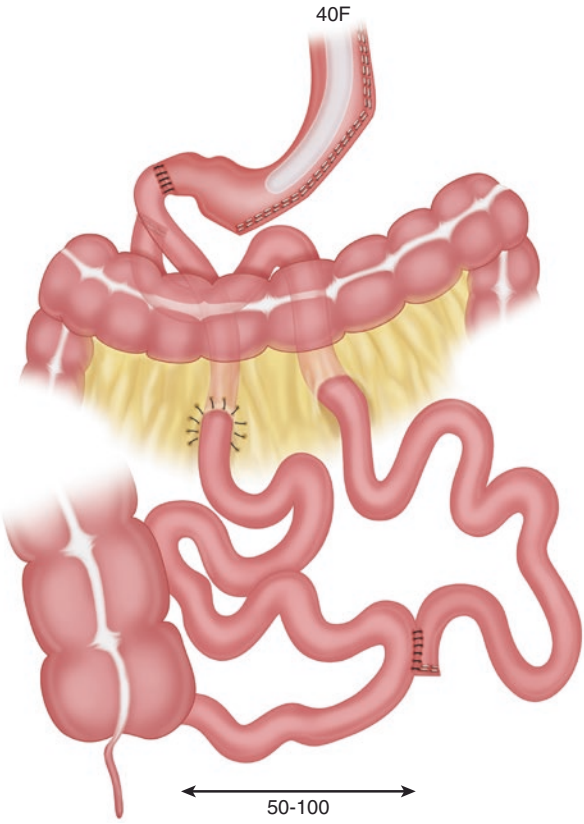

Fig. 1.4 Hess' (open) duodenal switch procedure, designed by Douglas Hess from the USA in the late 1980s. When present, the gall bladder is removed. The stomach is reduced in volume (some 70%) by resecting the greater curvature part of the stomach, leaving antrum (i.e., the distal 5 cm of the stomach) pylorus and proximal duodenum intact. As in DeMeester's procedure, the duodenum is transected and re-anastomosed to a Roux limb. The latter is however obtained after measuring the entire small bowel, and transecting the jejunum, leaving 40% of the entire length as distal part, to be anastomosed to the proximal duodenum end. The remaining 60% of (proximal) small bowel will not come in contact with nutrients and constitutes the biliopancreatic limb, which is sutured to the ileum between 50 and 100 cm cephalad to the ileocecal valve, depending on the patient's measured bowel length and weight

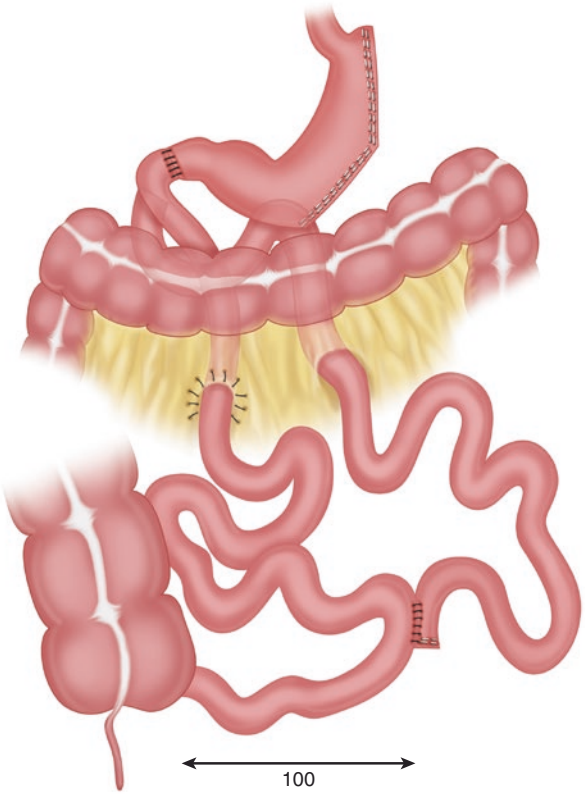

Fig. 1.5 Marceau's (open) duodenal switch procedure, designed by Picard Marceau from Canada, almost simultaneously with Douglas Hess. The gall bladder is removed when present. Marceau's gastric pouch is left somewhat bigger than with Hess, and the duodenum transected in a similar fashion. Conversely with the Hess technique, the bowel length is not measured. Rather, the (distal jejunum) bowel is transected some 250 cm from the ileocecal valve and the distal end lifted through the transverse mesocolon for anastomosis with the duodenum; the proximal end of the transected jejunum is re-anastomosed to the ileum at 100 cm from the ileocecal valve. This technique was adapted for laparoscopy by Michel Gagner in 1999. The result was an identical construction, except for the cholecystectomy that was not routinely performed

1.4 The Laparoscopic DS (Gagner) and the Idea of Staging

All MBS techniques, including BPD-DS, were fraught with substantial morbidity/mortality until some 20 years ago.

