Duodenal Switch and Its Derivatives in Bariatric and Metabolic Surgery

A Comprehensive Clinical Guide

Andre Teixeira · Muhammad A. Jawad · Manoel dos Passos Galvão Neto · Antonio Torres · Laurent Biertho · João Caetano Marchesini · Erik Wilson *Editors*

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Foreword

Christian Albert Theodor Billroth would have never thought that gastrectomy and gastrojejunal anastomosis, one day, would establish the major pillars for metabolic and bariatric surgery.

Bypassing the duodenum and adding early offer of the gastric content to distal small bowel promote, through several different mechanisms, early satiety, hunger control, and increased energy expenditure. This condition causes, consequently, sustained weight loss and control or a resolution of associated diseases.

Soon after the use of the Billroth II technique, some complications were observed. One of them was inadvertent gastroileal anastomosis, which resulted in malnutrition and severe weight loss.

Nicola Scopinaro, based on such complications, proposed a new operation called biliopancreatic diversion. It was a distal gastrectomy with gastroileal anastomosis in a Roux-en-Y fashion.

Douglas Hess and Piccard Marceau modified Scopinaro's operation. Instead of doing a distal gastrectomy, they performed a vertical sleeve gastrectomy with pylorus and part of the duodenal bulb preservation. The anastomosis of this pyloroduodenal end was also done with the ileum in a Roux-en-Y manner.

This was the birth of the duodenal switch.

How was this new operation named?

Hess and Marceau borrowed the name of an operation proposed by Tom DeMeester as a treatment for duodeno-gastric reflux and alkaline gastritis.

Duodenal switch has been the root of some other bariatric operations such as sleeve gastrectomy, single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI'S), gastric plication, endoscopic gastric plication among several others.

SADI'S also have several variations or at least several different names such as single anastomosis duodenojejunal bypass with sleeve gastrectomy (SADJB-SG), stomach intestinal pyloric sparing surgery (SIPS), one anastomosis duodenal switch (OADS), loop duodenojejunal bypass with sleeve gastrectomy (LDJB-SG), distal loop duodeno-ileostomy (DIOS) and proximal duodeno-jejunostomy (DJOS).

All efforts have been done to improve the final results of these procedures.

Despite being the most effective operation to control hunger and satiety and to promote sustainable weight loss, unfortunately, nutritional complications have been the major reason for its low application.

The number of duodenal switches remains low worldwide, even though, they keep showing the best results for weight loss, lasting effect, and reversal of comorbidities.

Besides nutritional issues, some other reasons may contribute to its low application.

Higher laparoscopic technical complexity, difficulty to be performed, less experienced bariatric surgeons adequately trained, submission to a longer learning curve, time-consuming operation, low patient appeal, more difficult follow-up, inadequate patient choice for this operation, surgical risks, and side effects may explain the low number of duodenal switches performed and published in the medical literature.

Once malnutrition is controlled the bariatric and metabolic results justify increasing the numbers of duodenal switches and/or their modifications.

I have learned from my own experience of more than two decades and above 700 patients operated upon that there is an ideal patient for the original duodenal switch.

Even though the indication is based on BMI over 40 with or without comorbidities, super obese patients and those with metabolic syndrome have the best benefits. Patients that eat more fatty foods have better results compared to the ones that eat more starch. Economic conditions also make difference. They need to afford continuous use of Vitamins, Minerals, and other supplements. Patients that are not kept on track may develop complications. Follow-up is very important. The patient needs to understand the surgery to cooperate during the long postoperative period.

All modifications that duodenal switch suffered during these years look after the necessity to protect the patients from malnutrition consequences.

We need to look forward to having these side effects better controlled to offer our bariatric and metabolic patients the best solution for their disease.

Duodenal Switch and Its Derivatives in Bariatric and Metabolic Surgery: A Comprehensive Clinical Guide comes now to up-to-date studies on this particular field of bariatric and metabolic surgery.

This publication joins the most important and most experienced metabolic and bariatric surgeons in the world as well as associated experts. Here, they present their experiences, their opinions, and their indispensable teaching.

This publication covers all fields of metabolic and bariatric surgery related to duodenal switches and similar operations.

Starting with an anatomical review and physiologic principles, it is followed by types of derivative operations, advantages and disadvantages, complications, revisional procedures, nutritional matters, and many other issues. It is a complete book on this subject.

I believe it will help all metabolic and bariatric surgeons and associated professionals to offer to these patients what exists as the best for this very important field of medicine.

Enjoy the reading.

University of Parana
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João B. Marchesini,

Preface

Obesity is a major cause of disability and is correlated with various diseases and conditions particularly cardiovascular diseases, type 2 diabetes, obstructive sleep apnea, certain types of cancer, and osteoarthritis. High BMI is a marker of risk for, but not a direct cause of, diseases caused by diet and physical activity.

Obesity has individual, socioeconomic, and environmental causes. Some of the known causes are diet, physical activity, automation, urbanization, genetic susceptibility, medications, mental disorders, economic policies, endocrine disorders, and exposure to endocrine-disrupting chemicals.

Although there is no effective, well-defined, evidence-based intervention for preventing obesity, obesity prevention will require a complex approach, including interventions at community, family, and individual levels.

The initial idea for this book came around October 2020 and by December 2022 we had a rough draft of the editors and the main authors for the chapters. The initial chapter index had 37 chapters and rapidly grew to 72, we settled for 67 chapters.

The project took 18 months to be completed and was by far one of the most difficulty projects to be completed due to the sheer volume of chapters, in the midst of Covid 19 ravaging through our lives.

The goal of this book is to be used as the main source of information and learning techniques on duodenal switches in metabolic and bariatric surgery. We recruited authors that are heavily involved in the care of patients that are going through the process or already have a duodenal switch procedure done.

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The most important acknowledgment is to my wife Maria and my son Enzo for their amazing support and understanding for the countless hours that were devoted to this project until its completion.

Andre Teixeira MD, FACS, FASMBS

Contents

Part I
Introduction

Chapter 1
A Brief History of the Duodenal Switch

Jacques M. Himpens

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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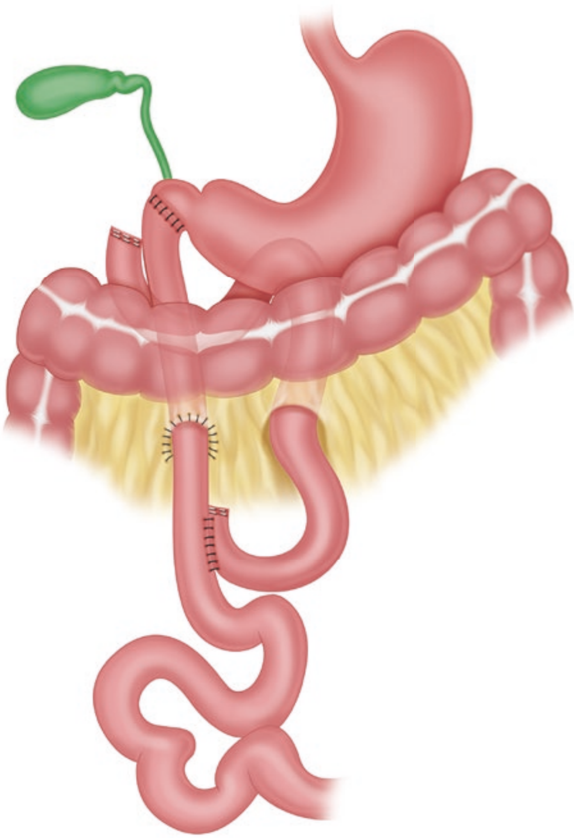

Fig. 1.1 The (open) duodenal switch procedure, designed by DeMeester (USA) in the 1980s. The stomach is left untouched, the duodenum is transected some 3–4 cm distal to the pylorus, and the proximal edge is anastomosed in end-to-end fashion to a Roux-en-Y limb going through the transverse mesocolon. 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,

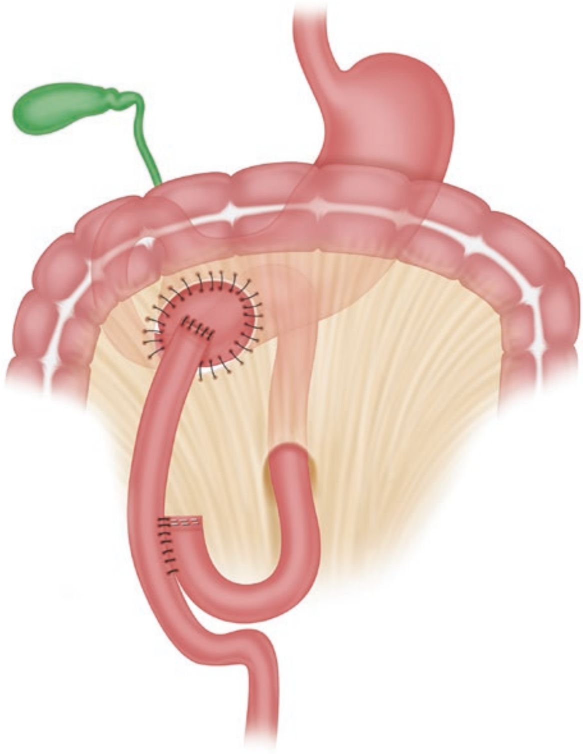

Fig. 1.2 The original Roux-en-Y procedure, invented by the Swiss surgeon César Roux in the 1880s. After opening the mesocolon, portion of the greater curvature of the stomach is pulled in an infra-mesocolic position. The proximal jejunum is transected, and the distal edge is anastomosed to the thus prepared 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

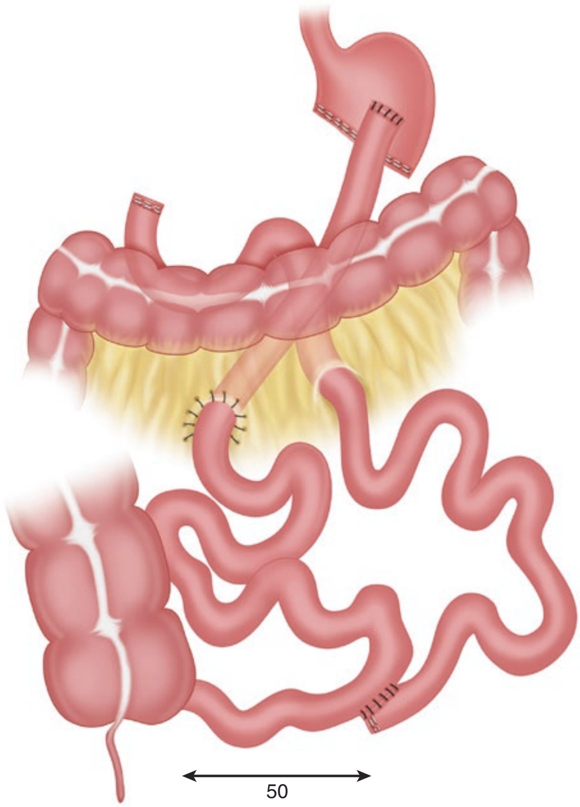

Fig. 1.3 Scopinaro's (open) biliopancreatic diversion (Italy, 1982). When present, the gall bladder is removed. The stomach is reduced in volume by a wide antrectomy, leaving 200–300 cc of fundus (the "ad hoc stomach"), depending on the patient's body mass index. A Roux limb is created at the distal 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).

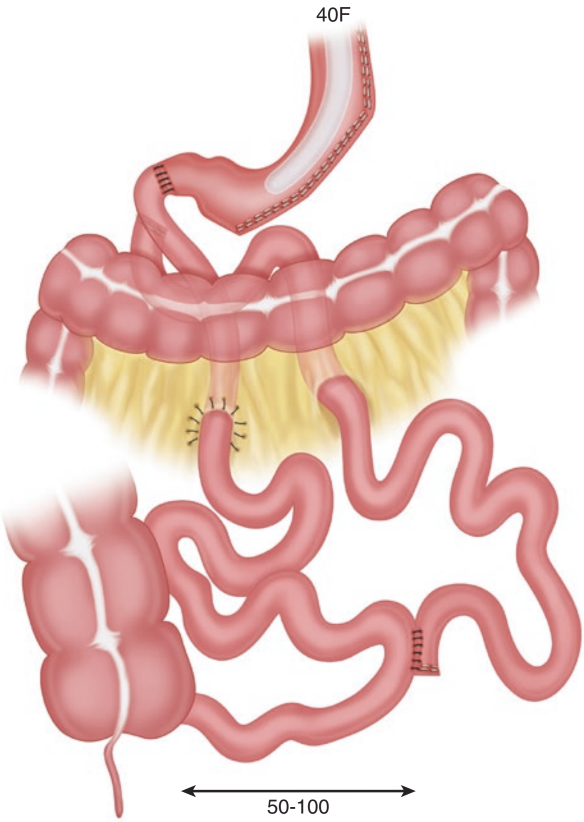

Fig. 1.4 Hess' (open) duodenal switch procedure, designed by Douglas Hess from the USA in the late 1980s. When present, the gall bladder is removed. The stomach is reduced in volume (some 70%) by resecting the greater curvature part of the stomach, leaving antrum (i.e., the distal 5 cm of the stomach) 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

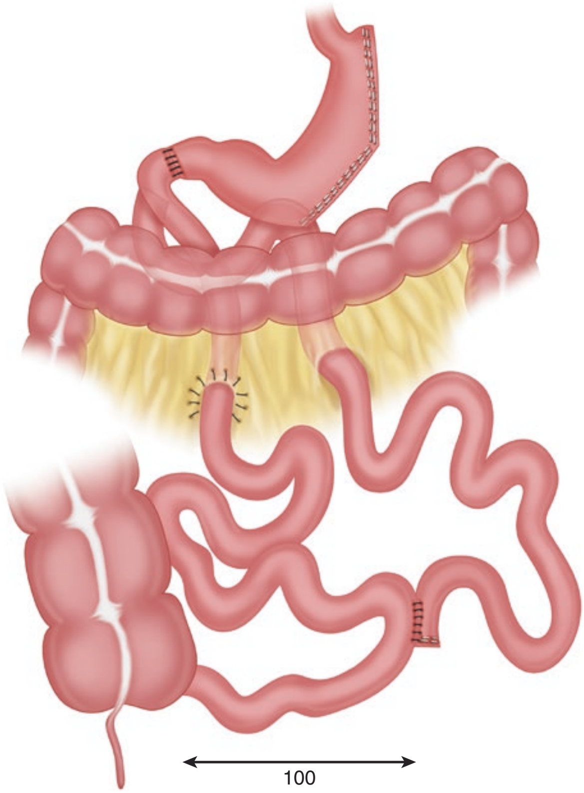

Fig. 1.5 Marceau's (open) duodenal switch procedure, designed by Picard Marceau from Canada, almost simultaneously with Douglas Hess. The gall bladder is removed when present. Marceau's gastric pouch is left somewhat bigger than with Hess, and the duodenum transected in a similar fashion. Conversely 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

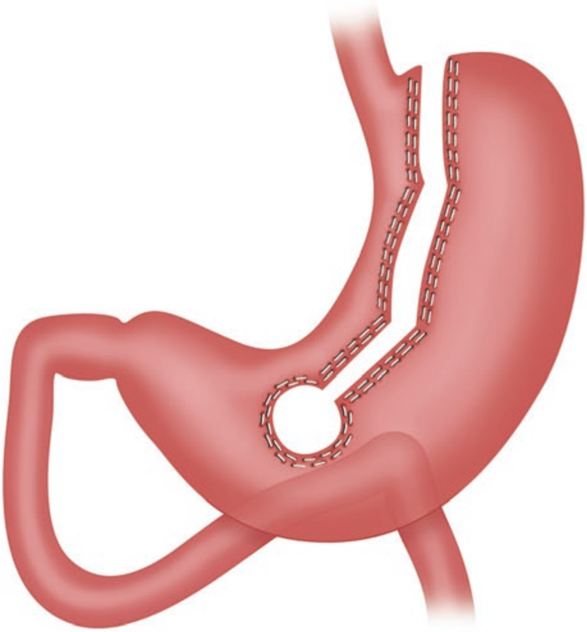

Fig. 1.6 Johnston's (open) Magenstrasse and Mill procedure (Leeds, UK, 1993). In an effort to preserve the antrum (the "Mill"), the pylorus, and the duodenum, a transgastric stapled opening (window) is performed at the level of the incisura and a tube of stomach (the "Magenstrasse") constructed by stapling 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

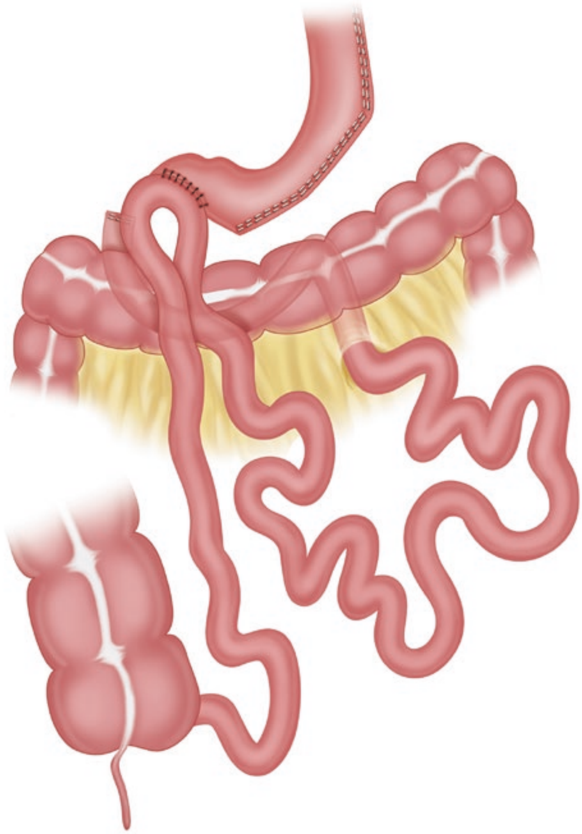

Fig. 1.7 The single anastomosis laparoscopic DS (SADI-S), created by Torres and Sanchez-Pernaute from Spain in 2007. After performing the sleeve gastrectomy, the duodenum is (immediately or at a later stage) transected some 3–4 cm distal to the pylorus. A loop of small bowel (distal jejunum) is snapped 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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Chapter 2
Duodenal Switch: Mechanisms of Functioning

Andrés Sánchez-Pernaute, Miguel Ángel Rubio Herrera, and María Elia Pérez Aguirre

2.1 Introduction

Restriction and malabsorption are old and probably outdated concepts in the bariatric surgery physiology. However, we have to accept that the most successful weight loss and metabolic operations gather to some extent a limitation in the entrance of energy and a limitation in the absorption of nutrients.

The duodenal switch is a type of biliopancreatic diversion, and as such it is based in a moderate gastric restriction along with an intestinal bypass with a long biliopancreatic limb and a short and known common channel. Gastric resection in the duodenal switch pretends to be more physiologic than the traditional distal resection proposed by Scopinaro. Based on an old experimental operation for the treatment of peptic ulcer, the resection introduced by Douglas Hess is a vertical gastrectomy that removes the greater curvature and leaves a tubularized lesser curvature. The gastro-ileal bypass from the original biliopancreatic diversion is changed into a duodeno-ileal bypass, based on DeMeester's duodenal switch developed to treat duodenal-gastric reflux [1, 2] (Fig. 2.1).

The operation has demonstrated over the years to be the most effective bariatric surgery although it is considered to be technically challenging, and long-term secondary effects and sequelae may counteract its benefits.

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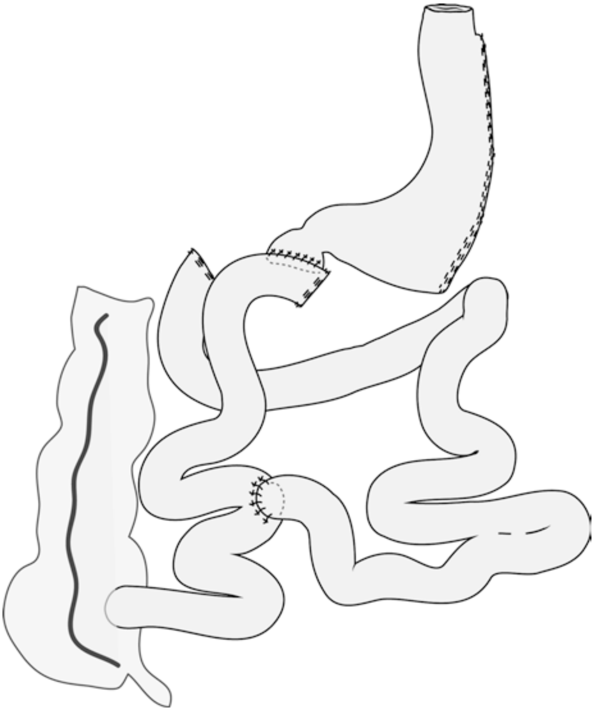

Fig. 2.1 Scheme of the duodenal switch

2.2 The Sleeve Gastrectomy

When Douglas Hess developed the duodenal switch, the performance of a sleeve gastrectomy was accidental. The first cases of duodenal switch were reoperations for weight regain. The author introduced the duodeno-ileal anastomosis for two reasons: the first one was to avoid a new anastomosis in a previously operated area, which was difficult to approach and dangerous due to potential problems of vascularization; the second one was to avoid marginal ulceration [1]. Once the decision was taken for an anastomosis to the duodenum, the only possibility to reduce the gastric volume was a vertical gastrectomy. In those early years of the new technique the residual volume of the stomach was approximately 150 cc, calculated by filling the stomach with water after completing the resection. The calibration was made over a 40 French bougie.

The limitation in gastric capacity is the first and simple mechanism of restriction. If the fundus of the stomach is the place where one can collect great quantities of food thanks to its great compliance, its elimination must drastically reduce the total intake. But there are more mechanisms related to the restriction of the sleeve gastrectomy and, what is probably more important, related to the contribution of the sleeve to the reduction of intestinal absorption.