In 2002, Michel Gagner and colleagues published their preliminary outcomes on the BPD-DS performed entirely laparoscopically, a procedure they conceived 3 years before [14]. Obviously, the laparoscopic approach reduced the invasiveness of the technique. So as to further improve morbidity outcomes in the most frail patients, in laparoscopic BPD-DS candidates suffering from super-obesity or who

presented high operative risks, Gagner came to the idea to stage the procedure and to perform SG as a first isolated step, delaying the completion of the DS, or RYGB, in selected cases to a later date [15]. Quite unexpectedly, he noticed that the isolated SG succeeded in inducing good weight loss, with a magnitude of 35% of excess weight loss (EWL). Other authors implemented this new strategy of staged procedure in high-risk patients and recorded similar good weight loss figures, up to 45% EWL with the SG alone [16].

Independently from the Hess and Marceau schools, but following similar reasoning, other investigators focused on the isolation of the fundus and the greater gastric curvature from the flow of nutrients. In the 1990s, Johnston from the Leeds Infirmary, UK, designed a bariatric procedure whereby the greater curvature was separated from the lesser curvature, and both parts of the stomach reunited at the antrum level. He named this procedure the "Magenstrasse and Mill" (MM) [17] (Fig. 1.6). The relative complexity of the MM however did not allow its implementation by the

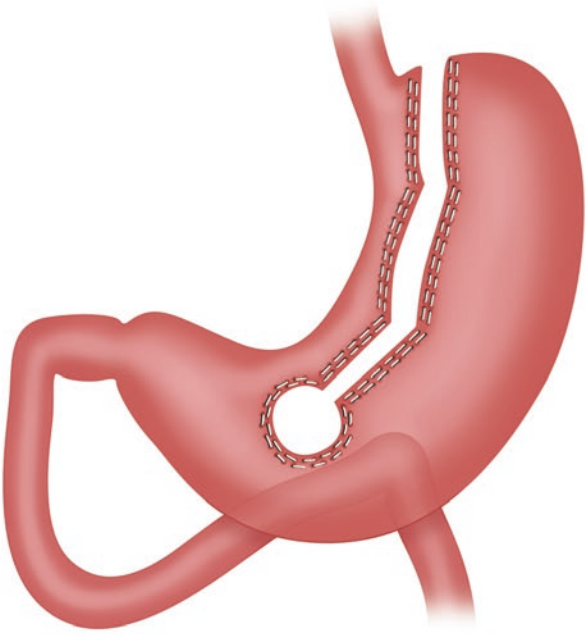

Fig. 1.6 Johnston's (open) Magenstrasse and Mill procedure (Leeds, UK, 1993). In an effort to preserve the antrum (the "Mill"), the pylorus, and the duodenum, a transgastric stapled opening (window) is performed at the level of the incisura and a tube of stomach (the "Magenstrasse") constructed by stapling in cephalad direction alongside a 32 French orogastric tube hugging the lesser curvature, until separation is achieved from the incisura up to His' angle. This technique was adapted for laparoscopy by Michael McMahon at the end of the twentieth century. Rather than creating a window to start the stapled transection of the stomach, he resected the entire greater curvature part, leaving a sleeve of stomach that looked like a hockey stick (the sleeve gastrectomy)

laparoscopic approach with the tools that were available at the time. McMahon, at Leeds University, simplified the procedure and [18] redesigned the MM principle by simply removing the greater curvature, thereby achieving a "sleeve gastrectomy." He presented the preliminary outcomes at the international federation for the surgery of obesity and metabolic disorders (IFSO) world congress in Crete, in September 2001. The most significant merit of the Leeds school was to introduce sleeve gastrectomy in patients who did not suffer from super-obesity and to view the SG operation as an isolated MBS procedure. It is interesting how SG became part of the armamentarium of the bariatric surgeon based on the simultaneous work of different surgical schools.

The volume of the sleeved stomach is critical in BPD-DS. Quite similar to BPD, the BPD-DS is mainly an absorption reducing (malabsorptive) procedure. Consequently, when the size of the stomach does not allow sufficient caloric intake [12], the reduced absorption may create malnutrition, and, when severe, hepatic insufficiency. The late professor Scopinaro often insisted on the importance of the ingested volumes in malabsorptive procedures [19]. When performed in two stages, the BPD-DS theoretically diminishes the danger of insufficient caloric intake because with time the sleeve component will have become more compliant and allow more ingested volumes after sufficient waiting time before proceeding with the intestinal bypass stage [20]. Staged BPD-DS thus allows for safer surgery in patients with morbid or super-obesity. There is some controversy as to what procedure should be the natural second step after SG. According to the literature, gastroesophageal reflux will be better addressed by conversion to RYGB, but for weight issues (e.g., weight regain after initial good weight loss, or weight loss that is judged insufficient by the multidisciplinary work-up) conversion to BPD-DS is the procedure of choice [21]. Actually, staged BPD-DS provides outcomes that do not significantly differ from the one-stage technique [22]. Moreover, staged BPD-DS may avoid the second step (i.e., the DS procedure) in a significant number of patients. In addition, the risk of surgical complications appears to be smaller in the staged than the one stage operation [23]. Finally, one seldom mentioned additional advantage of the staged procedure is that it allows the individuals who show poor compliance with the postoperative follow-up. These individuals are likely suboptimal candidates for the completed BPD-DS procedure, the outcomes of which are highly dependent on adequate follow-up [24].

1.5 Clinical Outcomes

In terms of overall outcomes after laparoscopic DS, our team published the department's 10+ years of data [25]. The results in terms of weight loss, arterial hypertension, dyslipidemia, and type 2 diabetes were excellent. The downside was the incidence of excessive weight loss, with or without protein malnutrition (10.6%), and the stunning number of reoperations (42.5%). On the brighter side, probably because the laparoscopic approach did not cause substantial adhesions, when needed, reoperations not only proved to be quite effective but also to carry

acceptable complication numbers. Consequently, patient acceptance was good. Our results are quite superimposable with those of Marceau et al. [26] and are actually in close match with Scopinaro's long-term outcomes [27].

1.6 New Developments: The Loop-DS

Despite the fact that the clinical results of the BPD-DS procedure have proven to be excellent, and appear to provide superior metabolic outcomes, its acceptance by the surgical community is still modest. In fact, the cohort of BPD-DS patients constitutes only a negligible part of the total and ever-increasing group of BMS procedures over the world [28]. The low prevalence most likely has to do with the perceived difficulty of the duodenal dissection, and with the overall need for resecting, stapling, and performing more than one anastomosis [29]. To address these concerns, Torres and Sanchez-Pernaute developed a significant technical adjustment to the BPD-DS construction, which they named the SADI-S procedure (single anastomosis duodeno-ileal-sleeve) [30] (Fig. 1.7). The technique was introduced in the USA as the SIPSS

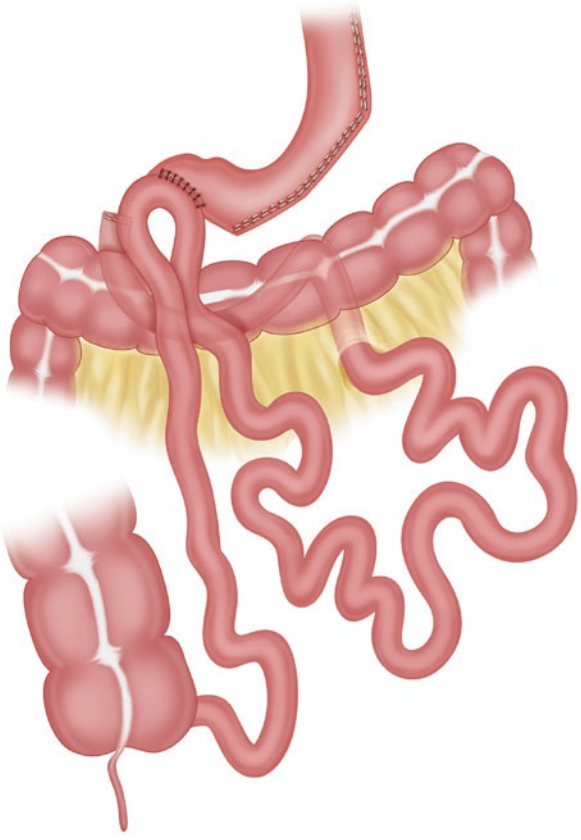

Fig. 1.7 The single anastomosis laparoscopic DS (SADI-S), created by Torres and Sanchez-Pernaute from Spain in 2007. After performing the sleeve gastrectomy, the duodenum is (immediately or at a later stage) transected some 3–4 cm distal to the pylorus. A loop of small bowel (distal jejunum) is snapped and brought in antecolic position to the proximal cut surface of the duodenum. A (usually manual) anastomosis is then performed, initially at 200 cm of the ileocecal valve, but recently the common limb is usually left longer (250–300 cm)

(stomach intestinal pylorus sparing surgery) operation [31]. In this technique, the duodenum is transected (as in classic BPD-DS) but continuity is restored by anastomosis to a loop of undivided bowel, so as to keep some 200, or, more recently, 250–300 cm of distal bowel in contact with the nutrient flow. The fact that the pylorus is left intact at least theoretically prevents the reflux of digestive juices from the proximal part of the bowel loop into the stomach and/or the esophagus. The pylorus may thus play a significant role in the SADI-S construction, and may constitute a great benefit compared to the one-anastomosis gastric bypass (OAGB), which is characterized by a loop anastomosis of the jejunum, with, in consequence, unhindered passage of bile and other digestive juices into the gastric pouch. The question stays if "in real life" the pylorus remains functional in the long term. Csendes [32] quite recently showed that in a significant number of patients, evaluated some 10 years after isolated laparoscopic sleeve gastrectomy (LSG), the pylorus actually remains immobile and open in a stunning 82%. To date, however, there is no hard data concerning the remaining function of the pylorus long term after SADI-S. Nevertheless, the clinical outcomes after SADI-S appear to be quite promising and equivalent to BPD-DS, with fewer incidences of malabsorption [33]. Those positive outcomes were almost perfectly duplicated by Topart in France [34] and by Roslin in the USA [35].

In 2021, the DS procedure is seldom performed. Its position has almost entirely been taken over by the SADI-S procedure.

Conflict of Interest

1. No commercial conflicts.
2. The artist work is original.

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