In the first years of the present century, the sleeve gastrectomy was reborn as a single standing weight loss operation [3]. Some reasons contributed, and probably the most important was its simplicity. But another important reason was that the observed weight loss was greater than expected; greater than that obtained with similar operations performed in the past, as it was the vertical banded gastroplasty or the Magenstrasse and Mill operation introduced by Johnston [4, 5]. The achieved weight loss with a sleeve gastrectomy was quite close to that obtained after a Roux-en-Y gastric bypass. The main difference between the sleeve gastrectomy and those old operations was the removal of the fundus instead of leaving it separated from the new gastric pouch. The fundus of the stomach is one of the places where the orexigen hormone ghrelin is secreted. It is true that ghrelin is also produced in the small intestine, the testicles, placenta, liver, or central nervous system, but when the fundus is removed, the levels of ghrelin are shown to drop drastically, and this seems to be related to early satiety and successful weight loss [6].

The decrease in ghrelin levels is a direct effect of the fundus resection. However, there are other hormonal effects not directly related to resection of its production area, as is the rise in glucagon like peptide-1 (GLP-1) secretion in patients submitted to sleeve gastrectomy. This has been demonstrated by Vives et al. [7] and appears to be related to the acceleration of gastric emptying after the sleeve resection combined with the poor processing of ailments in the operated stomach. On one hand, the gastric resection decreases the first processing of food, as there is no antral mill where the particles are sieved into small ones that can be absorbed. In the other one, the rapid gastric emptying delivers this poorly processed food into the distal small bowel, stimulating the secretion of GLP-1 which, among different actions, accelerates satiation.

The gastric resection decreases nutrient absorption at least partially. This is secondary to the limitation in the gastric phase of digestion. Secretion of pepsinogen, pepsin, hydrochloric acid, etc., is reduced, and this limits the initial gastric digestion of proteins and other nutrients, thus decreasing its absorption in the distal parts of the small bowel. The decrease in acid secretion also decreases the reduction of cations into absorbable ions in the duodenum and proximal ileum, so iron and calcium absorption is expected to be substantially reduced.

2.3 Pyloric Preservation

The preservation of the pylorus is an extremely important part of the operation. To achieve a correct functioning of the valve we advocate a complete vascular and neural preservation, what means avoiding dissection at the lesser curve of the antrum and duodenum, leaving the right gastric artery untouched. The motor branches of the vagus nerve to the pylorus typically arise from the hepatic branch, which is a division of the anterior vagus nerve, and accompany the right gastric artery to reach the pylorus and innervate both this muscle and the proximal part of the duodenum [8]. Division of the right gastric artery will, invariably, also sever pyloric innervation.

To improve mobilization of the duodenum with preservation of the lesser omentum, a full detachment of the posterior wall from the pancreatic surface must be achieved, while dissection should go beyond the gastroduodenal artery down to the common bile duct level. At this point is where the lesser omentum has to be incised to warrant full mobilization of the proximal duodenal stump without eliminating vascularization or innervation (Fig. 2.2).

Empirically we speculate that if the pylorus regulates gastric emptying, and if gastric emptying regulates the incretinic response, the preservation of a normally functioning pylorus has to be important in the regulation of the metabolic syndrome, especially in diabetic patients [9]. The regulation of gastric emptying has the great advantage of the elimination of the dumping syndrome, which has been linked to bariatric operations since the very first development of the gastric bypass. Dumping syndrome has been considered an adjuvant effect for weight loss, helping patients to abandon sweet-eating due to the unpleasant effect of the rapid gastric emptying. The post pyloric anastomosis eliminates this undesired complication improving the quality of life without affecting weight loss.

Another advantage, that is not empiricism, and has been thoroughly demonstrated, is the great benefit in terms of long-term complications of a postpyloric anastomosis. The alkaline mucous secretion of the duodenum protects the anastomosis from ulceration and stricture, complications seen frequently in the gastrojejunal anastomosis of the Roux-en-Y gastric bypass. Even in heavy smokers no such complications are observed affecting the proximal anastomosis of the duodenal switch. The duodenal mucous secretion tamponade is not the only protection against anastomotic problems, as was demonstrated by the group of DeMeester in 1992, when they reported that a postpyloric anastomosis favored gastric emptying and maintained a normal gastric acid secretion, while on the other hand, a prepyloric one was related to a delay in gastric emptying and a greater—probably secondarily—gastric acid secretion with frequent anastomotic ulcer formation [10].

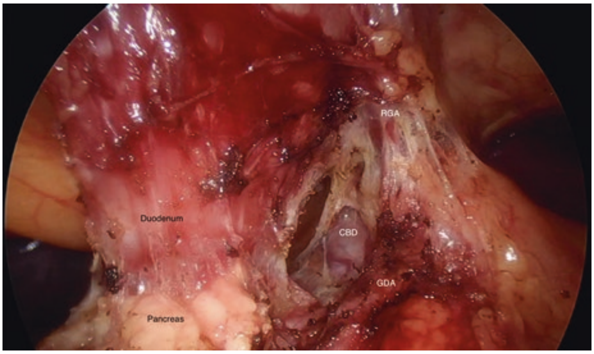

Fig. 2.2 Complete duodenal dissection with preservation of lesser curve vascularization and innervation. *CBD* common bile duct; *RGA* right gastric artery; *GDA* gastroduodenal artery

2.4 Biliopancreatic Diversion

The term biliopancreatic diversion is referred to the separation of bile and pancreatic juices from the area of the intestine where the aliments pass initially. The limb carrying these secretions will come together with the limb transporting the aliments distally in the small bowel, thus differing absorption to the distal intestine. Scopinaro introduced this concept of division of the small bowel to reduce the problems derived from the presence of a long blind limb, by anastomosis this one to the proximal stomach. In this way three different limbs could be distinguished: the alimentary one, the biliopancreatic, and the common channel, this last one being where absorption will mainly take effect [11–13]. This diversion was applied also to the Mason's gastric bypass at the end of the 1970s by Ward O Griffen [14]. The difference between both types of surgery laid on the long biliary limb and short common channel characterizing the biliopancreatic diversion.

Duodenal switch, as was Scopinaro's operation, consists on a limited, usually 200–250 cm, alimentary limb in which only a short amount of starch and proteins is absorbed, while water, electrolytes, and hydrosoluble vitamins absorption is maintained. As the alimentary limb commences usually at the level of the proximal ileum, little if any hexose receptors are present at the mucosal surface, so absorption of hexoses is drastically reduced, what appears to be an early control mechanism of glycemia in diabetic patients.

Bile and pancreatic juices circulate through all the jejunum, losing part of their power to contribute in the absorption of proteins and fat, and come together with the ingested nutrients at 60–100 cm from the ileocecal valve, where the common channel starts. The length of the common channel warrants the maintenance of the entero-hepatic cycle, and, on the other hand, limits caloric absorption to not more than 1500 Kcal per day, independently of the amount of the intake [15].

The duodenal switch is possibly the most powerful metabolic operation, along with the Scopinaro procedure, as it gathers most of the mechanisms implied in the remission of diabetes: the bypass of the duodenum and pancreatic regions (foregut hypothesis); the emptying of the first duodenal portion directly into the ileum, what causes early satiety and cooperates with gastric restriction, but also avoids contact of glucose with sodium glucose transport protein (SGLT) receptors; the stimulation of Takeda receptors in the intestinal L cells, what increases GLP-1 secretion; and the selective fat malabsorption, which secondary depletes liver fat deposits and also intra-myocyte fat, both related to insulin resistance and diabetes.

GLP-1 is probably the most amazing hormone related to obesity and obesity surgery. Its study has helped to develop powerful drugs currently used to treat obesity and diabetes or as adjuvant therapy to bariatric surgery. GLP-1 secretion is directly related to the amount of calories ingested, mainly carbohydrates. It is degraded by dipeptidyl peptidase-4 (DPP4). It enhances glucose-dependent insulin release and inhibits gastric emptying. It probably also has a direct effect on appetite-regulating centers in the central nervous system, as it also has an effect during starvation. A rise in postprandial levels of GLP-1 is detected in patients submitted to duodenal switch, as well as in patients submitted to other types of malabsorptive operations [16]. Other intestinal peptides related to weight loss and metabolic improvement after duodenal switch and other bariatric surgeries are oxyntomodulin, which acts as GLP-1 inhibiting gastric emptying and reducing food intake, peptide YY (3–36), also liberated by the L cells in the ileum, but not so potent as GLP-1, and neurotensin, which is directly related to lipid absorption and insulin sensitivity and increases higher after biliopancreatic diversions than after the standard Roux-en-Y gastric bypass [17].

Malabsorption-based operations do not enjoy a good press, in some respects deservedly; wrongly selected patients and non-compliant patients can have a highly impaired quality of life, mainly because of diarrhea and malnutrition. In a large series of experienced groups, these represent less than 5% of the cases, and those are because patients are thoroughly selected and followed, and supplementation is maintained from the early postoperative period [18]. Nutritional recommendations for patients undergoing duodenal switch include at least a total daily protein intake between 60 and 120 g of pure protein, 1–1.5 g/kg of ideal weight; fat should never exceed 30–35% of total caloric amount, as 20 g daily is enough to warrant the absorption of essential fatty acids and an adequate function of the gallbladder. Vitamin D, calcium, and iron are the usually recommended supplementation, and sometimes also vitamins A and E.

2.5 Conclusion

Duodenal switch includes virtually all mechanisms involved in weight loss and metabolic improvement after a bariatric operation. Intake restriction, changes in bile acids and peptide secretion, and a controlled limitation to absorption are all present in this highly effective operation. Selection of patients and an adequate performance of the surgical technique to decrease postoperative and long-term complications should warrant a satisfactory and maintained long-term effect.

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Chapter 3
Duodenal Switch and Its Derivatives

Yen-Yi Juo and Ranjan Sudan

3.1 Introduction

Despite the relative popularity of Roux-en-Y gastric bypass and sleeve gastrectomy [1], DS results in both the greatest magnitude of excess weight loss and the most reliable resolution of comorbidities, especially type II diabetes [2].

However, duodenal switch is currently not widely practiced. As of 2019, DS accounted for only 0.9% of all bariatric surgeries performed in the USA [3]. This is likely a result of factors such as the performance of DS requires both advanced laparoscopic technical skills, expert judgement in patient selection, and reliable follow-up for nutritional parameters. Also, the procedure is generally perceived as having higher peri-operative complications as well as increased risks of long-term nutritional deficiencies [4].

Nevertheless, DS is recently enjoying a resurgence of clinical interest, partly due to the spread of advanced laparoscopic skills, and, perhaps most importantly, the rising prevalence of super morbid obesity (BMI > 50 kg/m^2) [5] and weight recidivism after sleeve gastrectomy [6]. Due to these reasons, we believe that DS should continue to be in the arsenal for high-volume bariatric surgeons.

In this chapter, we seek to provide an in-depth overview of the pre-operative, procedural, and post-operative clinical management of patients undergoing DS surgery or one of its derivative procedures.

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3.2 History

Biliopancreatic diversion was initially described by Scopinaro et al. as a combination of two procedures: a partial gastrectomy and distal intestinal bypass. The partial gastrectomy involves a creation of a 250 mL gastric pouch and the distal intestinal bypass creates a 50 cm common channel and a 250 cm alimentary limb [7]. This procedure was subsequently modified due to the relatively high rate of dumping and marginal ulcers. The modernized version of this procedure, also known as biliopancreatic diversion with duodenal switch (BPD-DS), involves the creation of a sleeve gastrectomy, thereby preserving the pylorus, and the creation of a duodenal-ileal anastomosis [8]. This would allow preservation of the pylorus and reduce the parietal cell mass, leading to decreased rates of dumping and ulcer formation.

3.3 Derivative Procedures of Duodenal Switch

While early reports of BPD-DS were of open surgery, Ren et al. described the earliest laparoscopic BPD-DS [9] and our group reported the first report of robotic-assisted BPD-DS in 2000 [10]. With the evolution and advancement of robotic technology, this technique has evolved from a hybrid procedure to a totally robotic technique. By docking the robot one time, there is less dependence on a bedside assistant and improved efficiency within the operation. This book chapter describes and illustrates the robotic-assisted BPD-DS technique utilized by our group since November 2011.

Besides the advance in minimally invasive surgical approaches, the recent evolution of BPD-DS has developed several derivative procedures. The most popular derivative procedure is the adoption of sleeve gastrectomy as a standalone bariatric procedure, the details of which will be described in a separate chapter in this book. One other variation of BPD-DS that has gained increasing attention is the SADI-S (single-anastomosis duodeno-ileal bypass with sleeve gastrectomy), also known simply as "SADI," "loop DS," or "SIPS" (stomach intestinal pylorus sparing). SADI was first described by Sanchez-Pernaute et al. in 2007 [11]. The main differences between SADI and a formal BPD-DS are the omission of the ileo-ileal anastomosis, thus converting the Roux-en-Y configuration of the duodeno-ileostomy into a loop configuration and the alimentary limb lengths.

Whether it is appropriate to abandon the Roux construction is one of the most contentious debate subjects among bariatric surgeons. Many surgeons are concerned about the potential for bile reflux from a loop duodeno-ileostomy. In fact, duodenal switch was initially described as a treatment for bile reflux gastritis [12]. On the other hand, some argue that SADI anatomy actually reduces bile reflux gastritis in comparison with normal anatomy, because bile will first be diluted and partially absorbed as it travels through several meters of the small intestine before reaching the area of the anastomosis. Furthermore, bile must resist the forward peristalsis of the small intestine and reflux through the anastomosis and the pylorus before reaching the gastric mucosa. Currently there is no strong evidence supporting the claim that bile reflux from SADI anatomy could cause gastric dysplasia and esophageal cancer [13].

On the other hand, SADI is attractive to modern surgeons due to the creation of a longer common limb, lessening the fears of some regarding the malabsorptive risks of formal BPD-DS. In fact, many see it as a "milder" version of BPD-DS. It has been endorsed by american society of metabolic and bariatric surgery (ASMBS) as an appropriate metabolic bariatric procedure, with caution advised regarding concerns about intestinal adaptation, nutritional issues, optimal limb lengths, and long-term outcomes [14]. Short-term weight loss efficacy appears comparable between SADI and BPD-DS, but recent studies are demonstrating significantly inferior total body weight loss and excess weight loss for SADI than formal BPD-DS. On the other hand, there is also a lower incidence of protein deficiency and bowel obstruction after SADI than formal BPD-DS [15].

3.4 Pre-operative Consideration

3.4.1 Indications for Surgery

No consensus indications for BPD-DS exists outside that of those for bariatric surgery based on the 1992 National Institutes of Health Consensus Development Conference Statement, namely, BMI greater than or equal to 40 kg/m^2 or a BMI of 35 kg/m^2 or greater with significant medical comorbidities [16]. However, BPD-DS is often reserved for patients with BMI over 50 kg/m^2 [17] or poorly controlled metabolic diseases [18].

As with any bariatric procedure, a multidisciplinary evaluation is necessarily pre-operatively. This includes a medical, nutritional, and psychological evaluation. The medical evaluation includes a comprehensive laboratory evaluation, preoperative electrocardiogram, and chest X-Ray. Additional preoperative tests are performed on an individualized basis and beyond the scope of this chapter but the readers are referred to a detailed publication on the subject [19]. Pre-operative weight loss is frequently recommended with either the patient's primary care physician or with the bariatric surgeon.

3.4.2 Contraindications

Some contraindications to BPD-DS are similar to bariatric surgery in general, such as inability to tolerate general anesthesia, non-correctable coagulopathy, preexisting malabsorptive disorder such as inflammatory bowel disease or celiac disease, or active malignancy.

Relative contraindications to BPD-DS include severe gastroesophageal reflux, which may be worsened by the sleeve gastrectomy anatomy, according to some [20]. Furthermore, due to the relatively higher incidence of malnutrition after surgery, a higher standard for psychosocial ability to comply with postoperative instructions is necessary. BPD-DS candidates need to demonstrate adequate social support, full understanding of nutritional consequences of the procedure, ability to maintain close follow-up, and absolutely no active alcohol or substance abuse. Furthermore, the patient needs to demonstrate willingness and financial ability to obtain the necessary nutritional supplementations on a long-term basis after surgery.

3.5 Procedural Details

3.5.1 Patient Positioning and Port Placement

The patient is placed in a supine with position, with the arms spread out at right angles and the legs together. Secure strapping of the patient and a footboard is mandatory, as a steep reverse-Trendelenburg position will be necessary during portions of the procedure involving the upper abdomen. Extremities are padded meticulously to prevent skin breakdown or neuropathy from pressure. The operating surgeon stands to the patient's right side for the majority of the case while the assistant stands to the patient's left. The scrub nurse stands at the foot of the bed next to the assistant.

Peritoneal access is obtained based on surgeon preference. In our practice, we routinely create pneumoperitoneum with a Veress needle (Medtronic, Norwalk, CT) at the Palmer's point before entering the peritoneal cavity under direct visualization with an 8 mm optical trocar in the supraumbilical midline, approximately 15 cm below the xiphoid process. Port positions are described for the Xi version of the Intuitive Surgical robot. A 12 mm accessory laparoscopic port for the bedside assistant is placed in the left and right subcostal area. Additional 8 mm robotic ports are placed in the left anterior axillary line (arm 1), right midclavicular line (arm 3), and the right anterior axillary line (arm 4). The camera is in the supraumbilical position and docked to arm 2 (see Fig. 3.1).

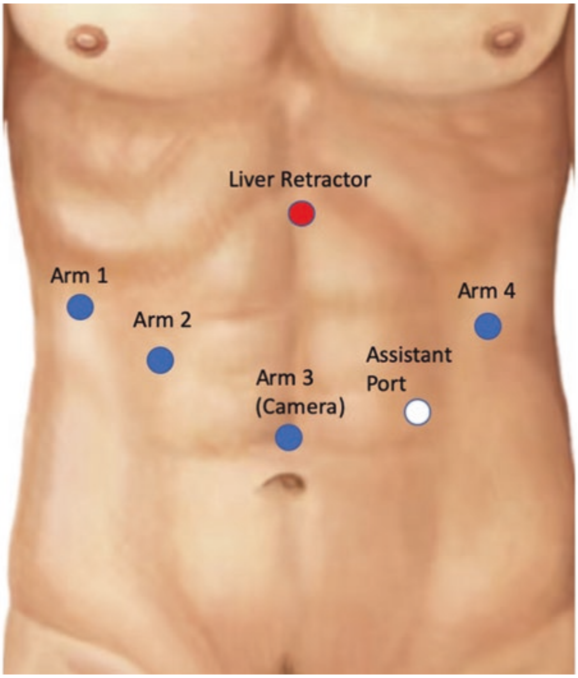

Fig. 3.1 Port position illustration. Arm 1 at the right anterior axillary line, arm 2 at the right midclavicular line, and arm 4 at the left mid clavicular. Arm 3, the camera port, is in the midline. Liver retractor (LR) is at the subxiphoid area slightly left of midline. An assistant port for laparoscopic instrument access is placed in the left subcostal area between arm 3 and 4

3.5.2 Laparoscopic Portion

The patient is first placed in Trendelenburg position to allow identification of the terminal ileum. With laparoscopic instruments, the ileum is measured in a retrograde manner from the ileocecal valve, until marking stitches could be placed at 100 and 250 cm from the ileocecal valve. We then anchor the small bowel at the 250 cm mark to the anterior abdominal wall, in the right upper quadrant, in proximity to the duodenum. This allows it to be easily identified when fashioning the duodeno-ileal anastomosis later (see Fig. 3.2).

We then place the patients in a steep reverse-Trendelenburg position for placement of a Nathanson retractor before docking the robot from the patient's right flank.

3.5.3 Cholecystectomy

Due to the anticipated dramatic weight loss and the wasting of bile, patients often have cholelithiasis or choledocholithiasis after BPD-DS [21], therefore, we have adopted it as standard practice to perform concomitant cholecystectomy during BPD-DS.

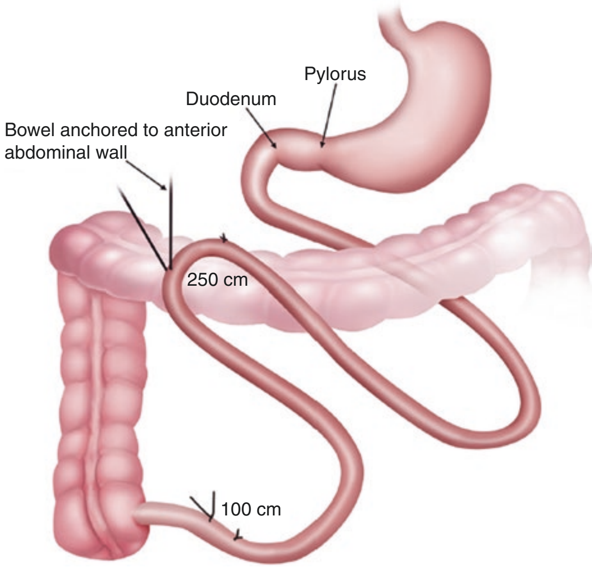

Fig. 3.2 Ileum is marked at 100 and 250 cm from the ileocecal valve and secured to the anterior abdominal wall at the 250 cm mark before docking the robot

With the shaft of robotic arm 4, the liver is retracted. The gallbladder infundibulum is retracted laterally and inferiorly toward the right lower quadrant with arm 3, while the harmonic scalpel in arm 1 is used to dissect out the critical view. Once this is done, the cystic duct and artery are divided in the standard fashion and the gallbladder is dissected off the cystohepatic place using the harmonic scalpel from arm 1. We use indocyanine green and the firefly mode to help identify the biliary structures to prevent injury to common bile duct or hepatic ducts.

3.5.4 Sleeve Gastrectomy

The sleeve gastrectomy portion of BPD-DS is performed in a similar fashion to standalone sleeve gastrectomy except the stomach is typically sized to be larger in capacity. First, the greater omentum is mobilized off the greater curvature of the distal stomach to the angle of His. Second, the sleeve gastrectomy is fashioned with a 40 French bougie inside the stomach, positioned to follow along the curvature of the lesser curvature. The stomach was divided from approximately 5 cm proximal to the pylorus all the way to the angle of His. In our practice, we utilize multiple loads of 45 mm linear cutter stapler (black load, Medtronic or equivalent) for dividing the thicker portion of the stomach near the antrum, and transition to a purple load at the more proximal, thinner, portion of the stomach. Staple line reinforcement of the surgeon's preference is recommended. We routinely use Seamguards® (Gore, USA).

3.5.5 Duodenal Dissection and Duodeno-Ileostomy

The duodenal dissection is the technical portion of the BPD-DS that is least familiar to bariatric surgeons not familiar with the procedure. While several different techniques exist, we mobilize the greater curvature of the stomach to about 4 cm distal to the pylorus. In stand-alone sleeve gastrectomy, this dissection typically stops at 4–5 cm proximal to the pylorus. At this point, the pylorus is retracted superiorly and the proximal duodenum is mobilized off the pancreas/retroperitoneal with the ultrasonic dissector. This dissection is carried distally and inferiorly until the gastroduodenal artery is visualized. This is approximately 4 cm distal to the pylorus. A tunnel is created between the gastroduodenal artery and the posterior wall of the proximal duodenum until reaching a window at the superior edge of the duodenum. The duodenum is then divided with a 60 mm linear staple load (tan load, Medtronic or equivalent). We minimize dissection at the superior border of the proximal duodenal stump in order to maintain perfusion of the anastomosis. Some authors have described dividing the right gastric for further mobilization of the stomach but we have typically not found the need to perform this maneuver.

We then retrieve the intestine that was anchored to the abdominal wall at the beginning of the case, which represents the ileum at 250 cm from the ileocecal valve. An antecolic duodeno-ileal anastomosis is then fashioned between the ileum and the proximal duodenal stump. We first secure the duodenal stump to the side of the ileal segment in an end-to-side fashion with a backrow of barbed absorbable suture. We then create enterotomies on each side before creating a full thickness handsewn anastomosis by circumferentially sewing the duodenal and ileal wall to each other (see Fig. 3.3).

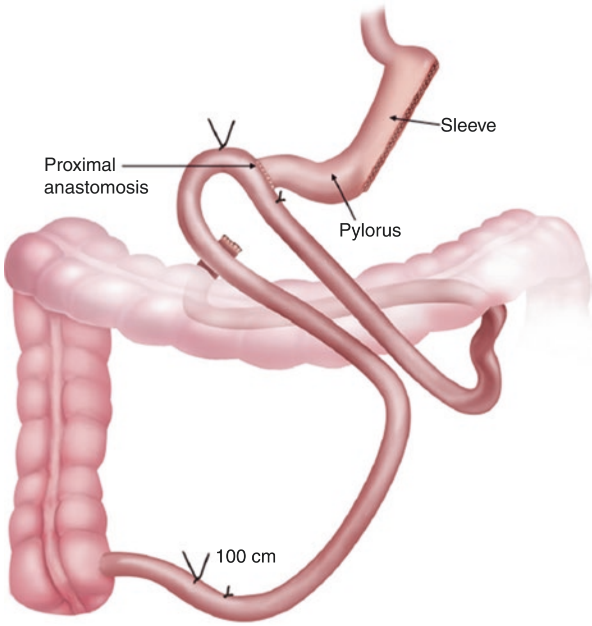

Fig. 3.3 Illustration of duodeno-ileal anastomosis and sleeve gastrectomy. This marks the completion of a SADI procedure

At this point, we usually infuse indocyanine green through an orogastric tube to evaluate for dye extravasation to ensure water-tightness of the anastomosis. Alternatively, an esophagogastroduodenoscopy could be used to ensure patency of the anastomosis, absence of intraluminal bleeding, as well as allow an air leak test of the anastomosis.

3.5.6 Ileo-Ileal Anastomosis

The main difference between formal BPD-DS and SADI is whether the surgeon chooses to proceed with the creation of the ileo-ileostomy. Traditional Roux-en-Y configuration of BPD-DS requires transection of the BP-limb and creation of the ileo-ileostomy while the surgery is considered complete after creation of the duodeno-ileostomy in a SADI.

The proximal end of the ileal loop is then transected with a 60 mm cutting stapler (tan load, Medtronic or equivalent), thus separating the biliopancreatic limb on the proximal end from the Roux limb on the distal end. We run the Roux limb in an antegrade fashion until identifying the previously placed marking suture at 100 cm. A stapled side-to-side anastomosis is then performed between the ileum at the 100 cm mark and the distal end of the biliopancreatic limb using a single load of 60 mm linear stapler (tan load, Medtronic or equivalent). The common enterotomy is closed in a handsewn manner using a barbed absorbable suture (see Fig. 3.4).

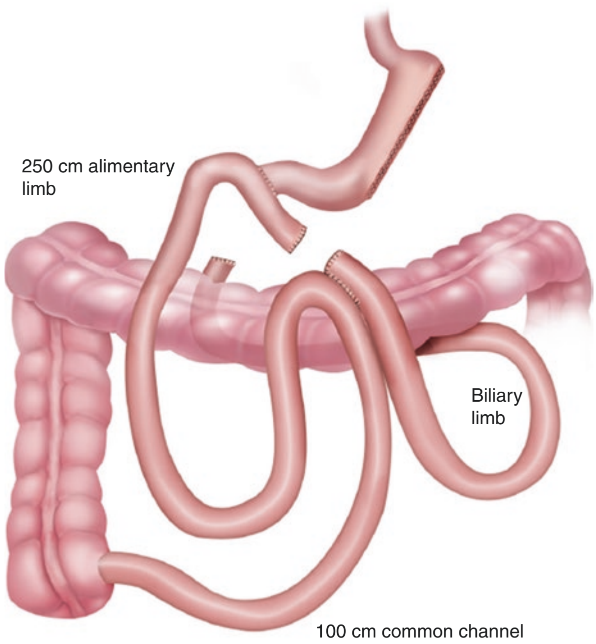

Fig. 3.4 The ileo-ileal anastomosis is performed to create a 100 cm common channel, before the biliary limb is divided from the duodeno-ileal anastomosis

3.5.7 Mesentery Defect Closures

At the end of the procedure, mesentery defects at the newly created ileo-ileal anastomosis and the duodeno-ileostomy are both closed with a running barbed non-absorbable suture in order to reduce internal hernia risk in the future.

3.6 Post-operative Care

Guiding principles of postoperative care after DS are similar to other bariatric surgeries. Routine intensive care unit admission is not necessary, but we recommend telemetry and continuous pulse oximetry given high prevalence of sleep apnea in this patient population.

We generally allow patients to have sips for comfort with maintenance IV fluid support as early as the evening of surgery. Pain is managed with a multi-modality regimen consisting of acetaminophen, ketorolac, and gabapentin. Oxycodone is only administered on an as needed basis if the pain is not controlled with the medications mentioned previously. Patients are required to ambulate on the evening of surgery and have pneumatic compression sleeves while in bed. Deep venous thrombosis chemoprophylaxis is typically started by the next morning after surgery. Incentive spirometry is also routinely used to prevent atelectasis and pneumonia.

By postoperative day 1, patients are started on their bariatric liquid diet regimen, consisting of 1–2 Oz sips of clear liquid diet every 15 min while awake. They are discharged home when pain and nausea are under control and they can demonstrate sufficient oral intake to maintain hydration.

Patients stay on the clear liquid diet until their 2–3 week follow-up appointment, at which time nutritional supplementation with two multivitamins, Vitamin B12, Vitamin D, and calcium citrate are started in accordance with published guidelines [22]. They are routinely followed up at 3, 6, and 12 months post-operatively, and then annually afterward. Follow-up frequency may be increased as needed for concerns related to failure to thrive.

3.7 Complications

DS is generally considered the most complex and technically challenging of bariatric procedures. Traditionally, higher morbidity and mortality rates were reported than gastric bypass [23]. However, it is important to keep in mind that these early figures also represent early learning curves in patients with higher BMI and procedures with longer operative times.

Certain complications from DS are common to other anastomotic bariatric procedures, and their incidence is proportional to the baseline risk profile of the patients. These include bleeding, pulmonary complications, bowel obstructions, anastomotic strictures, or leaks.

One of the most commonly feared long-term complications of DS is its potential for inducing nutritional deficiencies from protein, vitamin, and mineral malabsorption. Many erroneously compared the DS to the historic jejunoileal bypass, citing its short common limb as a concern for malabsorption, whereas jejunoileal bypass actually derived its major poor outcomes as a consequence of its long blind loop resulting in bacterial overgrowth. In our experience, the long-term nutritional deficiency risk can often be overcome by careful patient selection and follow-up. In a large case series [24], protein deficiency occurs in up to 25% of patients in the first 6 months, but then gradually tapered off to only 5% during follow-up at 2 years after surgery. Only 0.6% of patients ultimately required limb lengthening revisional procedures. Other micronutrient deficiencies can be as prevalent as 30–60% despite compliant supplementation intake. However, micronutrient deficiency is frequently present in morbidly obese patients even before surgery, sometimes up to 70% in several series [25].

All these concerns argue for a selective patient criteria and higher vigilance for both pre- and postoperative nutritional deficiencies. Daily vitamin supplementation is a lifelong commitment that must be strongly emphasized during preoperative counseling.

3.8 Outcomes

Meta-analyses of available literature has repeatedly shown that BPD-DS is superior to all other bariatric procedures with regard to weight loss efficacy, resulting in 70.1% excess weight loss, in contrast to 61.2% for gastric bypass [26] and 49% for sleeve gastrectomy [27]. Furthermore, this difference is especially pronounced with patients with BMI over 50 kg/m^2. In a large case series of patients with super morbid obesity, Prachand et al. found BPD-DS patients to have higher percent excess weight loss, percent absolute weight loss, and percent change in BMI than patients undergoing gastric bypass during 3 years of follow-up [18]. In another landmark multi-institutional randomized controlled trial, BPD-DS again demonstrated a higher excess BMI loss than gastric bypass (75 vs. 54%, $p < 0.001$). Despite longer operative time and length of stay for the BPD-DS group, no significant difference in morbidity or mortality was found in this trial [28].

Perhaps more important than the body weight loss, BPD-DS patients experienced more comprehensive resolution of obesity-related comorbidities including diabetes, hypertension, and sleep apnea. Prior literature has shown a 98% resolution of diabetes among BPD-DS patients, which is higher than 84% after gastric bypass [26] and 47% after sleeve gastrectomy [29]. Again, this effect is more pronounced in patients with super morbid obesity, with case series reporting 100% patients being free of all diabetic medications after BPD-DS, in comparison with 60% of patients after gastric bypass [18].

3.9 BPD-DS as Revisional Surgery for Weight Regain

With the accumulating prevalence of post-bariatric patients in the population, there is also an increasing concern for weight regain, usually resulting in recurrence of obesity-related comorbidities and decrease in quality of life [30]. In fact, up to 36.9% of gastric bypass patients have been reported to experience weight recidivism, defined as >25% weight gain from nadir, during a 6.9-year follow-up in a study by Cooper et al. [31] As the most effective and long-lasting bariatric procedure available, BPD-DS is now receiving increasing interest as a destination revisional procedure after weight regain following other bariatric procedures.

Laparoscopic sleeve gastrectomy has only begun to be performed as a standalone procedure since 2008 and by 2014 has become the most popular bariatric procedure both in the USA and worldwide [32]. Recently, data began to emerge that weight recidivism during follow-up beyond 12 months could be substantial [33]. Weight regain in the order of 0.5–1.5 kg/m^2 in a slow upward trend fashion has been reported, with weight recidivism ranging from 5.7% at 2 years to 75.6% at 6 years [34]. When faced with recidivism, conversion from sleeve gastrectomy to BPD-DS has been shown to be more effective than other options such as "re-sleeve" or conversion to RYGB [35]. A large case series showed that 1-year conversion to BPD-DS resulted in larger BMI decrease, total weight loss, than either Roux-en-Y gastric bypass, SADI, or re-sleeve. Major 90-day and long-term complications were similar among all comparison groups [36].

Conversion of Roux-en-Y gastric bypass to a BPD/DS is a technically challenging undertaking, involving four anastomoses. Most existing literature consists of small sample-size case series [37]. In one study, average operative time was about 402.6 min and mean EWL% after surgery was 64.1% [38]. A systematic review of revisional surgeries after RYGB for weight regain also showed that excess body mass index loss was the highest at 1- and 3-year follow-up for BPD-DS (47.6% and 47.3%, respectively), in comparison with alternative options such as distal bypass (54% and 52.2%, respectively) and gastric pouch/anastomosis revision (43.4% and 14%).

3.10 Summary

DS, or its recent derivative, SADI, remains the most effective bariatric procedure available. With a more stringent patient selection criteria and vigilant postoperative follow-up, DS can achieve excellent outcomes in weight loss and metabolic syndrome resolution. Our comprehensive clinical guide describes our robotic-assisted technique in performing DS in such a way as to maximize efficiency in operating in different quadrants of the abdomen.

Key Learning Points

1. Duodenal switch (DS) remains the most effective bariatric operation currently being practiced, both with regard to weight loss and resolution of obesity-related comorbidities.
2. Due to its higher risk for long-term nutritional deficiencies, patient selection criteria must be even more stringent for DS than other bariatric procedures. Currently it is frequently reserved for patients with BMI > 50 kg/m^2 or severe, uncontrolled metabolic syndrome.
3. Single-anastomosis duodeno-ileal bypass (SADI) is recently receiving much attention due to it being perceived as a less malabsorptive nature than a formal DS with Roux-en-Y duodeno-ileostomy configuration. The long-term efficacy of SADI in comparison with DS has yet to be proven.
4. DS is enjoying a recent surge in interest due to its role as an option for revisional surgery for weight regain after sleeve gastrectomy. Its efficacy for weight loss has been shown to be higher than alternatives such as "re-sleeve" or conversion to Roux-en-Y gastric bypass.

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Chapter 4
Primary Single Anastomosis Duodenal Switch: Perspective from a Lengthy Experience

Mitchell Roslin, Michael Marchese, Daniyal Abbs, and Donna Bahroloomi

4.1 Historical Perspective of Weight Loss Procedures

There is no consensus regarding the ideal bariatric procedure. Although different surgeries have gained popularity at points in bariatric history, all procedures have side effects and complications. It can be argued that side effects are an inherent issue with weight loss surgery. In comparison to the majority of surgical procedures that remove or repair damaged tissue, bariatric surgery creates a controlled abnormality. Thus, by design normal anatomy is distorted. The goal of bariatric surgery is finding the appropriate balance between lasting weight loss and unpleasant side effects or nutritional complications. To achieve this goal, either the stomach alone, or the stomach and intestine are altered.

Procedures that only manipulate the intestine, such as the jejunoileal intestinal bypass (JIB), were fraught with complications, often required reversal, and have been abandoned. However, both weight loss and lasting resolution of diabetes was achieved in numerous patients. Realizing the dangers of short bowel syndrome, Mason described the vertical banded gastroplasty (VBG) in 1982 [1]. He hypothesized that targeting the stomach was safer and with decreased risk for anemia, bone loss, and other issues that result from intestinal manipulation. Although true, other issues became apparent with this procedure. The fixed outlet and vertical staple line creates a high-pressure system resulting in staple line dehiscence, gastroesophageal reflux disease (GERD), and maladaptive eating of calorically dense foods which pass with less effort [2]. A study published by the Mayo Clinic in 2000 demonstrated that fewer than 25% of patients who underwent VBG were content with their long-term results [3].

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In the late 1990s and early 2000s, bariatric surgery gained popularity with annual case numbers in the United States increasing from under 20,000 to over 200,000. Numerous factors accounted for this growth including the development of laparoscopy, the growing severity of the obesity epidemic, increasing awareness of the complications of morbid obesity and improved outcomes with surgery, as well as the absence of alternative effective therapies. Roux-en-Y gastric bypass (RYGB) became the second most prevalent operation during this period to VBG. Sugerman compared open RYGB to VBG in a single center randomized trial. He concluded that RYGB offered greater weight loss especially in patients that were identified as "sweet eaters." He justified this finding secondary to adverse dumping symptoms seen after carbohydrate ingestion following RYGB.

With the introduction and approval of laparoscopic adjustable gastric banding (LAGB) in 2004, the debate between gastric only or combined procedures was reignited. Many opined that LAGB was preferred for "bulk eaters" and RYGB for "sweet eaters." These theories were difficult to prove because characterization of eating patterns is fraught with subjectivity. With increased usage of LAGB, complications became more apparent including intractable GERD, weight loss failure, and novel issues such as prolapse and erosion. Although once on pace to be a disruptive technology representing 40% of domestic procedures, in 2009, that trend started to wane. LAGB now accounts for less than 5% of bariatric cases.

As LAGB declined, another gastric only procedure emerged, the laparoscopic sleeve gastrectomy (LSG). Initially proposed by Dr. Gagner as part of a staged duodenal switch in patients with high BMI, it was observed that LSG alone provided lasting weight loss. Introduced in 2004, LSG has since become the most prevalent world-wide procedure. Advocates of LSG highlight weight loss results that rival gastric bypass but with lower surgical risk, decreased rate of anemia, and bone loss. Antagonists of LSG highlight increased weight regain without manipulation of the intestine, higher rate of GERD, and inferior diabetes resolution compared to RYGB. Additionally, there have been reports of de novo Barrett's esophagus following LSG, with an incidence as high as 18.8% [4].

With the increasing popularity of LSG, RYGB numbers declined. According to the American Society for Metabolic and Bariatric Surgery (ASMBS) database, RYGB represented 36.7% of all bariatric procedures performed in 2011. In 2018, that number decreased to 17%. The reasoning behind this decline is unclear but theories include physician preference for what is perceived as a simpler procedure (i.e., LSG) as well as negative patient perception of bypass procedures.

4.2 The Next Frontier

Traditionally, there has been little correlation between the physiology of obesity and the mechanisms of surgical correction. Bariatric procedure development was observational and based on the realization that with gastric volume reduction (i.e., gastrectomy) and bowel resection, patients lost weight. The overall understanding was that a caloric deficit was created by gastric restriction, malabsorption, or both. The detailed physiologic derangements that cause obesity, as well as how surgical procedures improve these derangements, is only just beginning to be deciphered. It is conceivable that with an improved understanding of these two aforementioned variables, operations can now be designed with improved results.

4.3 To Treat Obesity, It Is Necessary to Understand the Cause

Historically, weight loss education was centered around calories in and calories out. In fact, LuLu Peters first described calorie counting as a form of weight management over 100 years ago. This dogmatic approach to weight loss cited success with simply burning more calories than consumed. Unfortunately, we now realize that weight loss is much more complex. First, all calories are not absorbed (created) equally. For example, a pretzel digested primarily via oral amylase is not the same mechanism as a piece of asparagus. Second, the accounting theory of weight loss assumes all individuals process calories in an identical manner. Yet, by experience we know this not to be the case. Theoretically, if one were to reduce input and increase expenditure, they would continue to lose weight indefinitely. Instead, we see many individuals reach a weight plateau after altering intake for a period of time. In truth, caloric intake influences caloric expenditure and caloric expenditure impacts caloric intake. Reduction of caloric intake is countered by the body improving metabolic efficiency and resisting weight loss. Increasing activity promotes appetite. Importantly, energy regulation is centrally controlled. This is made clear by the increased consumption during pregnancy and the observation that many drugs including insulin, anti-seizure, and anti-psychotic medications result in weight gain. Short-term caloric deprivation may lead to early weight loss, however this is rarely maintained. The simplistic approach of severe caloric restriction combined with increased activity is flawed and outdated with little evidence to support sustainable weight loss.

More likely, obesity is a hormonal disease resulting in an alteration of energy regulation. Two hormones that invariably cause weight gain are insulin and cortisol. Insulin is an anabolic hormone essential for glucose control as well as promoting lipogenesis and inhibiting lipolysis. Unfortunately, increased fat and insulin levels lead to insulin resistance. Thus once resistance develops, additional insulin secretion is necessary to maintain blood sugar. When fat stores are increased, they secrete another hormone called leptin. Leptin signals the brain that adequate adipose stores exist in the body. Similar to the pathophysiology of insulin resistance, obese individuals become leptin resistant. Few interventions are effective in breaking this hormonal imbalance especially once class III obesity (BMI > 40 kg/m^2) develops. To date, the most effective therapy is bariatric surgery. Although the improvement in diabetes is more often touted, bariatric procedures such as RYGB profoundly improve insulin resistance and reduce overall insulin secretion. Many mechanisms account for the effects of bariatric surgery on insulin, including reduced intake, reduction in hepatic insulin resistance, and increased incretins, which delay gastric emptying and increase insulin sensitivity.

Little about obesity was understood when RYGB and duodenal switch (DS) procedures were developed. It was believed fat was the cause of obesity and cardiac disease, a hypothesis titled the "heart health hypothesis" and popularized by an American physiologist Ancel Keys in the late 1950s. It seemed logical that since fats were more calorically dense, and calories were all that mattered, a low fat diet was optimal. Therefore, the most effective bariatric procedures would inhibit fat absorption by incorporating a diversion of bile and pancreatic juices with a short common channel. Today, many obesity experts have a strikingly different opinion. They opine that the reduction of fat in the diet resulted in the replacement with carbohydrates leading to reduced satiety and increased insulin resistance. It seems that at least in part, the obesity epidemic dates back to the heart health hypothesis. The replacement of whole foods with increased processed food, based primarily on carbohydrates, is another major factor. However, if massive fat malabsorption is not needed and potentially can be maladaptive, then it is imperative we take a fresh look at the construction of our bariatric procedures and abandon the traditional biases based on disproven assumptions.

4.4 The Next Domain: Glucose Variability and Matching Bariatric Surgery to Modern Obesity Treatment

The fundamentals of current obesity management center around glucose regulation with reduced insulin secretion. Although the specifics of paleo, whole 30, keto, and intermittent fasting differ, they all seek to reduce glucose spikes and the resultant insulin surge. Many have considered RYGB to be the gold standard bariatric procedure. Advocates state it offers the best balance of sustained weight loss and improvement in comorbid conditions while having an acceptably low long-term complication rate. Contrarily, opponents such as Dr. Mason argued that bypass leads to anemia, osteoporosis, and other long-term maladies [1]. In support of RYGB, Dr. Sugerman conducted a randomized trial between RYGB and VBG. This single center study strongly supported the use of RYGB for patients that were categorized as "sweet eaters." Although flawed, this became dogma and RYGB became the preferential procedure for patients who "snacked." It was suggested that a possible reason for this was sugar ingestion following RYGB can cause dumping syndrome with its symptoms thus deterring further consumption.

The question remains whether dumping is advantageous for weight loss. Dumping correlates with hypoglycemia and increased glucose variability. This is contrary to medical weight loss experts who seek to prevent glucose fluctuations and the resultant hunger stimulation [5]. It was this phenomenon of glucose variability that prompted our bariatric group to pursue alternative surgical interventions. Initially, glucose tolerance testing was performed in RYGB patients. These tests confirmed increased glucose variability with frequent hypo- and hyperglycemia events. Next, glucose tolerance was compared in patients who underwent LSG, RYGB, and DS. DS provided the greatest degree of glucose stability while RYGB had the greatest degree of glucose variability. Interestingly, despite the maintained anatomy, LSG patients had only intermediary variability. A finding that implies pyloric preservation is not the sole mechanism for glucose stability [5]. More than absolute values, it is the fluctuations in glucose that results in oxidative stress [6]. Further studies demonstrate that patients with increased glucose variability are less likely to have resolution of diabetes [7].

Despite the observation that DS offers superior lasting weight loss and resolution of diabetes, it remains a rarely performed procedure. According to the ASMBS database, DS accounts for only 1% of primary bariatric procedures. Reasons for this paucity include the technical challenges of the duodenal switch and concerns for micronutrient deficiencies. There have been multiple case matched studies comparing duodenal switch and gastric bypass, demonstrating similar patient satisfaction and complication rates [8–11]. Despite these, the DS has never reached comparable popularity to RYGB.

There persists a need for a bariatric procedure with less glucose variability than the RYGB and lower risk of micronutrient deficiencies than the DS. In Spain, Dr. Antonio Torres and Dr. Sanchez-Pernaute described a single anastomosis duodenal switch, which they named the single anastomosis duodeno-ileal (SADI) [12]. In their modification, Dr. Torres and Dr. Sanchez-Pernaute performed a sleeve gastrectomy over a 54-French bougie and anastomosed the transected post-pyloric duodenum to the jejunum (approximately 200 cm from the ileocecal valve). This procedure was further modified to a common channel of 250 cm in an effort to decrease diarrhea. In 2012, Dr. Roslin and Dr. Cottam began the US experience with single anastomosis duodenal switch. They designed an operation called stomach intestinal pylorus sparing surgery (SIPS), which included a sleeve gastrectomy over a 42 bougie and a post-pyloric anastomosis 300 cm from the ileocecal valve. In 2015, they presented their initial 1-year data suggesting an average BMI weight loss of approximately 21 units [13]. Further publications have cited weight loss following SIPS to be 30% greater than weight loss following LSG [14]. Despite initial concerns for micronutrient deficiency following DS, studies demonstrate that postoperative iron, vitamin A, and vitamin D levels are similar in DS and RYGB patients [15]. Given these positive findings, both the International Federation for the Surgery of Obesity and Metabolic Disease (IFSO) and the American Society of Bariatric Metabolic Surgery (ASMBS) added single anastomosis duodenal switch (SADI/SADS) to the endorsed list of bariatric procedures in 2018 and 2019, respectively [16].

4.5 Rationalization for Patient Selection

Although there are many benefits for bariatric surgery, weight loss is often the primary objective. Often patients' unstated goal is to no longer be viewed as obese, thus a realistic discussion of probable results is mandatory prior to any surgical intervention.

Commonly cited, LSG offers 60% excess weight loss, RYGB 70%, and DS 80%. However, analysis of results obtained in over 600 LSG patients demonstrate that historical figures for weight loss following LSG are inaccurate as BMI increases. In fact, the majority of patients with BMIs greater than 45 who undergo LSG will remain obese [17]. For those with a BMI >50, the probability of reaching a BMI < 30 following LSG is approximately 5%. Additionally, obesity-recidivism also increases with increasing BMI [13]. Consequently, patients with increased BMI (i.e., > 45) should be recommended more aggressive procedures that include intestinal bypass to improve long-term success [18].

Another issue mitigating the success of LSG is insulin resistance. Whereas there have been several randomized controlled trials that have compared LSG, RYGB, and medical therapy for individuals with Type 2 diabetes, Mingrone first compared BPD, RYGB, and medical therapy in 2012 [19]. BPD, an obsolete version of the modern DS, was shown to be superior especially in patients with the increased homeostatic model assessment (HOMA) and increased degree of insulin resistance. Therefore, patients managed on home insulin therapy with persistently elevated HbA1c should be considered for a SADI-type procedure [12].

An increasing number of bariatric patients experience weight regain or inadequate initial weight loss following a gastric only procedure (i.e., LAGB or LSG). Initial assessment of these patients includes an understanding of current anatomy. If tests fail to document anatomic flaws, attempts to further restrict are unlikely to result in long-term success. Bariatric surgery is far more than just mechanical. Success involves altering the gut–brain interaction. Thus, activating an additional mechanism of action such as an intestinal conduit is the most logical approach.

In patients with a high BMI, severe insulin resistance or metabolic syndrome and those who have failed a previous weight loss procedure, an aggressive approach combining a gastric resection and intestinal bypass is necessary. Several principles have emerged. Stomach restriction promotes early weight loss, but the intestinal malabsorption maintains weight loss. Both reduction in weight and metabolic control correlate directly with the length of the biliopancreatic limb or degree of malabsorption. Unfortunately, micronutrient deficiency and hypoalbuminemia also correspond with length of the biliopancreatic limb. When designing an operation, consideration must be given to pylorus preservation, the importance of a bile-free roux limb and the ideal biliopancreatic limb length.

4.6 SADI/SADS vs. Traditional Roux DS

The major difference between SADI/SADS modification and the traditional DS is a single anastomosis in the former. So instead of biliopancreatic limb, a digestive roux limb and a common channel, there is an afferent and efferent limb without a bile-free digestive limb.

A roux construction eliminates bile reflux and the DS was initially proposed as a treatment for bile reflux gastritis. Bile is produced in the liver and secreted into the proximal duodenum. In SADI, bile enters into the bypassed duodenum and travels through a long afferent limb without food particles. In the normal digestive tract, the majority of bile salts are reabsorbed in the distal intestine as part of the entero-hepatic digestive cycle. Studies have shown that binding to lipids is a major inhibitor of bile reabsorption [20]. In the long afferent limb following SADI, where there are no lipids acting as inhibitors, the majority of bile is reabsorbed prior to the anastomosis. The combination of this situation and the fact that fats are not the primary culprit of obesity explains the similarity in weight loss following traditional DS and SADI/SADS modification-type procedures. Cottam et al. have shown no significant weight loss at 3 years between these procedures [21]. A randomized trial from Spain also demonstrated no significant difference in weight loss with the caveat that there may be a trend toward higher weight loss in those with BMI > 60 following DS.

Another advantage of a Roux limb is that it allows for a shorter common channel while preserving adequate bowel length to prevent fluid and electrolyte disturbances. The Roux limb maintains the ability to digest virtually all simple carbohydrates and alcohol. Additionally, the Roux limb also absorbs most protein. A short common channel mainly limits fat absorption. Although there are no essential carbohydrates, there exists essential amino acids and fats that must be consumed via dietary sources and the importance of proper dietary fat is often underappreciated. Poor dietary fat intake correlates with decreased cognitive function. Therefore, if fats do not cause obesity, and fat absorption to some degree is key to homeostasis, then a short common channel is not mandatory.

Another obvious advantage of SADI is lack of a distal anastomosis and subsequent decreased perioperative risk of bleeding or leak. Although issues at the distal anastomosis are less common than the proximal anastomosis, they are often difficult to diagnose and can be lethal. Overall compilations following SADI were compared to RYGB. SADI procedures were found to have a lower risk of internal hernia, marginal ulceration, and anastomotic complications when compared to Roux procedures [22].

A cardinal principle of medicine states that every intervention should be justified by science. There must be a rationale beyond traditional bias to divide the small bowel and perform an entero-enterostomy. For the majority of patients undergoing metabolic surgery, performing an entero-enterostomy is not necessary and carries more risk than benefit. Flaws at the entero-enterostomy, although rare, are associated with a high morbidity and mortality. Interrupting bowel continuity disrupts the intestinal pacemaker mechanism and creates mesenteric windows that must be closed. However, some clinical conditions exist where the creation of a bile-free Roux limb is advantageous. One of these is a patient with Barrett's esophagus and a history of dysplasia, where any bile exposure could be deleterious. Another condition pertains to anastomotic complication following SADI. In this event, conversion to a traditional roux DS diverts bile and pancreatic juices from the proximal anastomosis and prevents reflux into the stomach. A final condition pertains to the rare patient that is referred for bile gastritis, for whom a traditional roux DS is a better approach. It is our anticipation that, with time, SADI will become more common, and DS reserved for few patients. Some have suggested that in the case of weight regain following SADI, conversion to DS might be a viable option. While further data must be collected, the benefit of such a conversion is debatable. The majority of patients with weight regain following SADI are consuming processed carbohydrates rather than excess fat from animal or plant-based sources.

4.7 SADS vs. RYGB

There are essential anatomic differences between SADS and RYGB. In SADS, the gastric pouch is a long tube that preserves the pyloric valve but the procedure includes resection of the majority of the stomach. Alternatively, in RYGB, the gastric pouch is generally 4–6 cm and based on the lesser curvature. The remnant is separated from the pouch, but not removed. The gastric pouch is then anastomosed to the jejunum.

There are several advantages of gastric resection in SADS procedures. Reducing gastric volume decreases acid production and subsequent risk of marginal ulceration. Both Hess and Marceau separately designed the concept of DS, with reduced gastric cell mass, in an effort to replace Scopinaro's BPD given the high incidence of marginal ulcers. Powerful data demonstrates that DS type procedures have a lower risk of marginal ulcer. Besides acid reduction secondary to resection, Brunner's glands in the duodenum secrete bicarbonate that neutralizes acid gastric secretions. Preservation of a 3–4 cm duodenal cuff is desirable. Further, gastric resection results in the reduction of hunger hormones produced in the fundus, including ghrelin. Finally, although rare, resection eliminates the possibility of pathology in the gastric remnant that can be difficult to assess via traditional endoscopy.

Conversely, there are advantages for gastric preservation in RYGB. A major benefit includes the ability for future conversion if necessary. The persistence of the gastric remnant allows for access to the biliary tree via percutaneous or laparoscopic cannulation and endoscopic retrograde cholangiopancreatography (ERCP) if indicated. Since the blood supply to the remnant is not altered, the stomach remains viable as a reconstructive conduit if esophageal cancer occurs. Although this is not a common scenario, one must be aware that the risk of esophageal cancer is increased in obesity and cases of de novo Barrett's esophagus following LSG have been documented.

In SADS, the pyloric valve is preserved. Under normal conditions, the pylorus controls the release of solid foods from the stomach. Although the degree of pyloric function following fundectomy is unknown, improved glucose regulation and high pressures detected following LSG demonstrate ongoing efficacy. RYGB patients exhibit a crescendo-decrescendo glucose response following carbohydrate ingestion. A fast rise in glucose correlates with a spike in insulin and resulting rapid decline in glucose. Use of continuous glucose monitoring following RYGB reveals that patients are frequently both hyper- and hypoglycemic. Hypoglycemia is perhaps the strongest stimulus for appetite. Increasing numbers of RYGB patients complain of weight regain secondary to inter-meal hunger. Alternatively, procedures that have lower glucose variability, including SADS, may have more advantageous long-term outcomes. Again, decreased glucose variability is demonstrated following a duodenal switch-type procedure.

While pyloric preservation has benefits in terms of decreased glucose variability, it is not without side effects. An active pylorus results in a higher resting pressure within the sleeved stomach. Sequelae of this increased pressure include increased risk for GERD, hiatal hernia formation, and intrathoracic migration of the stomach. Additionally, if a complication (i.e., leak) does occur in the sleeved portion it can be difficult to treat non-operatively due to the pressurized stomach. RYGB procedures should be suggested when a low pressure system is desirable, these circumstances include large hiatal hernias, esophageal dysmotility, Barrett's esophagus, and esophageal strictures.

4.8 SADS vs. OAGB (One Anastomosis Gastric Bypass)

The major differences between SADS and OAGB is the pylorus, which is preserved only in the former and the bypassed stomach remnant that is present only in the latter. Pyloric preservation in SADS reduces the rate of marginal ulcer and decreases glucose variability. Pyloric preservation also prevents bile reflux, which is a major drawback of OAGB [23]. An advantage of OAGB is relative technical ease compared to the SADS. OAGB does not require duodenal dissection and can be performed via a stapled approach versus the handsewn duodenal-enterostomy required in SADS.

4.9 Surgical Technique

Multiple techniques have been described to perform the single anastomosis duodenal switch [12]. Several of the key points that are utilized in our practice are highlighted below. Additionally, Fig. 4.1 is visual demonstration of the single anastomosis duodenal switch with the key anatomic points mentioned below.

- The initial action includes identifying the cecum and terminal ileum. We measure 300 cm of small bowel from the ileocecal junction. 300 cm is our suggested length as data cites 250 cm as an adequate amount, however there exists a 20% error when measuring. When 300 cm is reached, a marking stitch is placed between the efferent limb and the mesentery of the transverse colon.
- It is imperative that a proper sleeve gastrectomy is performed. The sleeve should be of a greater diameter than a primary sleeve gastrectomy. A major source of morbidity following duodenal switch is an overly narrowed sleeve (previously published papers have used as small as a 32-Fr bougie) [24]. A narrowed sleeve prevents adequate oral intake and results in rapid gastric emptying with increased malabsorption. Conversely, a less restrictive sleeve decreases risk of stricture and leak and reduces incidence of GERD. We prefer a 42-Fr bougie and start 5 cm proximal to the pyloric valve.
- Division of the duodenum and subsequent anastomosis represents major technical hurdles for surgeons learning SADS. Transection of the duodenum should be

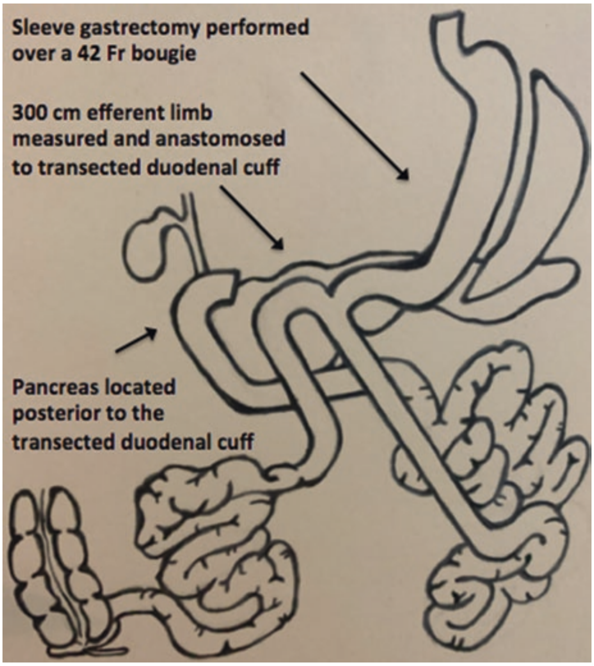

Fig. 4.1 SADS anatomy: visual representation of SADS anatomy including transected duodenal cuff anastomosed to efferent loop at 300 cm proximal to the ileocecal valve. Sleeve gastrectomy is performed over a 42-Fr bougie, a slightly larger bougie than traditional sleeve gastrectomy. Figure Source—Original artwork by one of the authors (Michael Marchese)

done at the level of the gastroduodenal artery. To accurately perform this, dissection is initiated down the greater curvature of the stomach with all posterior adhesions taken down and the stomach mobilized preserving only the blood supply to the lesser curvature. The dissection continues beyond the pyloric valve and the peritoneum is lysed on the superior aspect of the duodenum. Once in the correct plane, the gastroduodenal artery is visualized. This dissection should occur with ease and the pancreas should never be encountered. An articulating grasper encircles the duodenum past the pyloric valve. This is replaced by a linear stapler. Traction is placed on the stomach, pulling toward the patient's left to increase duodenal cuff length. The duodenum is transected.

- We perform a hand-sewn termino-lateral duodenal enteral anastomosis using a 2–0 pds on an SH needle. We place a single stay stitch between the top corner of the duodenum and the mesentery of the small bowel. A 2 cm duodenotomy and enterotomy are made. The posterior layer of the anastomosis is performed inside-outside on the duodenum and outside-inside on the small bowel, initiating at the superior corner. At the inferior corner, the suture is brought outside on the duodenum. An oral gastric tube is placed over the posterior wall and into the efferent limb. At the inferior corner, a stitch is taken outside-inside on the duodenum and inside-outside on the small bowel along the anterior wall. This is tied to both itself and the posterior wall suture. Starting at the superior corner, a suture is taken on the anterior wall and carried to and secured to the previous anterior suture. After completion of the anastomosis, both limbs of the small bowel are occluded and 60 cc of methylene blue infused, demonstrating distension of the sleeve and both limbs of the bowel. Several Lembert sutures are placed. Lastly, a stitch from the antrum to the omental fat and then afferent limb is placed to prevent torsion.

4.10 Issues in Complication Management

Early leaks (<5 days postoperatively) at the duodenal-enteral anastomosis are unusual [22]. An early leak is best treated with laparoscopic exploration. Anastomotic repair can be performed laparoscopically with endoscopy to confirm viability. Anastomotic tension must be ruled out. Because digestive enzymes from the pancreas will traverse the leak, consideration for conversion to traditional DS with a Roux limb should be undertaken. Conversion to DS offers the additional advantage of a feeding jejunostomy near the ligament of Treitz such that feeds do not traverse the area of concern. If extensive inflammation precludes anastomotic repair, resection of the pylorus and distal antrum with reconstruction of the small bowel and creation of a BPD at the level of the angularis is a viable option.

Delayed leaks (>5 days postoperatively), without systemic sepsis or peritonitis are best treated via percutaneous drainage, IV antibiotics, nothing per oral (NPO), and total parenteral nutrition (TPN). After initial therapy, endoscopy is performed. If a small leak is visualized, we recommend a 7-Fr double tailed pigtail for internal drainage. The drain is left in place for several weeks and a clamp trial performed prior to removal. If a large leak is visualized, the management algorithm is more complex. Adequate drainage parenteral nutrition is paramount. Endoscopic stenting can be performed, however the stent cannot travel across both limbs. Use of an endoscopic vacuum is technically challenging. In these complex cases, we advise sepsis control, natural healing, and delayed reconstruction. After 3 months the area is contained and reconstruction more feasible.

Fortunately, anastomotic complications following SADS are rare. In a multi-institute study with 6 years of patients undergoing SADI, the incidence of marginal ulcers, anastomotic strictures, and small bowel obstructions was lower than following RYGB and DS [22]. Torsion of the afferent limb and herniation posterior to the anastomosis has been reported but was managed successfully with laparoscopic reduction. There have been no reports of bowel ischemia following SADI [25].

4.11 Malnutrition: Input and Output Issues

Bypassing the intestine comes with the substantial risk of increased bowel movements, flatulence, anal rectal pathology, micronutrient and divalent cation deficiencies, and hypoproteinemia. Preserving 300 cm of small bowel, proper patient education, diet compliance, and nutritional supplementation mitigates the risk of these complications. Long-term follow-up with regular blood work checking protein, iron, calcium, fat-soluble vitamins, and parathyroid hormone (PTH) is mandatory. Morbidly obese patients are commonly nutrient deficient secondary to years of abusing food with limited nutritional value [26]. Following SADS, gastric volume is reduced and the proximal half of the small intestine bypassed, a combination that predisposes patients to further malnutrition. Exacerbating the issue, poor intake leads to edema, reducing the absorptive capacity of the sleeved stomach. Following any bariatric procedures that contain a malabsorptive element, complaints of weakness and fatigue must be investigated thoroughly. One critical deficiency is thiamine secondary to poor intake and/or increased emesis. The human body has limited reserves of thiamine and the half-life is only 7 days [27]. Deficiency is potentiated by an impulse for consumption of high dextrose, high osmotic solutions (i.e., sports drinks). Thiamine promotes glucose utilization and should be administered prior to dextrose rich solutions [27]. Acute thiamine deficiency can manifest with Wernicke’s syndrome and irreversible neurological damage. Additional factors that predispose SADS patients to malabsorption include altered pH of gastric contents, bypassed duodenum, and the site of cholecyctokinin (CCK) stimulation and small intestinal bacterial overgrowth (SIBO).

Hypoproteinemia following SADS can lead to clinically apparent edema [28]. When diagnosed, treatment is mandatory. The hallmark of malabsorption is weight loss despite adequate intake, however more often bariatric patients have both poor absorption and intake. In all cases of malnutrition, correction of deficiencies is the first step. Extensive blood work should be performed. Anemia due iron deficiency is frequently present. Electrolyte abnormalities are common and should be repleted. If fat malabsorption is present, calcium and magnesium bind to unabsorbed fat leading to depletion. Vitamin D levels are low exacerbating calcium deficiency. Management of malnutrition begins with thiamine repletion, followed by a programmed feeding regimen [27]. Intake should be titrated responsibly to prevent refeeding syndrome. TPN is often necessary. It is our practice to administer TPN gradually when indicated, utilizing low dextrose containing solutions to minimize steatosis. Adequate amino acids and essential fatty acids should be included in the TPN. TPN is continued until laboratory values normalize and PO intake improves or surgical revision is undertaken. Endoscopy and CT scan are utilized to rule out a mechanical etiology for malnutrition, however generally intake issues are difficult to solve with surgery alone. Mental health providers are important support. Appetite stimulants can be tried. Regardless, continued alimentation must persist until the patient is capable of resuming adequate feeding autonomously.

Following SADS, frequent bowel movements are a common complaint. Assessment of oral intake and bowel movements is key. Steatorrhea presents with abundant and dense floating stool. Lactase deficiency, which is potentiated by gastric restriction, presents with frequent and watery diarrhea. Watery diarrhea following bariatric surgery is more often associated with malabsorption of carbohydrates rather than fat. Poorly absorbed carbohydrates enter the colon and undergo fermentation by bacteria. Methane is produced presenting with bloating and flatulence and potentiating small intestinal bacterial overgrowth.

Output issues present later in the postoperative course. Laboratory abnormalities can occur, however this is not always the case. For patients with normal nutritional parameters despite frequent bowel movements, management is focused on control of diarrhea. As mentioned previously, carbohydrate abuse is often the etiology of diarrhea. Small intestinal bacterial overgrowth (SIBO) should be ruled out by a breath test. Treatment involves alteration of diet, the use of motility agents such as imodium and lomotil. An H2 blocker and PPI should be prescribed. Dietary modification with minimization of carbohydrate and fat is necessary (the so-called FODMAP diet). Fiber and probiotics should be encouraged through diet and supplemented. Cholestyramine, a bile acid binding agent, is often effective but poorly tolerated by many patients. Other medications include clonidine, octreotide, and GLP-1 agonists. GLP-1 agonists delay gastric emptying. The GLP-2 analogue teleglutitide is rarely used following bariatric surgery. Although its use leads to short-term gut hypertrophy, it is expensive and must be used regularly or the effect dissipates. If surgical revision is practical to reduce output it is often necessary given the paucity of alternatives.

If chronic diarrhea and poor nutritional parameters persist, liver failure may occur. Although more common following jejunoileal bypass in the past, liver failure can occur following modern bariatric surgery when the majority of usable calories are via simple sugars. Liver failure can be accelerated if bacterial overgrowth is present. Consideration should be given to surgical reconstruction following nutritional repletion whenever malnutrition is present. The primary goal of surgery is to increase the length of bowel taking part in absorption. Insertion of a jejunal feeding tube to augment postoperative oral feeding at the time of reconstruction should be considered.

4.12 Electrolyte and Micronutrient Deficiencies

Early findings of poor nutrition following bariatric surgery include hypokalemia and decreased BUN. These values are evident before hypoalbuminemia, as albumin has a half-life of 21 days [29]. Chronic patients can often compensate for these deficiencies, but may present with persistent hypokalemia and metabolic acidosis secondary to diarrhea. Iron, magnesium, and calcium can also be abnormal. Iron is absorbed predominantly in the duodenum. Anemia secondary to iron deficiency and chronic disease is common. B12 and folic acid levels can be diminished, however a microcytic anemia is more common. Calcium is also preferentially absorbed in the proximal intestine. Hypocalcemia is exacerbated by decreased vitamin D levels and via binding to unabsorbed fatty acids in the GI tract. Magnesium, although preferentially absorbed in the distal GI tract, can also be deficient due to binding to unabsorbed fatty acids as well as increased excretion.

4.13 Fat Soluble Vitamins

Decreased bile salts and absorptive capacity following SADS presents with a persistent deficiency of fat-soluble vitamins (ADEK) despite supplementation. Vitamin A deficiency can present with visual impairment and night blindness. Vitamin D deficiency worsens hypocalcemia and increases bone turnover via osteoclasts. Vitamin K deficiency can present with clotting disorders. All oral supplements given must be water-soluble versions to maximize absorption.

4.14 Vitamin B12

B12 is a water-soluble vitamin, absorbed primarily in the ileum. Absorption of B12 requires the presence of intrinsic factor. Intrinsic factor activity is dependent on gastric acid levels, which are decreased following SADS. If bacterial overgrowth is present, bacteria compete for B12 further decreasing absorption. B12 deficiency can present with megaloblastic anemia and neurologic symptoms. Supplementation is best given nasally, sublingually, or intradermally.

4.15 Trace Elements

Critical deficiencies of trace elements including zinc, copper, and selenium can occur following SADS. In general, they rarely occur in isolation and are representative of chronic malnutrition. Zinc deficiency is most common and can present with hair loss, diarrhea, and dermatosis. Copper deficiency can present with peripheral neuropathy and weakness. Selenium deficiency can cause heart failure. Trace elements are usually administered along with parenteral nutrition.

4.16 Metabolic Bone Disease

All bariatric procedures that bypass the proximal intestine increase the incidence of osteomalacia, osteoporosis, osteopenia, and secondary hyperparathyroidism secondary to decreased calcium absorption. Vitamin D absorption is also compromised. Supplements can be effective. However, in the presence of fat malabsorption, calcium binds to fatty acids increasing excretion. In response to hypocalcemia, increased parathyroid hormone recruits osteoclast mediated bone resorption. Elevated PTH leads to hypophosphatemia. The risk of hungry bone syndrome is decreased with adequate calcium and vitamin D supplementation. Routine bone density scans are suggested [30].

4.17 Nephrolithiasis

Another sequelae of malabsorption is nephrolithiasis, exacerbated by increased oxalate intake. Fat malabsorption leads to hypocalcemia secondary to calcium binding to free fatty acids. Subsequently, free oxalate is absorbed via the colon. Oxalate in the bloodstream is filtered by the kidney and binds calcium within the urinary tract. Calcium oxalate crystals precipitate causing nephrolithiasis. Management includes a low oxalate diet, increased calcium, and adequate hydration.

4.18 SADS Surgical Correction for Malabsorption

For patients with a single anastomosis, there are several options to lengthen the BP limb. The first is to take down the duodenal enteral anastomosis. We advise firing a transverse staple line. Another anastomosis can then be performed 150 cm proximally in the standard fashion. Figure 4.2 demonstrates this technique for correcting malabsorption via lengthening the BP limb.

Another option includes the creation of two small bowel anastomoses. The small bowel is transected proximal to the anastomosis and reattached 50 cm distally with conversion to a Roux. 150 cm of the BP limb is attached to the now proximal Roux limb. A feeding jejunostomy can be placed to supplement oral feeding. Figure 4.3 demonstrates this technique for correcting malabsorption via creation of two small bowel anastomoses.

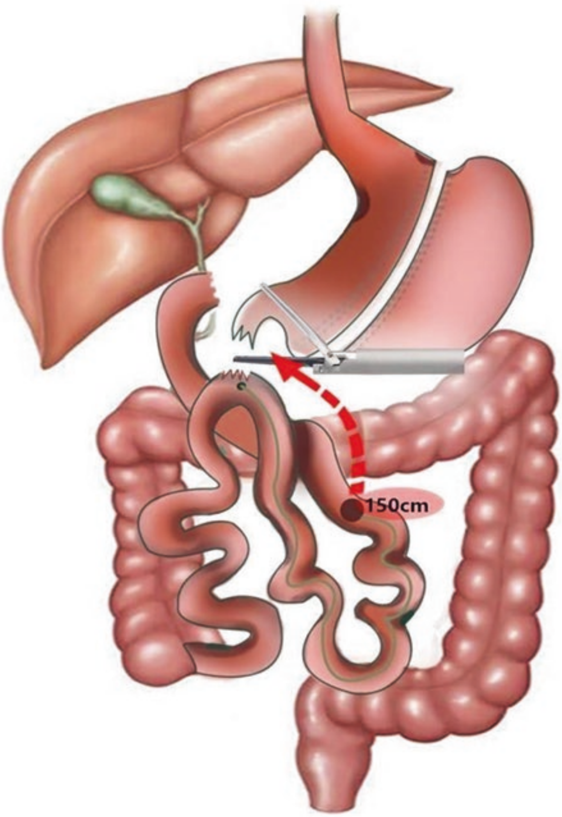

Fig. 4.2 SADS surgical correction #1: visual representation of lengthening the BP limp via transection of proximal duodenal enteral anastomosis and recreation of subsequent anastomosis 150 cm proximal. Figure source—Roslin et al.

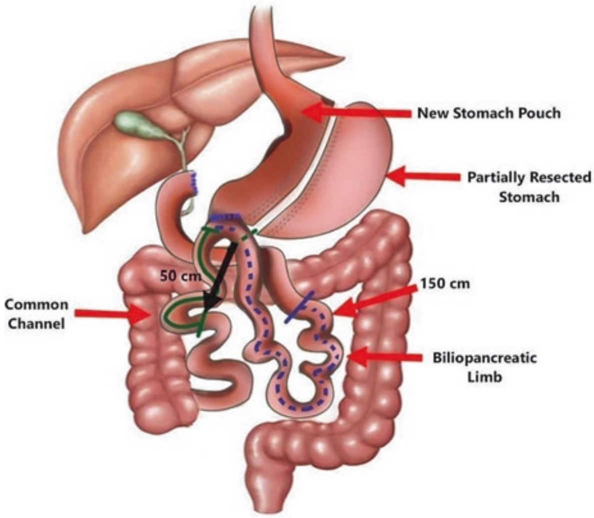

Fig. 4.3 SADS surgical correction #2: visual representation of the creation of two small bowel anastomoses via transection of small bowel proximal to anastomosis and creation of second distal anastomosis. Figure source—Roslin et al.

4.19 Additional Complications of SADS: Gastroesophageal Reflux Disease (GERD)

Another issue that can mandate surgical revision following SADS is refractory GERD. Similar to LSG, SADS involves a longitudinal gastrectomy. The degree of GERD is often inversely proportional to the size of the gastrectomy (i.e., 36-Fr for VSG and 42-Fr for DS). Patients with GERD symptoms are often managed effectively with medicine. However, for patients with GERD refractory to medical management, numerous options exist including endoscopic procedures, such as STRETTA and LINX [31].

STRETTA is an endoscopic radiofrequency procedure, which increases lower esophageal sphincter (LES) tone and therefore reduces esophageal acid exposure. A meta-analysis of controlled and cohort studies of patients with GERD demonstrated a significant reduction in erosive esophagitis and esophageal acid exposure, as well as a subjective improvement in heartburn symptoms and decreased proton pump inhibitor use following STRETTA [32]. Another approach is LINX, which includes placement of a magnetic ring around the esophagus to augment LES and decrease reflux [33]. A retrospective review of 7 patients following LINX placement demonstrated subjective improvement in GERD symptoms.

A surgical approach to refractory GERD includes hiatal hernia repair [34]. A recent experimental approach includes usage of the round ligament to provide a pseudo-plication [35]. However, without true fundoplication the long-term efficacy of this surgical repair is debatable.

For patients with severe esophagitis following SADS, conversion to an RYGB is a viable option. To accomplish this, the sleeved stomach is divided to form a pouch and the roux limb constructed from the previous BP limb. The distal sleeve is resected and an entero-enterostomy is performed where to loop was to prevent distal obstruction. This procedure is also indicated if chronic stricture or asymmetry of the sleeve is the etiology of GERD symptoms.

4.20 Conclusion

SADI/SADS offers many advantages. A larger sleeve is more compliant and allows for easier oral intake and reduces gastroesophageal reflux and other complications. Combining a sleeve gastrectomy with an anastomosis 300 cm from the ileocecal valve promotes lasting weight loss while maintaining adequate small bowel length for nutritional absorption. Weight loss following SADI/SADS has been demonstrated to be superior than that following sleeve gastrectomy and gastric bypass. Early data suggests similar weight loss following traditional DS and SADI/SADS. The increasing popularity of this procedure led to approval by the ASMBS. As awareness of this procedure expands, there will be an unmet need. We anticipate that SADI/SADS will be the fastest growing bariatric procedure in the

United States. Patients offered SADI/SADS include those with inadequate following LSG and those unlikely to meet their goals following a gastric-only procedure. While not without its previously mentioned complications, SADS is a robust procedure with a safety profile that can match RYGB.

The purpose of this review article was to highlight our experience with the SADS. Bariatric surgery is an imperfect method to treat a fatal and debilitating disease that works by creating a controlled abnormality. With proper technique, patient selection and education, and early detection of complications, SADS is an excellent weight loss option.

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Chapter 5
Duodenal Switch and Its Derivatives in Bariatric and Metabolic Surgery

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5.1 Introduction

Duodenal switch is a procedure that has been performed since the early 1980s but is estimated to only make up approximately 1% of all bariatric procedures performed in the United States. On the other hand, sleeve gastrectomy (SG) and Roux En Y Gastric Bypass (RYGB) make up 60% and 18%, respectively [1]. The first biliopancreatic diversion with duodenal switch (BPD/DS) was performed in 1988 by Hess et al. and Marceau et al. published their results and techniques later in 1993 [2, 3]. Later, both a laparoscopic as well as robotic approaches were reported on in 2000 [4, 5]. The benefits of BPD/DS are that it is the most effective operation for excess weight loss and resolution of diabetes and hyperlipidemia. However, it is not as effective as RYGB in controlling gastroesophageal reflux [6]. With these improved outcomes, the reason for slower uptake is thought to be due to the procedure being technically challenging, longer to perform, having more possible technical complications, and various nutritional deficiencies [7]. In this chapter, we will briefly review preoperative workup, operative techniques, postoperative care, and complications.

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5.2 Preoperative Workup

Indications for BPD/DS are similar to other bariatric operations but may be most appropriate for those with a high BMI, more severe diabetes, or hypercholesterolemia. Initially it was thought that patients with a BMI above 50 kg/m^3 would benefit most from a BPD/DS. However, there is evidence that a cutoff BMI does not affect excess weight loss or lead to increased malnutrition complications when either above or below a BMI of 50 kg/m^3 [6]. Therefore more typical criteria for bariatric surgery, BMI > 40 kg/m^3 or >35 with significant medical comorbidities, may be applied to patients proposed for BPD/DS.

Contraindications to BPD/DS include unresolved psychiatric conditions including substance abuse, overwhelming medical risk, noncompliance, or dense small bowel adhesions preventing appropriate mobilization. All proposed bariatric patients should undergo multidisciplinary evaluation including a mental health worker and a dietitian. In addition to multidisciplinary evaluation, careful assessment of the patient's vitamin levels should be performed and corrected pre-operatively as they are more difficult to correct post-operatively.

An additional consideration when assessing patients for BPD/DS it is the possibility of performing a staged procedure for the super-obese. The BMI considered to be super-obese varies by study with some considering it 60 and others over 80. In those patients where one stage BPD/DS may be prohibitive either due to patient size or medical comorbidities, an SG followed later by BPD/DS may be considered. However, the data about the efficacy and complication profile for this strategy is the subject of some debate [8–10]. The rationale for a staged procedure is to lessen the morbidity associated with the super-obese by allowing for weight loss similar to weight loss prior to a hernia repair leading to less recurrence [11]. Some have suggested that patients should not have their hernia repaired until their BMI is <33 [12].

5.3 Techniques and Derivatives of BPD/DS

For some time BPD/DS has been described as utilizing a laparotomy but now it can be performed in a minimally invasive fashion. Generally speaking, the operation requires a sleeve gastrectomy with creation of a gastric pouch larger than a standard sleeve, approximately 150–250 mL. Next, the pylorus is preserved and the first portion of duodenum is divided over the adherent portion of the pancreas. A post-pyloric anastomosis is then created, which can be done either stapled or sewn. Differing limb lengths have been described but most commonly a 250 cm alimentary limb is created with a 100 cm common channel. It is important to keep in mind that these measurements are in relation to the ileocecal valve unlike an RYGB which is in relation to the ligament of Treitz. The two most common configurations of BPD/DS include a standard Roux configuration or as a loop duodeno-ileostomy. Proposed benefits from a loop duodeno-ileostomy are a decreased risk of internal hernias and less technical complications due to one less anastomosis. However, in the more standard Roux configuration leaks are not complicated by bile spillage and there is less of a risk of bile acid reflux and its associated long-term complications [13].

Prior to starting the BPD/DS, it is important to properly pad and position patients. The average duration of a BPD/DS tends to be longer than an RYGB or sleeve gastrectomy and therefore patients are at a higher risk of injury from improper padding or positioning. Depending on the approach, patients are placed in either the supine or split leg position. After entry in the abdomen, either with a Veress needle or optical trocar, ports are placed in addition to a liver retractor. Next the greater curvature of the stomach is mobilized from the left crus to the first portion of the duodenum. Key areas to take extra care is the more cephalad short gastric near the spleen which can easily avulse and lead to bleeding. Another key area is dissection of stomach off the pancreas near the pylorus. Distal dissection should end near the gastroduodenal artery (GDA) and care must also be taken to avoid damage to the portal structures. Great care should be taken in both areas to avoid bleeding or thermal spread to surrounding organs. Typically, a 50–60 French bougie is used to size the stomach, which is larger than a more typical sleeve gastrectomy, and stapling is begun approximately 5 cm from the pylorus along the bougie [13]. Some surgeons will utilize buttress material including sutures, buttress material, or clips however there is no standardized approach and data is somewhat mixed on outcomes with each buttress strategy [14–17]. More importantly is to not make the sleeve too small and to avoid spiraling the staple line.

After creation of the gastric pouch, attention is turned to the duodeno-ileostomy. The small bowel at the premarked site (around 250 cm) is brought up to be anastomosed to the stapled end of the duodenum. This can be performed either antecolic or retrocolic. The omentum can be either divided or a window created. It is important to maintain appropriate orientation of the small bowel to prevent kinking, internal hernia, or a closed loop obstruction. Creation of the duodeno-ileostomy can be done in a variety of ways. The first we will discuss is the use of an EEA stapler. Typically, a size 21 anvil is utilized and passed orally through the pylorus and docked at the proximal duodenum. Next the stapler is passed through the small bowel and engaged with the anvil. The small bowel enterotomy is then closed. Due to the need to traverse the pylorus, anvil passage can be more difficult than in an RYGB. An alternative to the EEA includes a linear stapling configuration of hand-sewn anastomosis. However, it is recommended to avoid linear stapling across the pylorus as this can disrupt its function. Part of a successful BPD/DS is ensuring pyloric function post-operatively.

After completion of the proximal anastomosis the distal anastomosis is created. With the creation of a standard Roux approach, the common channel is created 100 cm from the ileocecal valve with a 250 cm alimentary limb. However, in a loop the typical limb used is longer, around 300 cm. Creation of the common channel can be done in either a stapled or hand-sewn fashion depending on surgeon preference. Most often a 60 mm stapler is used for anastomotic creation [13]. The key is to create a common channel that is at least 100 cm to avoid symptoms of short gut syndrome.

To prevent internal hernias, closure of the mesenteric defects between the alimentary limb and the biliary limb is performed using a running nonabsorbable suture. If the anastomosis is placed antecolic, closure of Peterson's defect may be performed but some debate whether this is necessary. Those who feel it should be closed is due to the risk of internal hernia, however those who do not close it state that a large defect is less likely to obstruct. There is no conclusive evidence either way at this time and the decision to close Peterson's defect is left up to the surgeon's preference. The final step of the BPD/DS is a leak test with methylene blue or intraoperative endoscopy. The method preferred is at the discretion of the surgeon.

Another consideration of BPD/DS is whether or not to perform a simultaneous cholecystectomy at the time of bypass. Reasons to perform a cholecystectomy include difficulty in accessing the common bile duct due to lack of remnant stomach and a possible higher rate of gallstone formation in the BPD/DS patient. The rationale is similar to evaluating patients who are having RYGB for gallstones to avoid the need for advanced intervention strategies for choledocholithiasis. Not only is access to the biliary tree more difficult but it also may be more technically difficult to perform a cholecystectomy after BPD/DS secondary to scarring from the duodeno-ileostomy. Reasons not to perform a cholecystectomy is not wanting to add additional length to the operation or increase potential morbidity from another surgical site intra-abdominally. Again, there is no consensus on simultaneous cholecystectomy and it is up to surgeon discretion on whether or not to perform it.

5.4 Post-operative Care

Monitoring on a bariatric floor, or other floor with bariatric trained support staff, should be utilized after BPD/DS the same way an SG or RYGB would be. BPD/DS patients have similar post-operative complaints to patients with an SG. There is some component of gastroparesis or pylorospasm which can predispose these patients to post-operative nausea and vomiting. Unlike RYGB, patients with a BPD/DS have a larger pouch and therefore can have high volume emesis. They are at risk for aspiration pneumonia. Post-operative nausea and vomiting should be managed with PRN anti-emetics and other adjuncts such as a scopolamine patch. Despite this BPD/DS patients are started on small volumes of liquids like SG and RYGB and do not have a significantly longer length of stay. If an intraoperative leak test was performed, it is unnecessary to get a upper gastro intestinal (UGI) post-operatively. Patients should also have their vitamins replaced in the usual way [7].

5.5 Complications

Generally, complications after BPD/DS fall into similar categories compared to SG and RYGB including technical, surgical, and nutritional. However, the rate of complications tends to be higher at 30 days and 1 year post-operatively [6]. Some of the more common complications include bleeding and leaks. Bleeding is typically managed conservatively with monitoring including intravenous fluid, holding deep venous thrombosis (DVT) prophylaxis, serial hemoglobin levels, and blood replacement. If these are unsuccessful, more invasive methods such as endoscopy, including epinephrine injections and clipping, or re-operation can be attempted. In the setting of a post-operative leak re-operation, stenting, drain placement, nothing per oral (NPO), and total parenteral nutrition (TPN) are all options that can be used in combination to treat leaks.

Longer term complications include oxalate kidney stones, stricture of the sleeve, intractable GERD, and bowel obstruction. In the setting of a sleeve stricture stritu-roplasty can be attempted [18]. Oxalate kidney stones form due to a lack of oxalate binding in the gut by calcium and can be prevented by oral replacement of calcium. If stone do form, adequate hydration and making the urine more acidic helps dissolve these stones. Patients with intractable GERD may need conversion to an RYGB which is a technically challenging revision given the history of BPD/DS. Finally, bowel obstruction can have disastrous complications if not corrected in a timely fashion. Namely, dilation of the biliary limb will lead to duodenum blow out. If there is any suggestion of abdominal pain or dilation of the biliary limb on imaging, exploration with evaluation of the entire length of small bowel is indicated. In addition patients are at risk for intussusception and internal hernia like with an RYGB. Unlike RYGB, BPD/DS patients are at a low risk for marginal ulcer formation [19].

Nutritional complications are some of the most feared complications when performing a BPD/DS. Typically, patients do not absorb fat soluble vitamins (A, D, E, K) well and are often more pre-disposed to vitamin D deficiencies. If deficiency in these vitamins occurs, they must be replaced in their water-soluble analogue forms. Mineral deficiencies include iron, copper, zinc, and magnesium. As discussed earlier, evaluating these pre-operatively to correct for deficiencies is of the utmost importance. Vitamin and mineral deficiencies should be evaluated annually and replaced as needed. It is also important to keep in mind that normally self-resolving, chronic nausea and vomiting can lead to vitamin B deficiency and should also be evaluated [20]. Protein deficiencies are another major concern in this patient population. There is some literature to suggested that a longer common channel may correct this but no definitive strategies other than vigilant monitoring of the patient's protein intake are routinely utilized [21].

5.6 Outcomes

Many retrospective single center studies have been performed examining BPD/DS outcomes. Less commonly multicenter or randomized controlled trials have been performed. Some of the pertinent studies will be reviewed here. Sudan et al. conducted a multi-institutional analysis comparing bariatric operations with 130,767 patients. While BPD/DS made up a small part of this cohort it did include 1436 patients. BPD/DS was compared to SG, RYGB, and adjustable gastric band (AGB). The study was supportive of BPD/DS efficacy in comparison to the other methods of bariatric surgery with a larger BMI reduction (10.6 units vs 9.3 units in RYGB and 5.7 units in SG) and greater remission of type 2 diabetes mellitus and hypertension. However, GERD was still best treated with RYGB and they found a higher rate of adverse events at 30 days and 1 year in patients who underwent BPD/DS. This included higher rates of bleeding, leaks, and pulmonary embolism [6].

Longer term single center retrospective studies do exist that corroborate the findings of Sudan et al. One study compared BPD and RYGB with findings of faster resolution of co-morbidities and weight loss in the BPD/DS patients. They however did not see an increase in morbidity and mortality [22]. Another study looked at 810 BPD/DS patients with BMI < 50 kg/m^2 and again showed similar findings with improved weight loss and rapid resolution of co-morbid symptoms. This study is of interest because it suggests that BPD/DS is appropriate for patients even if their BMI is not >50 kg/m^2 [23]. Studies looking at longer term outcomes show consistent excess body weight loss and resolution of medical co-morbidities [24, 25].

Single anastomosis duodeno-ileal bypass, with or without sleeve gastrectomy (also referred to as a loop), is a newer method of BPD/DS and its outcomes are still being defined. One small study found that patients who underwent single anastomosis duodeno-ileal bypass had a different hormone profile in comparison to traditional BPD/DS. Patients with a single anastomosis had higher glucose, GLP-1, insulin secretion, and glucagon. This suggests that while both are duodeno-ileal bypasses, they may have different endocrine mechanisms for weight loss [26]. One systematic review by Shoar et al. examined 12 studies and found that single anastomosis duodeno-ileal bypass was utilized most as a primary procedure (508 of 581 patients, 87.4%) with varying common channel lengths. The lengths include 300 cm (54.2%), 250 cm (23%), and 200 cm (13.4%). Percent excess weight loss (%EWL) was 85% at 2 years with co-morbidity resolution of 74.1% of DM, 68.3% HLD, and 96.3% for HTN. The most common reported complication was diarrhea (1.2%) with Vitamin A, selenium, iron, and protein deficiencies being the most common nutritional deficiencies [27].

Another systematic review by Spinos et al. reviewed 14 studies with similar findings. They found that at 12 months single anastomosis duodeno-ileal bypass had a mean total body weight loss between 21.5% and 41.2%. There was no weight regain after 24 months and co-morbidity resolution was 72.6% for DM, 77.2% HLD, and 59.0% for HTN. The most common post-operative complication was a need for reoperation with additional mentioned complications including nutrient deficiencies [28]. The most recent statement on single anastomosis duodeno-ileal bypass by the ASMBS states that it has "similar outcomes those reported after classic DS and should therefore be endorsed" with the "currently available peer-reviewed literature does not suggest outcomes differ substantially from those seen with classic DS" [29].

5.7 Conclusion

BPD/DS as either a staged procedure, primary procedure (either as a classic BPD/DS or a loop), or revisional strategy is important to have as an option for the bariatric surgeon. Increasing familiarity with the procedure and its performance in resolving EWL and medical co-morbidities should be weighed carefully when evaluating patients for bariatric surgery.

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Part II
Weight Loss Surgery

Chapter 6
Pathophysiology of the Cardiometabolic Alterations in Obesity

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6.1 Introduction

The global prevalence of obesity has significantly escalated over the past few decades, making this disease a major public health issue [1–3]. Obesity increases the risk for a number of comorbidities such as cardiovascular disease (CVD), hypertension, type 2 diabetes (T2D), dyslipidemia, and some cancers [2, 4]. Taken together, these conditions decrease life expectancy while also greatly affecting the quality of life of individuals living with obesity [1, 3].

Obesity is heterogeneous regarding its associated cardiometabolic risk, as some individuals will develop complications while others may appear relatively protected [5]. Some estimates indicate that as many as 30% of individuals with obesity may

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be characterized by a cardiometabolic profile exempt of obesity-associated cardiometabolic diseases, showing normal insulin sensitivity, normal blood lipids, and inflammation markers with no sign of hypertension, therefore qualifying this as having a metabolically healthy but obese (MHO) phenotype [6]. However, this condition does not appear to be stable in the long term [7], which could make it a transient phase in obesity [8]. In fact, the MHO phenotype shows a significant incidence of all-cause mortality and CVD, and is still considered at higher risk than normal-weight healthy individuals [9, 10]. The definition of metabolically healthy obesity as a temporary condition is further supported by a study conducted in more than 6000 individuals, where 40% of apparently healthy individuals deteriorated their metabolic health over 5 years [10]. Similarly, another study found that half of individuals with the MHO phenotype developed the metabolic syndrome (MetS) after 12 years [11], stressing the unreliability of metabolically healthy obesity as a stable predictor of metabolic health. In this context, weight management may represent a key factor, because individuals with MHO phenotype who gain weight are more likely to transition into an unhealthy state compared to others [12]. Taken together, evidence demonstrates that stable protection from cardiometabolic diseases in obesity does not manifest in the long term, suggesting that lifestyle management may be valuable for all individuals regardless of their metabolic status [13].

The absence of a stable and reliable predictor of cardiometabolic risk in obesity raises the question about the pathophysiological mechanism justifying such a diverse distribution of metabolic risk among individuals with obesity. Nowadays we know that body fat distribution, and more importantly the accumulation of intra-abdominal adipose tissue, rather than total adiposity, has a critical prognostic role in obesity [5, 14]. Across the entire spectrum of BMI values, adipose tissue dysfunction closely relates to a central body fat distribution pattern and represents a fundamental mechanistic feature of the metabolic alterations leading to T2D and CVD. In this chapter, we will review the definition of body fat distribution and excess visceral adiposity, how they relate to adipose tissue dysfunction and cardiometabolic risks. The short- and long-term improvements occurring after bariatric surgery will also be briefly addressed.

6.2 Body Fat Distribution and Excess Accumulation of Visceral Adipose Tissue

The development of powerful imaging technologies such as computed tomography (CT) or magnetic resonance imaging (MRI) led to an in-depth characterization of human adiposity based on its location throughout the body [2, 5]. We distinguish subcutaneous adipose tissue (SCAT) [15] and internal adipose tissue [2, 16]. The former refers to the tissue layer found in the hypodermis, between the dermis and fasciae of the muscles [16], which then subdivides into superficial and deep SCAT [2]. Internal adipose tissue is classified as visceral (VAT) and non-visceral adipose tissue [16]. According to Shen and colleagues [16], the former comprises intra-abdominopelvic adipose tissues including fat depots of the greater omentum and mesentery. Most of the literature on adipose tissue biology is based on SCAT and VAT as the main fat depots. This generalization stems mostly from methodological issues in accessing the various fat compartments in clinical studies of human participants. Yet, major cellular, molecular, and physiological differences exist between these two adipose tissue compartments, which can clearly be found at this classification level [17, 18].

Excess VAT accumulation is an increasingly recognized marker of lipid storage in ectopic sites such as the liver, muscle, heart, or pancreas [2, 19, 20] and likely emerges from adipose tissue dysfunction, which can be defined as adipocyte hypertrophy, impaired adipogenesis, low free fatty acid uptake, reduced triglyceride synthesis, resistance to the inhibitory effect of insulin on lipolysis, fat tissue fibrosis, immune cell infiltration, and inflammatory cytokine secretion [21–24]. As illustrated in Fig. 6.1, the amount of VAT can be highly variable, even among individuals

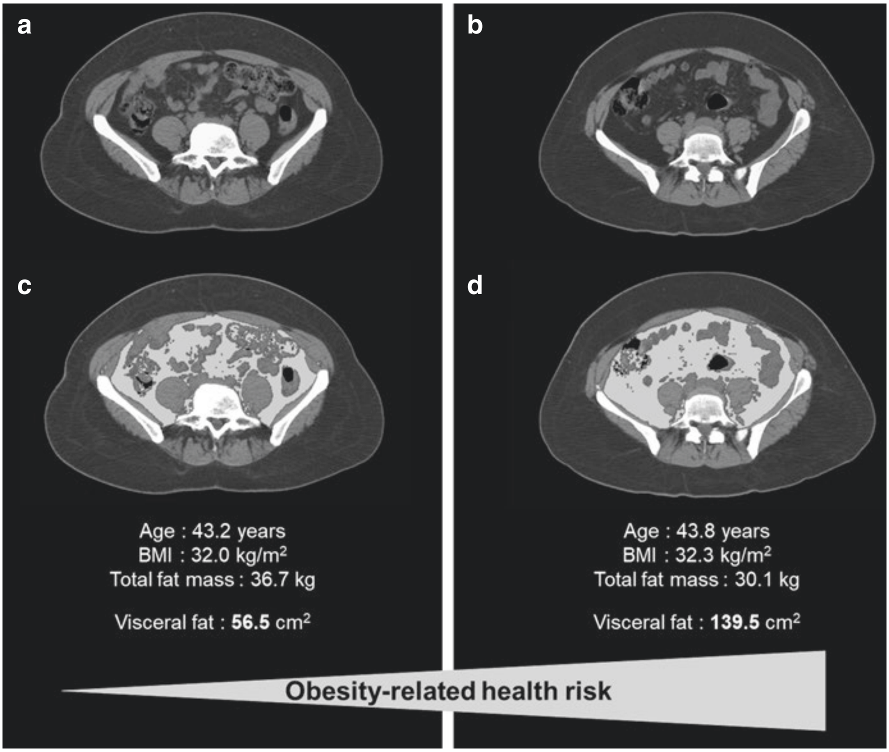

Fig. 6.1 Representation of the obesity-related health risk associated with visceral fat accumulation. Comparison of computed tomography scans from two women with similar age and body mass index (BMI), but showing different visceral adiposity which is higher in **b**, **d** compared to **a**, **c** despite lower total body fat mass in **a**, **c**. Visceral adipose tissue area highlighted in light grey (**c** vs. **d**) correlates with increased cardiometabolic risk

with comparable BMI values and age. The specific accumulation of VAT, also called visceral obesity, has been consistently associated with greater cardiometabolic risk regardless of sex, age, or total adiposity [2, 5].

A detailed analysis of the etiological factors underlying preferential VAT accumulation is beyond the scope of this chapter and the topic has already been extensively reviewed [2, 25]. Briefly, literature supports the role of genetics, age, sex, and steroid hormones. In particular, the contribution of genetics to obesity has been extensively studied in the past decades, by the completion of genome-wide association studies (GWAS), thereby allowing the identification of a large number of candidate genes as well as several quantitative trait loci and single-nucleotide polymorphisms (SNP) associated with obesity and body fat distribution [26–29]. Despite the arguably small contribution of genetic predisposition to preferential VAT accumulation and the probable involvement of other factors like epigenetics, gene–gene, and gene–environment interactions [30–33], body fat distribution indisputably represents a heritable trait [34–37].

Changes in body fat distribution are known to occur with age, mirrored by an increase in waist-hip ratio (WHR) or waist circumference (WC) [38]. This is observed in both sexes, where an increase in the VAT/SCAT ratio is generally found [39]. Hormonal changes of the menopause are also thought to accelerate visceral fat accumulation relative to other fat compartments [40–42]. However, age relates to an altered metabolic status and increased visceral adiposity even in premenopausal women [43], supporting the notion that age and excess VAT accumulation contribute to alterations in the metabolic profile both before and after the menopause.

Sex also is a well-known determinant of VAT accumulation. It is well recognized that men typically display an android fat distribution profile whereas women preferentially accumulate adipose tissue especially in the lower body, defined as a gynoid fat distribution profile [25, 44]. Women have less VAT than men for the same waist circumference [45], a phenomenon that has also been reported when controlling for BMI and total body fat [46]. As mentioned, this sex dimorphism may be attenuated with the occurrence of menopause [42].

The sex dimorphism in body fat distribution provides indirect support for a strong contribution of sex steroid hormones. The most discussed in the literature are testosterone [25, 47–49], dehydroepiandrosterone (DHEA) [25, 50, 51], dihydrotestosterone (DHT) [25, 49, 52], and estrogens [53]. Studies on the regulation of fat distribution by sex hormones are remarkably inconsistent and difficult to summarize [25]. A detailed account of this topic is beyond the scope of the present chapter. Overall, studies suggest that hypogonadal men tend to preferentially accumulate visceral fat and are often found with an impaired metabolic health, a condition that can be reversed with testosterone replacement [54]. On the other hand, due to the clinical manifestations of polycystic ovary syndrome (PCOS) [55], women with androgen excess are thought to be predisposed to abdominal obesity, although this hypothesis has been challenged [52]. Changes in estrogen metabolism [41, 56] or the expression of the estrogen receptors in adipose tissue [57], especially with the occurrence of menopause, have also been proposed as drivers of the shift in adiposity in women. Glucocorticoids also seem to be involved, which not only may influence androgen metabolism [58, 59] but have also been associated with visceral obesity [60], as seen in Cushing's syndrome [61]. Local adipose tissue glucocorticoid excess is likely to play a role in obesity [62] and preferential VAT accumulation [58]. In sum, available literature suggests that individual differences in visceral adiposity are multifactorial and are likely affected by age, gender, genetic background, as well as the hormonal milieu. These factors interact individually or synergically to increase cardiometabolic risk through the modulation of fat distribution. As explained in the next section, this mainly occurs through altered adipose tissue function.

6.3 Pathophysiology of the Cardiometabolic Alterations in Obesity: Adipose Tissue Dysfunction

Adipose tissue stores excess energy in the form of triglycerides through lipogenesis [25, 63]. As illustrated in Fig. 6.2, under a positive energy imbalance and postprandially, adipose tissue expands either through hyperplasia (i.e., increase in adipocyte number) or through hypertrophy (i.e., increase in adipocyte size of existing cells), those two mechanisms not mutually excluding each other [3, 64]. In hyperplasia,

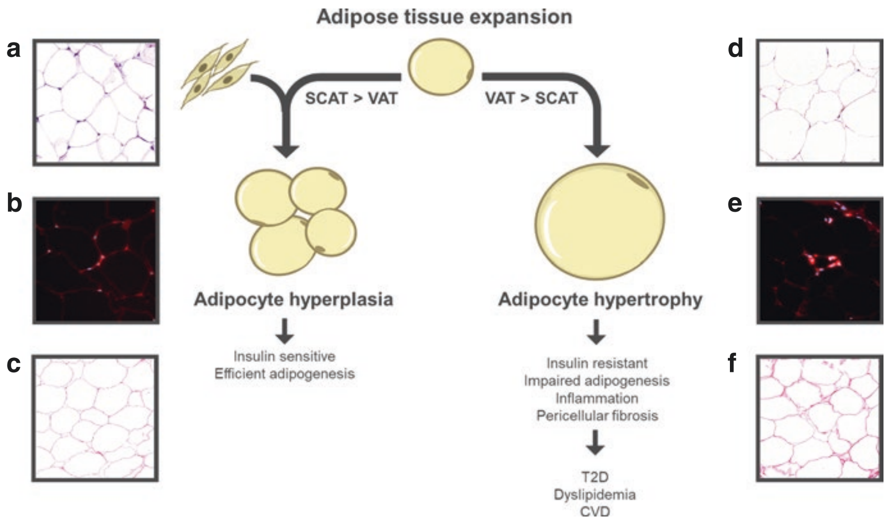

Fig. 6.2 Illustration of adipose tissue expansion through hyperplasia and hypertrophy. Adipose tissue expansion through hyperplasia is predominant in subcutaneous adipose tissue (SCAT) and helps maintain adipose tissue function, illustrated by a larger number of small cells (**a**), reduced immune cell infiltration (**b**), and fibrosis (**c**); whereas hypertrophy is predominant in visceral adipose tissue (VAT) and represents a marker and effector of adipose tissue dysfunction, illustrated by a smaller number of large cells (**d**), increased immune cell infiltration (**e**), and fibrosis (**f**). The latter factors mediate the occurrence of obesity-related comorbidities. Representative images are shown from different patients. *CVD* cardiovascular disease; *T2D* type 2 diabetes

adipocyte precursor cells [65], in particular preadipocytes, differentiate into adipocytes through a process called adipogenesis. As a result, adipose tissue expands by creating new adipocytes, each of them, however, remaining smaller in size [25]. Thus, high adipogenic capacity is associated with smaller adipocytes and low adipogenic capacity relates to larger, hypertrophic cells [5]. Adipocyte hypertrophy may in fact be the result of an intrinsically low capacity for adipogenesis [3]. The adipogenic potential of preadipocytes has been shown to differ between adipose tissue depots. Hence, for a given individual, the adipogenic potential of VAT is lower than that of SCAT [64]. Moreover, reduced SCAT adipogenesis is intrinsically related to VAT hypertrophy and excess visceral adiposity independent of BMI [64]. Although the association between SCAT adipogenesis and VAT hypertrophy may be independent of adiposity, adipocyte hypertrophy *per se* is tightly associated with obesity and positively relates to a number of adiposity indices such as the WC, total body fat mass, trunk fat mass, as well as computed tomography-measured VAT and SCAT areas [66].

Preadipocyte commitment is pivotal to initiate adipogenesis and maintain functional adipose tissue. The specific mechanisms regulating the recruitment of adipocyte precursor cells (APC) has yet to be discovered, but over the past decade a number of genetic and epigenetic factors have been proposed [67]. Signaling pathways such as WNT and factors such as BMP4 and VSTM2A seem to play an important role in the early phase of adipocyte differentiation [67–69], while transcription factors like PPARγ and C/EBPα are involved in maintaining the expression of key genes essential for mature adipocyte function [67]. However, a blunted adipocyte commitment may not only result from altered cell signaling but also from a decrease in the availability of preadipocytes. In this context, APC senescence has recently gained attention as an age-independent phenomenon [70] associated with adipose tissue dysfunction [71]. Recent studies suggest that progenitor cells not successfully differentiating are characterized by increased senescence and secretion of factors reducing the adipogenic potential of non-senescent precursors [72]. Adipose tissue senescence seems to be higher in SCAT compared to VAT [70] and has been found to be associated with hypertrophy, insulin resistance, and dyslipidemia [70, 71].

Paradoxically, fatty acid storage is impaired in obesity (see Sect. 6.4). This is particularly true in individuals with abdominal obesity [73]. Despite the fact that fatty acid uptake does not differ between small and large adipocytes, the enzymatic pathways involved in triglyceride synthesis are likely to be affected [74]. In particular the activity of diacylglycerol acyltransferase (DGAT), the enzyme controlling the last step of adipose tissue triglycerides synthesis, might be diminished in visceral obesity [74, 75] especially in hypertrophic visceral adipocytes [75]. The highly regulated switch between triglyceride storage and mobilization taking place at the interface between fasting and feeding is one of the defining roles of adipose tissue. This regulation is provided, among other signals, by insulin which exerts an inhibitory effect on lipolysis during the postprandial period [25]. Increased circulating non-esterified fatty acids (NEFA) has been proposed as a mechanism altering insulin sensitivity in the muscle and other organs [76, 77], creating a vicious cycle between insulin resistance and impaired triglyceride storage.

Adipocyte hypertrophy is one of the most important pillars defining adipose tissue dysfunction (see Fig. 6.2). Our group demonstrated that adipocyte hypertrophy is associated with increased macrophage infiltration in adipose tissue [23, 78]. Interestingly, visceral adiposity predicted macrophage infiltration in both VAT and SCAT in overweight women [23]. Beyond macrophage infiltration, many other immune cell types can be observed in human adipose tissue. In a recent single-cell sequencing analysis performed in subcutaneous and visceral fat, we were able to identify 14 different clusters of immune cells, including 5 different macrophage subtypes, dendritic cells, monocytes, as well as T, B, and natural-killer cells in both compartments [17]. Specifically, we identified $CD9^{+}$ adipose tissue macrophages expressing lipid metabolism genes typical of obesity [17]. The presence of pro-inflammatory macrophages and other immune cells combined with hypertrophic adipocytes leads to a shift in the adipokines secreted by these cells. Notably, the presence of pro-inflammatory cytokines such as TNFα, interleukin 6 and 18 (IL-6, IL-18), as well as an increase in the secretion of leptin concomitant with a reduction in adiponectin can be observed in individuals with obesity [79]. These cytokines are known to affect both lipolysis and insulin sensitivity [2], which again stresses the role of impaired fatty acid storage and insulin resistance in adipose tissue dysfunction. Adipose tissue macrophage infiltration is not only related to low-grade inflammation but also to altered extracellular matrix remodeling. Pericellular fibrosis resulting from the collagen filaments found around the adipocyte has been shown to be positively related to macrophage infiltration [21]. In addition, pericellular fibrosis in VAT has been found to be associated with metabolic dysfunction [80]. Adipocyte hypertrophy and altered adipokine secretion may also inhibit angiogenesis and induce hypoxia in adipose tissue [81, 82]. This would then lead to extracellular matrix remodeling, adipose tissue fibrosis, and chemotaxis of pro-inflammatory macrophages and other immune cells [81, 82].

In conclusion, adipose tissue dysfunction includes a set of morphological and metabolic characteristics that significantly impair the adequate functioning of adipose tissue, specifically affecting the handling of triglycerides and energy excesses. Hence, reduced adipogenesis, adipose tissue senescence, adipocyte hypertrophy, altered triglyceride storage and synthesis, pericellular fibrosis, insulin resistance, increased macrophage infiltration, and pro-inflammatory cytokine secretion [5] significantly contribute to the development of a dysmetabolic state eventually leading to T2D and CVD [14].

6.4 Cardiometabolic Alterations Associated with Visceral Obesity

The accumulation of excess adipose tissue in the abdominal cavity has been consistently associated with deteriorated cardiometabolic health. Among the most commonly cited alterations are insulin resistance, leading to the development of T2D, non-alcoholic fatty liver disease (NAFLD), low-grade inflammation and dyslipidemia, which in turn are associated with atherosclerosis and a prothrombotic state [2, 5, 14].

Insulin resistance has long been known to be associated with excess VAT accumulation. Analyses from a subgroup of individuals with obesity of the Dallas Heart Study found that volume VAT, rather than SCAT, predicted fasting glucose, insulin, and the homeostatic model assessment of insulin resistance (HOMA-IR) even after adjustment for age, sex, race, menopausal status, and BMI [83]. Interestingly, similar results were reported in the Framingham Heart Study, where the BMI-adjusted odds ratios of insulin resistance in non-diabetic participants for VAT were 2.2 [84]. In spite of the fact that the results of those studies do not allow speculation about the directionality of the association, the large sample size and the consistency of the findings consolidate the link that exists between excess VAT and insulin resistance. Over the years, the contribution of inflammation to insulin resistance in the context of obesity has been emphasized. Indeed, adipose tissue dysfunction and visceral obesity in general have been associated with increased immune cell infiltration [23] and inflammatory cytokine in adipose tissue [85]. In humans and obese mouse models, insulin resistance has been repeatedly associated with adipose tissue inflammation [86]. The contributing role of inflammation has been demonstrated in a mouse model lacking the toll-like receptor 4 (TLR4), a cell-surface receptor responsible for the activation of the inflammatory cascade in adipose tissue. Mice lacking TLR4 significantly decreased their secretion of proinflammatory cytokines and were partially protected from insulin resistance [87].

Not only is obesity associated with insulin resistance, but also with increased NEFA spillover, especially in the postprandial state [88]. This condition is thought to result in part from altered insulin signaling in dysfunctional adipose tissue, leading to a blunted inhibition of basal lipolysis contributing to postprandial plasma NEFA [89]. A second non-exclusive hypothesis is that hypertrophic adipocytes reach their maximal storing capacity, which in turn impedes the appropriate trapping of dietary fatty acids in the form of newly synthesized triglycerides [89]. Recently, fatty acid spillover has been shown to be dependent, not on glucose tolerance, but on total fat mass [90]. The group additionally found that net VAT uptake of dietary fatty acids is higher in glucose-intolerant individuals, upholding the hypothesis that this could be a protective mechanism limiting the effect that increased postprandial NEFA may have on lean organs [90]. Altered inhibition of adipose tissue lipolysis and increased postprandial NEFA spillover are strongly associated with increased ectopic fat accumulation [88] including in lean organs such as the muscle, liver, and the pericardium [5]. Supporting this notion, a recent study found that liver triglyceride levels and fibrosis were positively and significantly associated with computed tomography-measured VAT area in both T2D and healthy controls [91]. These associations were independent of BMI and WC [91]. The contributing role of VAT excess in the development of insulin resistance and hepatic steatosis has been recently demonstrated in a mouse model where epididymal VAT was surgically removed [92]. Compared to controls, high fat-fed mice without VAT had improved insulin sensitivity and signaling in SCAT, muscle, and liver, with significantly lower triglyceride content in the liver [92].

Excess VAT, ectopic fat, and insulin resistance have been repeatedly associated with dyslipidemia [2, 5, 93]. Over the years, a number of large epidemiological studies conducted all over the world consistently demonstrated that visceral obesity is a predictor of cardiovascular risk, independent of other measurements of adiposity [5]. Interestingly, increased VAT but not SCAT predicts small low-density lipoprotein (LDL) particle size, increased plasma triglycerides, and low high-density lipoprotein (HDL) concentration, even after adjustment for BMI and HOMA-IR in the Dallas Heart Study [83]. These are key factors contributing to the development of atherosclerosis [94] which are aligned with the notion that excess visceral adiposity accelerates the progression of atherosclerosis [95]. Overall, abundant evidence has shown that VAT is a strong marker of adipose tissue dysfunction and ectopic fat deposition, which in turn is a critical effector for impaired cardiometabolic health.

6.5 Reversal of Metabolic Dysfunction After Bariatric Surgery

Bariatric surgery remains the designated approach to induce sustained weight loss for individuals with severe obesity [96]. On that basis, several authors report that bariatric surgery is more beneficial than lifestyle intervention and best medical approaches for long-term weight loss and remission of metabolic impairments in individuals with severe obesity [97, 98]. The most commonly performed surgeries include sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB), whereas biliopancreatic diversion with duodenal switch (BPD) is less frequently performed but provides the most significant weight loss and favorable long-term metabolic outcomes [99–101]. Bariatric surgeries induce variable loss of SCAT, but a relative mobilization of the VAT compartment has been postulated with weight loss regardless of the type of intervention [19, 102–105]. Accordingly, many metabolic improvements are associated with surgical procedures and visceral fat mobilization [106, 107].

In terms of metabolic changes, improvement in hepatic insulin sensitivity has been shown to occur within a few days after surgery, even before significant weight loss takes place. This immediate effect is likely due to the fasting and reduced caloric intake occurring before and after such procedures, as fasting protocols mimicking caloric intake of the surgery patients have generated similar effects on insulin sensitivity in unoperated individuals with severe obesity [108]. A significant reduction in postprandial cardiac uptake of NEFA concomitant with improved VAT NEFA uptake was also observed on average 12 days after surgery, consistent with a rapid reduction in substrate flux to ectopic sites after surgery [109]. Peripheral insulin sensitivity improvements are, on the other hand, weight loss-dependent and, therefore, appear in the longer term [98]. The changes associated with weight loss are observed with a simultaneous improvement in the adipokine profile [110] and lower average adipocyte size [98], reflecting globally improved adipose tissue function.

6.6 Conclusions

The risk of developing metabolic alterations and comorbidities in obesity is strongly dependent on body fat distribution patterns, specifically excess accumulation of ectopic and intra-abdominal, visceral adipose tissue. Considering the high inter-individual variability in visceral fat accumulation across the entire spectrum of BMI values, additional means are necessary to help clinicians take into account body fat distribution, as WC alone does not represent a useful marker in severe obesity [111, 112]. This chapter provided a brief overview of the evidence supporting visceral adiposity as a critical marker of the increased cardiometabolic risk observed among individuals with obesity, which is likely mediated by adipose tissue dysfunction. Interestingly, bariatric surgery has been shown to be a reliable method to reverse the course of most metabolic impairments observed in individuals with severe obesity.

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Chapter 7
Pathophysiology of Bile Acid Regulation

Joseph A. Sujka and Christopher G. DuCoin

7.1 Introduction

Bile acids and their regulation has emerged as an important topic in understanding obesity, metabolic disorders, diabetes, and non-alcoholic fatty liver disease. Bile acids are steroid molecules that can act as important modulators. In this chapter we will review the normal physiology of bile acids and then summarize the pertinent bile acid signaling on medical conditions and co-morbidities.

7.2 Physiology of Bile Acid

Bile is an endogenous steroid produced from cholesterol and is secreted by hepatocytes. It has two major roles in human physiology, the first is absorption of lipids and the second is to allow for transport and excretion of toxins and cellular metabolites. The pathway of bile secretion starts in the biliary canaliculi. These coalesce into small bile ducts and subsequently portal triads. Four to six triads create a hepatic lobule, the smallest functional unit of the liver. Hepatocytes communicate with sinusoidal surfaces through the Space of Disse. Passage of bile salts through the space of Disse allows for hepatocyte uptake via sodium cotransport and sodium-independent pathways. Other organic anions are transported including unconjugated (indirect) bilirubin. With this communication the circulating components of bile are absorbed and secreted into the bile canaliculi. This step is the rate limiting step of bile salt excretion.

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Bile also contains proteins, pigments, and lipids. Major lipid components include cholesterol and phospholipids, which function to dispose of LDL and HDL but also to protect hepatocytes and cholangiocytes from bile toxicity. The source of cholesterol is hepatic synthesis and circulating lipoproteins. Although all the previously listed molecules play an important role in nutritional homeostasis, bile is a major route for toxin disposal. For example, bile pigments such as bilirubin are bound to albumin in the blood and transported to the liver and hepatocytes. There it is converted to conjugated (direct) bilirubin and excreted in both stool and urine.

Volume of biliary flow is an osmotic process and not affected by bile salts due to the formation of micelles, spherical pockets of bile salts that provide no osmotic activity. However, cations secreted into the biliary tree with the bile salt, which is an anion, provides osmotic pressure to draw in water and increase biliary flow. Some of the biliary flow is salt-independent, serving to expel toxins and metabolites, but more so flow is due to chemical, humoral, and neural stimuli. This includes vagal activity, secretin, and cholecystokinin (CCK). CCK specifically induces biliary tree secretion and gallbladder wall contraction increasing excretion of bile into the intestines.

Instead of a constant high rate of bile acid production, most bile is recycled through enterohepatic recirculation, terminal ileum reabsorption, and portal venous return. Approximately 0.2–06 yg/day of bile is produced by the liver daily with 95% of bile being recycled. Only 5% of bile salts are lost each day in the stool. If this amount increases bile has a powerful effect on the colonic lumen resulting in inflammation and diarrhea [1].

7.3 Pathophysiology of Bile Acid Regulation

7.3.1 Receptors and Signaling

Two major bile acid receptors that have a large role in metabolic disorders are farnesoid X receptor (FXR) and Takeda G protein-coupled receptor (TGR5). These receptors along with gut microbiota affect the synthesis, distribution, and metabolism of bile acids [2]. FXR is expressed in hepatocytes as well as enterocytes of the distal small intestine and colon, while TGR5 is expressed in enteroendocrine cells as well as bile duct epithelial cells and the gallbladder [3]. It should be noted prior to further description that these receptors have been most studied in mouse models and their translation into humans should be approached with care.

TGR5 has been suggested to play a role in the regulation of bile acids and regulation of energy expenditure potentially playing a role in the development of obesity. However, this mechanism is not fully understood. One study showed an increase in bile acid in TGR5-deficient mice that was potentiated by cholic acid (CA) feeding while another showed a decrease in bile acid pool in TGR5 deficient mice [4, 5]. Interestingly, a study by Watanabe et al. found that high-fat-diet-induced obesity could be reversed by supplementing CA, which underwent transformation to a more biologically active form of deoxycholic acid (DCA) stimulating TGR5-mediated intracellular thyroid hormone activity [6]. Another study found that TGR5 helped regulate glucose homeostasis through increased energy expenditure in muscle and brown adipose tissue. It was also shown to increase glucose-like peptide (GLP)-1 release in intestinal L cells and alpha cells in the pancreas [7, 8]. FXR receptors appear to have an opposing effect on GLP-1 signaling to TGR5, with stimulation of FXR receptors leading to inhibition of GLP-1 synthesis [9]. Another molecule INT-777, a derivative of chenodeoxycholic acid (CDCA), a TGR5 agonist, was shown to ameliorate hepatic steatosis and adiposity along with improving insulin sensitivity in mice with high-fat-diet-induced obesity [8].

FXR has also shown somewhat conflicting results in mice models. In one study, FXR deficient mice on normal diets developed hyperglycemia and hypercholesterolemia [10]. By contrast other studies found that FXR-deficient mice bred to be genetically obese or fed with a high-fat diet were protected against obesity and had improved glucose hemostasis [11–13]. This is thought to be somewhat due to opposite actions of FXR in the liver and intestines. Hepatic expression of FXR has shown to protect against steatosis while intestinal deletion of FXR improved high-fat-diet-induced steatosis and obesity [14–16]. Increasing the complexity even further FXR agonism and antagonism can be beneficial for host metabolism and the full scope of FXR's role is not clear [15].

Overall, animal studies have suggested that bile acids affect metabolism and energy expenditure. As a result, numerous cross-sectional studies in humans have been performed with the goal of establishing connections between BMI, circulating bile acids, and insulin resistance. These studies have shown an increase in total bile acid levels in humans with obesity [17]. Patients who have insulin resistance have been shown to have enhanced bile acid synthesis and an increase in 12α-hydroxylated bile acids. This suggests that an increase in 12α-hydroxylated bile acids may negatively affect the function of insulin, like increased GLP-1. Other studies have shown that low levels of 12α-hydroxylated bile acids can improve glucose tolerance [18]. This interaction is thought to be due to Forkhead box protein (FOX)01, a transcription factor involved in gluconeogenesis that controls the production of 12α-hydroxylated bile acids through Cyp8b1 regulation [19]. In obese humans who have lost weight and improved their metabolic control through lifestyle modification, there was a shift in bile acid composition toward increased 12α-hydroxylated bile acids to non-12α-hydroxylated bile acids [20]. These same changes have not been seen in patients who have type 2 diabetes mellitus (T2DM) [17]. The only study so far with a positive effect of bile acids on energy expenditure examined CDCA. CDCA was shown to increase whole body energy expenditure and increase brown adipose tissue activity in 12 healthy women given a dose of 15 mg/kg body weight for 2 days [21].

One of the potential therapeutic targets for bile acids is depletion of bile acids as means of improving glycemic control. A meta-analysis examined 17 studies with colesevelam or colestimide, bile acid sequestrants, in 2950 patients. They showed that those who that received either bile acid sequestrant had a lower hemoglobin A1c compared to the control group [22]. Another study compared colesevelam to placebo and found increased GLP-1 and GIP, as well as cholesterol and bile acid synthesis in those patients who were in the colesevelam group. This again suggests that depletion of human bile acids may improve obesity and metabolic syndrome. Metformin is another medication examined and was found to affect patient's gut microbiome [23]. The exact mechanism and downstream effect of this finding are currently being examined. Further studies will be needed to see what other effects medication can have on both bile acid synthesis and gut microbiome effects.

7.3.2 Obesity, Bariatric Surgery, and Diabetes

Bariatric surgery has been shown to be the most effective long-term treatment for morbid obesity with both decreases in body weight but also improving co-morbid complications for patients. Common procedures include Roux-en-Y gastric bypass (RYGB), vertical sleeve gastrectomy (VSG), and biliopancreatic diversion (BPD/DS). Interestingly the metabolic improvements (increased insulin sensitivity) occurs early after surgery, a few days, far before post-operative weight loss occurs [24]. This would suggest that it is more than just weight loss that leads to improvement in patient's metabolic profile after surgery.

One of the suggested mechanisms effecting this improvement is a change to bile acids [25]. In RYGB the patient's circulating bile acid pool is increased in both fasting and postprandial phases along with an elevation in the ratio of 12α-hydroxylated/non-12α-hydroxylated bile acids [17]. Similar changes to bile acid profile occurs in BPD/DS [26]. On the other hand VSG has a less consistent change to bile acid profiles with some studies showing unchanged, increased, or decreased bile acids [17]. This may be why VSG is less effective in improving glucose metabolism in comparison to RYGB and BPD/DS [27]. After RYGB, bile acids have been shown to have a positive correlation with several other metabolically active peptides. These include GLP-1, peptide YY, and adiponectin [26]. This could be secondary to bile acid–mediated TGR5 activation, however studies to support this conclusion are missing [28].

Additional studies have examined the mechanism for improved metabolic profile through bile acids after bariatric surgery. One study examined obese insulin-resistant patients after receiving tauroursodeoxycholic acid (TUDCA), which is typically increased after RYGB, and found that there was improved hepatic and peripheral insulin sensitivity [29]. This would suggest that increases in the bile acid TUDCA may play a role in improving patient's metabolic syndrome after RYGB. Similarly, murine models of RYGB and VSG confirmed increased circulating bile acids were associated with improved metabolic features [30]. While malabsorption and changes to bile acids may play a role in the metabolic benefits of bariatric surgery, consideration for whether or not calorie reduction plays a role is needed. One study found that calorie reduction does not affect the size of bile acid pool or composition in humans [31]. Further studies need to be conducted to confirm this finding but at this time it does not appear that calorie reduction affects the size of the bile acid pool or its composition.

Another potential way that bariatric surgery improves metabolic features of obesity is changes to the gut microbiome. Several studies have shown that there is a shift in the gut microbiota 3 months after surgery and that these changes are still present 9 years later [32, 33]. Not only is there a change in the level of postprandial bile acid levels but there was also reduced fat gain in mice [32].

While it appears that changes to bile acids play a role in improvements after bariatric surgery, how specific receptors mediate this change remains less clear. One study examined mice lacking FXR and found that they had reduced weight loss and less glucose improvement after VSG, however in contrast mice with bile diversion to the ileum, a model of RYGB, showed reduced FXR signaling [34, 35]. These results at first glance appear to be contradictory but also suggest that the role of FXR signaling differs in restrictive and malabsorptive procedures. Two studies examining TGR5-deficient mice after VSG showed improved glucose metabolism, insulin signaling, and fat accumulation in the liver but body weight reduction was unclear [36, 37]. This helps show that TGR5 is involved in the beneficial aspects seen with VSG.

7.3.3 Non-alcoholic Fatty Liver Disease and Non-alcoholic Steatohepatitis

Non-alcoholic fatty liver disease (NAFLD), a chronic disease of the liver, represents another area where bile acids can play a role in both progression and improvement of this condition. Non-alcoholic steatohepatitis (NASH) represents a disease on the same spectrum as NAFLD and will be discussed together with it. Bile acids are seen to be elevated in both adult and pediatric patients with NAFLD/NASH with both increased fasting and postprandial serum bile acids. This correlates with the severity of NASH present in patients [38, 39]. The changes to the profile of serum bile acids is not entirely clear at this point. Some studies found that hepatic bile acids are increased in NASH, with prevailing CA, while other studies showed decreased CA levels [40, 41]. In either situation it suggests that the bile acid pathway is affected by liver disease leading to alternative pathways of bile acid production and potential therapeutic targets.

Changes to the gut microbiota may also play a role in NAFLD/NASH. Increased bile acid production may be due to changes from a strong FXR agonist, such as CDCA, to a weak agonist DCA [42]. Given these changes it stands to reason that modulation of intestinal microbiota may provide a therapeutic avenue for these patients. In fact, various studies have examined the FXR signaling pathway and have suggested that through modulation there was the potential to reverse insulin resistance and fatty liver disease [13, 16, 43]. Experiments examining FXR inhibition have utilized ileum bile acid transporter (IBAT) inhibitors. These result in increased fecal excretion of bile acids, which cannot be fully compensated for with increased bile acid synthesis and was found to be protective against NAFLD in an experimental high-fat-diet-treated mouse model [44, 45].

At this time, there are no currently approved treatments for patients with NAFLD/NASH other than dietary and lifestyle modification. Some testing has been done with bile acid receptor modulation with limited results. Two randomized placebo-controlled trials using UDCA did not show overall improvement in inflammation associated with NAFLD but one study did show that high dose UDCA showed improvement in circulating markers of inflammation, fibrosis, and insulin resistance [46]. In contrast the semisynthetic bile acid, obeticholic acid (OCA), has shown some promise. OCA is 100 times more potent an FXR agonist in comparison to CDCA. In phase 2 and 3 trials, OCA improvements in insulin sensitivity and reduced body weight in those with NASH +/− DM was seen [47]. A multicenter double-blinded randomized placebo controlled phase 3a trial with OCA (FLINT) looked at 283 patients with NASH +/− DM and found that after 72 weeks of treatment NASH activity score and fibrosis improved. However, insulin sensitivity worsened with increased LDL and decreased HDL levels [48]. Unfortunately, these results were corroborated in healthy volunteers as well taking OCA [49]. Further studies are needed to determine ideal treatments for NAFLD/NASH patients but it appears that modulation of bile acid pathways may play a role in eventual therapeutic interventions.

7.4 Conclusion

Bile acids, once thought to only play a role in digestion and toxin excretion, appears to play a more expanded role than previously considered. TGR5 and FXR receptors seem to have a role in the results of bariatric surgery and may eventually be used as targets for NAFLD/NASH patient treatment. Clearly the full pathway for affecting this change has yet to be fully described but as our understanding of this complex system further improves, it should lead to targets to improve patient outcomes and care.

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Chapter 8
Nonalcoholic Steatohepatitis (NASH)

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8.1 Introduction

Nonalcoholic steatohepatitis (NASH) is a more severe form of the spectrum of disease known as nonalcoholic fatty liver disease (NAFLD). Both are characterized by hepatic steatosis, or abnormal retention of lipids in the liver, in the absence of excessive alcohol use, but NASH is associated with hepatocyte ballooning degeneration, lobular inflammation, and apoptosis that can lead to fibrosis, scarring, and finally cirrhosis [1–5]. NASH can be considered a diagnosis of exclusion once testing has ruled out other causes of elevated liver enzymes and lipid buildup, such as alcoholic liver disease, hepatitis C, or Wilson disease. Many people have fat deposition in the liver, and it is still unknown why some show no symptoms while others show signs of fibrosis and cirrhosis characterized by inflammation and cell death.

8.2 Epidemiology

Prevalence—NAFLD is most commonly identified in patients during their 40 s or 50 s [4]. NAFLD is evident worldwide but is considered the most common liver disease in Western industrialized countries, most likely because this is where the

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major risk factors for NAFLD, central obesity, type 2 diabetes mellitus, dyslipidemia, and metabolic syndrome are most rampant [5, 6]. Studies looking at the United States population have shown evidence for NAFLD in 10–46% of the population, with most biopsy-based studies suggesting a prevalence of NASH of 3–5% [7, 8]. Worldwide, NAFLD has a median reported prevalence of 20%.

Patient Demographics—The sex distribution of the disease is debated, with some suggesting it is more common in women [9] and others suggesting it is more common in men. Ethnic differences also seem to be characteristic of NASH [10, 11]. Hepatic triglyceride levels were measured in 2287 patients from a multiethnic, US population-based sample. The findings showed a higher prevalence of hepatic steatosis in Hispanics (45%) as opposed to their White (33%) or Black (24%) counterparts. The higher prevalence in Hispanics was explained by a greater prevalence of obesity [10].

Association with other diseases: Since NASH results from fat deposition in the liver, this disease commonly affects individuals with metabolic syndrome, characterized by at least 3 of the following 5 symptoms:

1. Obesity
2. Hypertension
3. Diabetes
4. Hypertriglyceridemia
5. Hyperlipidemia

This connection was shown in a study looking at the liver biopsies of 163 patients diagnosed with NAFLD but without overt diabetes. Of these, 120 (74%) were significant for NASH [12]. Metabolic syndrome was seen in 67% of those with simple steatosis (NAFLD) on biopsy, and in 88% of those with NASH on biopsy. It is estimated that in patients with type 2 diabetes, the prevalence of NAFLD and NASH is 76% and 56%, respectively [13].

Other risk factors include [14]:

- Severe weight loss
  - Jejunoileal bypass
  - Gastric bypass (less common than jejunoileal bypass)
  - Severe starvation
- Medication-induced
  - Amiodarone
  - Diltiazem
  - Tamoxifen
  - Steroids

8.3 Pathogenesis

The leading theory for the development of NAFLD, and later NASH, is the development of a lipotoxic environment in the liver that can damage hepatocytes at the cellular level [13]. Overabundance of lipids may cause oxidative stress and mitochondrial damage within the cell due to the hazardous peroxidative derivatives from lipid metabolism. Susceptibility to lipotoxic damage may come from a range of factors such as those seen in PNPLA3 polymorphisms (a protein associated with hydrolase activity toward triglycerides and whose dysfunction is linked with steatosis [15]) and metabolic syndrome.

8.4 Clinical Manifestations

While those with NAFLD are often asymptomatic, patients with NASH may present with nonspecific symptoms like fatigue, malaise, and vague upper right abdominal discomfort [16]. The diagnosis is typically made in asymptomatic patients during routine screening or testing for other concerns when test results show abnormal liver chemistry tests such as elevated alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), abnormal hepatic ultrasonography, or computed tomography (CT).

Physical findings—NASH patients often show evidence of hepatomegaly on physical examination due to fatty deposition on the liver [17] though the extent can be highly variable. In one study looking at 12 patients with NASH, 11 had hepatomegaly (defined as a liver span of >18 cm on CT), with a mean liver span of 21 cm. However, in a different study looking at the CT scans and ultrasounds of 144 patients with NASH, 18% were noted to have hepatomegaly, and there was a positive correlation between increased levels of hepatomegaly and those with more advanced stages of fibrosis (28%) [18]. Since NASH can progress to cirrhosis in its later stages, if left untreated, the patient may have symptoms of chronic liver disease like ascites, palmar erythema, and spider angiomata.

8.4.1 Diagnosis

The diagnosis of NASH requires both physical exam, patient history, and imaging to rule out any other possibilities. The patient must not have any history of significant alcohol consumption, nor any indication of existing diagnoses for chronic liver disease including chronic viral hepatitis, Wilson disease, lipodystrophy, abetalipoproteinemia, hemochromatosis, autoimmune liver disease [19], etc. A magnetic resonance imaging (MRI) or computed tomography (CT) must show evidence of hepatic steatosis.

CT and MRI are both utilized to identify features common to both NAFLD and NASH such as steatosis, but they are often not sensitive to inflammation or fibrosis characteristic solely of NASH. However, it is difficult to study the accuracy and specificity of CT and MRI in diagnosing NASH because not everyone is sent for liver biopsy, which is the only confirmatory test for NASH. There are studies that have looked at the efficacy of CT and MRI in diagnosing NASH via confirmatory liver biopsy. One study that used confirmatory liver biopsy to find evidence of hepatic steatosis found that CT lacked sensitivity while MRI lacked specificity. The study looked at 131 individuals undergoing both liver biopsy and radiologic evaluation with non-contrast CT, contrast-enhanced CT, or MRI. The sensitivities were 33, 50, and 88%, and the specificities were 100, 83, and 63%, respectively. Therefore, the sensitivity and specificity of liver biopsy (95 and 88%, respectively) is higher for liver biopsy, making it the gold standard for diagnosis [20].

NASH is also associated with advanced liver fibrosis. While liver biopsy remains invasive and expensive, the enhanced liver fibrosis (ELF) score is an extracellular matrix marker set consisting of metalloproteinases, amino-terminal propeptide of type III procollagen, and hyaluronic acid that has shown goo correlation with fibrosis stages in chronic liver disease. Individuals with an ELF score of 10.51 or higher are diagnosed with advanced liver fibrosis and a higher correlation with NASH [21].

A liver biopsy is the only way to definitively confirm the presence of steatosis and distinguish it from NAFLD. Biopsy is also necessary in order to grade and stage the disease [22, 23]. A biopsy is obtained if there is:

- Evidence of chronic liver disease, splenomegaly, or cytopenias (evidence of cirrhosis)
- A serum ferritin greater than 1.5× the normal limit (NASH and advanced fibrosis)
- Age over 45 with obesity or diabetes as comorbidities (NASH and advanced fibrosis)
- Concern from the patient regarding the presence of inflammation or fibrosis

Biopsy helps to assess for NAFLD, which requires a minimum of greater than 5% steatotic hepatocytes in a liver tissue section [24–26]. NASH can be distinguished from NAFLD with this minimum criterion in addition to hepatic lobular inflammation (typically in acinar zone 3) and hepatocyte ballooning degeneration. Evidence of fibrosis is not necessary but is frequently encountered. The appearance of NASH may be histologically identical to that of alcoholic steatohepatitis, but the patient's social history should rule this possibility out. Other histological findings specific for NASH may include:

- Apoptotic bodies
- Collagen deposits around the sinusoid that may make acinar zone 3 have a characteristic "chicken wire pattern"
- Mallory bodies

NASH may exist alongside other liver diseases, which can make the diagnosis of NASH difficult. Patients with NASH may also have co-morbidities like alcoholic liver disease, but the means to distinguish the contributions of each to the disease's progression does not exist at this time. In a study analyzing 3581 liver biopsies from patients with some type of chronic liver disease, the prevalence of steatohepatitis ranged from 1.6% (autoimmune hepatitis) to 7.9% (alpha-1 antitrypsin deficiency), none of which had significant alcohol consumption in the patient history [25].

After enough hepatocellular damage, NASH can progress to cirrhosis and may make the inflammation and steatosis less evident in the liver. The progression to cirrhosis also causes the risk for hepatocellular carcinoma (HCC) to increase. The increased association between NASH and HCC comes from studies examining the risk for HCC and diseases strongly connected to NASH, like metabolic syndrome and diabetes. Studies looking at the connection between these diseases have found that the features commonly linked to NASH are more frequent in patients who had HCC than in age- and sex-matched patients who had HCC due to a well-defined viral or alcoholic origin [27].

The NAFLD activity score (NAS) is used to grade the severity of NAFLD [25]. The NAS is the sum of the biopsy's scores for steatosis and lobular inflammation (on a scale from 0 to 3) and hepatocellular ballooning (0–2). Fibrosis is not graded. Scores ranging between 5–8 are largely considered diagnostic of NASH. Other histologic scoring systems for NASH exist but are not discussed here.

8.5 Treatment

Certain general measures are applied to a patient's lifestyle in order to manage disease progression and lower the chances of developing other co-morbidities.

Alcohol use—Heavy alcohol use is associated with advanced disease progression so all patients with NASH are advised to abstain from alcohol, but in particular avoid an episode of heavy drinking (defined as more than 14 drinks per week or more than 4 drinks on a single day for men and more than 7 drinks per week or more than 3 drinks on a single day for women) [28].

Vaccines—With a damaged liver, a patient may be more susceptible to developing certain infections. Vaccination for available hepatitis serotypes should be given to patients without serologic evidence of immunity. Other vaccines recommended for patients with chronic liver disease include pneumococcal, influence, tetanus, and other vaccines given to the general population.

Weight loss—Lifestyle interventions can help to improve fat deposition on the liver, liver biochemical tests, serum insulin levels, and overall quality of life. This is especially important for overweight and obese patients with NASH. Patients are advised to adhere to a diet and exercise plan tailored to their goals. If these goals have not been met within 6 months, bariatric surgery or drug therapy may be considered. For suspected NASH, patients are advised to lose 1–2 lbs per week with their plan with the overall goal of losing 5–7% of their body weight. For biopsy confirmed NASH patients, the treatment is more intensive, with an overall goal of 7–10% body weight drop within 6 months [29, 30]. Several studies suggest that a minimum drop of 5% body weight is needed to see improvement in hepatic steatosis, while greater than a 7% drop has been associated with a reduction in the patient's NAS score [31].

8.6 Medication

- Metformin—evidence for the use metformin in treating NAFLD and NASH has shown little benefit in both children and adults. It may be more effective than no treatment at all in reducing metabolic parameters to a normal level, but it does little to improve the inflammation and fibrosis seen in NASH [14].
- Glitazones, peroxisome proliferator activated receptor stimulators that reduce insulin resistance, are recommended for individuals with advanced liver fibrosis to help reduce the progression. Adding vitamin E to this treatment has also been shown to further reduce fibrosis progression. The patient's other comorbidities should be considered before administering this treat (i.e., glitazones are contraindicated in heart failure, current or previous history of bladder cancer, etc.). Long-term outcomes of this treatment have not been identified [14].
- New therapies like NGM282, a recombinant fibroblast growth factor 19 analogue, have been associated with greater than 30% decrease in liver fat content across 12 weeks in patients with NASH, and one study looking at 43 patients with NASH, and the effect on the stage of fibrosis, showed improvement in liver histology and stage of fibrosis in 50–68% of patients. These therapies are still undergoing long-term testing and adverse effects are still being evaluated. Due to its limited availability, this drug is also very expensive.
- Other options used for NAFLD, like statins and orlistat, are not recommended for treating NASH, specifically.

Bariatric surgery—If patients do not meet their goals after 6 months, they may be referred for a bariatric surgery evaluation. Bariatric surgery has been shown to improve quality of life and demonstrate improvements on histological evaluation. Bariatric surgery, in patients with obesity, reduces liver fat and progression of NASH. Several retrospective studies, and one study monitoring patients for a 5-year period after surgery, have shown that bariatric surgery can improve or even reverse NAFLD, NASH, and fibrosis [32, 33]. However, there is some evidence that suggests that bariatric surgery is associated with worsening liver enzyme levels and they need to be monitored over a 3-month period post-operatively [22]. Foregut bariatric surgery is not recommended yet specifically for treating NASH.

Liver transplantation—Liver transplant has been shown to be an efficacious therapy for decompensated liver disease caused by NASH. The European Association for the Study of the Liver has guidelines for when patients with NASH with concurrent HCC or liver failure can be considered for liver transplant. A few of the indications for assessment for transplant include:

- Acute liver failure
- Ascites
- HCC
- Encephalopathy

Some of the contraindications for liver transplant are the following:

- AIDS
- Liver cancer with metastases
- Continuous alcohol or illicit substance abuse
- Sepsis

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Chapter 9
Patient Selection

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Duodenal switch is one of the most powerful bariatric procedures we have, despite this, it only represents 2% of the total bariatric procedures performed worldwide [1]. It was described in the late 1980s-early 1990s by Hess [2] and Marceau [3] as an evolution of the biliopancreatic diversion (BPD) in order to deal with its side effects. BPD had shown excellent weight loss results but some severe side effects as marginal ulceration, excessive diarrhea, and malnutrition.

The first papers about duodenal switch (DS) were focused on technical facts and the rationale for vertical gastrectomy and the length of the limbs, but they did not discuss too much about patient selection [3–5]. Nowadays, there is overall consensus about the benefits of this procedure in heavier patients, but special indication in super-obesity. The greater benefits in terms of comorbidity improvement compared to other procedures are also well known [6, 7]. Finally, it is important to remark that even if it is a safe procedure, as other hypo-absorptive surgeries, DS is not indicated for all potential candidates, because factors like social conditions, incomes, access to supplementation, and good follow-up have to be taken also into account.

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9.1 Potential Candidates for Duodenal Switch

DS is one of the most powerful bariatric tools we have. It combines the restriction of a sleeve gastrectomy with the malabsorption of a distal intestinal bypass. The most common constructions of the bowel limbs consider a total alimentary limb of 250–300 cm, with a 75–100 cm common channel. Some original descriptions also took into consideration percentages of the total limb length, leaving a 50% of total alimentary limb where 10% of the bowel was left as common channel.

In an overall view, DS is considered for the same population as other bariatric procedures:

- BMI > 40 kg/m^2 or BMI > 35 kg/m^2 plus other medical condition related to obesity
- Failed non-operative treatments for weight loss
- Mental health clearance
- No contraindications for surgery

Super-obese patients (SOP) are usually considered the best candidates for hypo-absorptive procedures. Restrictive procedures may have limited effect on this population. DS has important advantages to BPD and distal Roux-n-Y gastric bypass (RYGB) as it is a less ulcerogenic procedure and because vertical gastrectomy allows better food tolerance. The earlier descriptions of the duodenal switch already show good and sustained weight loss results in this population.

Risstad et al. [8] presented in 2015 a randomized controlled trial comparing DS vs RYGB y patients with BMI 50–60 kg/m^2. They found after 5 years of follow-up that DS achieved sustained greater weight loss, plus greater improvement in lipid profile. Quality of life did not differ between both procedures, but DS was associated with more surgical, nutritional, and gastrointestinal adverse effects. There are also some other comparative studies that show similar results.

The Clinical Guidelines cosponsored by American Association of Clinical Endocrinologists/American College of Endocrinology, The Obesity Society, American Society for Metabolic & Bariatric Surgery, Obesity Medicine Association, and American Society of Anesthesiologists in its last review from 2019 [9] consider DS as an effective procedure for patients with very high BMI.

However, BMI 50 kg/m^2 does not represent a frontier line to indicate or not indicate DS. Patients with lower BMI may also benefit from this powerful tool. The metabolic benefits of this procedure have been widely published [10–12], so it may also be indicated in patients with BMI 40–50 kg/m^2 with strong metabolic comorbid conditions.

9.2 Selection Algorithms

Buchwald presented a very interesting patient selection algorithm in 2002 [13]. Even though this paper may have severe limitations, it describes the aim of the potential candidate for duodenal switch. This algorithm considers 6 items: body mass index (BMI), age, gender, race, body habitus, and comorbidities. Following this algorithm, the more complex the patient, the more suitable he may be to a DS.

Himpens has also presented some algorithms with the same rationale. The Himpens Obesity Severity Score follows the same rules from the Buchwald's algorithm but referring to other factors established the severity of the disease. Some years ago, the same author published his personal long-term experience with the DS [7]. In this publication, it is referred to a personal algorithm about his personal selection protocol. This protocol reflected that DS was considered for metabolic patients, without GERD, and with binge eating.

9.3 Contraindications for Duodenal Switch

Contraindications for DS may be considered the same for all bariatric procedures:

- Pregnancy
- Severe psychiatric illness
- Eating disorders
- Patient-related contraindications to undergo surgery (cardiovascular risk, anesthetic risk)
- Substance misuse (alcoholism)
- Severe coagulopathies

We may also add contraindications for sleeve gastrectomy as severe reflux (esophagitis greater than B) or big hiatal hernias; and contraindications for hypo-absorptive procedures:

- Inflammatory bowel disease
- Immunosuppressant therapies
- Hypo-absorptive syndromes
- Familial polyposis colonic disease
- Colonic resections
- Fecal incontinence

Some of these contraindications should be considered relative contraindications, and a tailored approach is mandatory in those cases.

The main specific contraindication for DS is related to its potential side effects. As a hypo-absorptive procedure, with high risk for protein malnutrition and a significant association with micronutrient deficiencies, DS patients will have to follow a strict supplementation program [14, 15]. Some of these supplementations may be expensive and patients need to be conscious preoperatively. Patient adherence to the follow-up program by the multidisciplinary team is crucial to avoid long-term side effects. Even though it is difficult to predict how the patients will behave after surgery, it is important to try to detect those who may fail postoperative consultations.

In this procedure social conditions and incomes may also play a role as a potential contraindication for DS. Patients with poor incomes with difficult access to supplementation, or they may be reluctant to continue the follow-up program, should not be considered for DS.

9.4 Duodenal Switch as a Staged Procedure

DS is considered one of the most complex bariatric procedures technically speaking, as it includes sleeve gastrectomy, dissection and section of the first portion of the duodenum, and two anastomoses. It is commonly indicated to higher BMI patients, so it is a difficult combination to deal with. From the paper of Regan and Gagner in 2003 [16] staging the bariatric surgery in those complex patients is a strategy to take into account.

Staged DS is thought to convert a high-risk procedure into two low-moderate risk procedures. Sleeve gastrectomy is challenging in these patients, but the dissection of the duodenum and the duodeno-ileal anastomosis may be very difficult (heavy and short mesenteries, high volume liver). After a strong weight loss, the procedure is quite straightforward.

There are some papers [6, 17–19] that demonstrate that DS is not charged with extra morbidity or mortality in patients with BMI up to 60 kg/m^2, so the real benefit for this staged strategy might be for BMI over 60 kg/m^2. Second stage allows at the end the same weight loss as a primary procedure. This second stage can be scheduled 12 to 24 months after surgery, but the ideal time interval has not been defined.

On the other hand, there are also some patients initially planned for staged procedures that continue losing weight and do not require a second stage [20]. They represent around 10–15% of the primary sleeve gastrectomies.

9.5 Duodenal Switch as a Rescue for Failed Primary Procedure

DS has also been described as an indication to rescue a failed primary procedure [21]. SG, RYGB, and single anastomosis DS (SADI-S) can be converted into DS.

SG to DS is a straightforward procedure. Failed SG, especially when SG had not been properly indicated, can be rescued by converting into DS. It is important to perform an adequate preoperative workup. GERD has to be excluded prior to going to the operating room, as it cannot be clearly stated if it may be related to overweight or to sequelae of the SG. On the other hand, it is also important to evaluate potential dilation of the gastroplasty as the restrictive component may also be restored.

Failed RYGB can also be converted into DS [22, 23]. It has been stated that conversion into DS is the most effective solution for a failed RYGB, but it is also the most challenging. Conversion from RYGB to DS is a complex procedure that can be performed in one or two stages. We may find several series of cases in the literature but high morbidity but with good weight loss results.

Finally, SADI-S can be converted into DS just by adding a Roux anastomosis. This is the most effective solution in case of bile reflux after SADI-S, but it has also been proposed to fail weight loss. There is just a little evidence about the potential benefit from this conversion.

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Chapter 10
Psychological and Psychiatric Workup

Hélio Tonelli and Andréia Tonelli

10.1 Introduction

Bariatric surgery is the most effective treatment for morbid obesity [1], a condition that is increasingly common worldwide and that affects children particularly. Shortly, the costs of preventing and treating obesity, as well as its metabolic complications, shall not be fully covered by health systems [2]. Biliopancreatic diversion with duodenal switch (BPDDS), along with gastric bypass (RYGBP), is among the surgical techniques leading to weight loss and its maintenance over time [3]. BPDDS includes three specific components: (1) a longitudinal gastrectomy, providing caloric restriction and decreasing acid production, while maintaining normal gastric emptying; (2) a 250 cm total alimentary limb whose role is to reduce caloric absorption; and (3) a 100 cm common channel where the bolus mixes with biliopancreatic juices, resulting in decreased absorption of protein and fat [4]. Although long-term data on health-related quality of life (HRQL) after BPDDS is scarce, Aasprang et al. [5] accessed HRQL through a self-administered questionnaire, before and 1, 2, 5, and 10 years after BPDDS, showing long-term improvement in physical and mental scores. Søvik et al. [6] showed a reduction in uncontrolled and emotional eating behaviors, as well as an improvement in psychosocial function both after duodenal switch and RYGBP. Despite these results, 20% of patients undergoing bariatric surgery fail to maintain weight loss 2 years after surgery [1]. A significant number of these patients suffer from dysfunctional eating behaviors

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(DEB) leading to a recurrence of obesity after bariatric surgery [7], which makes the prompt identification and treatment of DEB in bariatric patients imperative. This chapter aims to discuss the many psychological and psychiatric variables that may jeopardize BPDDS short-, medium-, and long-term outcomes. It is important to highlight that the literature on psychological and psychiatric aspects specifically related to BPDDS is still scarce; hence, many of the points discussed here stem from studies not necessarily performed with patients undergoing BPDDS.

10.2 Important Psychological Aspects on the Evaluation and Follow-Up of Candidates for Bariatric Surgery

Despite the countless benefits currently documented of bariatric surgery, not only related to significant weight loss and its long-term maintenance, but also regarding measures of quality of life and psychopathology, less is known about the origin of post-surgical undesirable psychological and behavioral outcomes affecting patients' eating behavior [8]. Data on patients undergoing BPDDS are even more scarce. Undesirable psychological and behavioral outcomes possibly reflect psychological and behavioral problems present before surgery, which, if not properly identified and treated, will certainly interfere negatively with BPDDS results. Nevertheless, it is important to remember that obesity is a complex pathological condition in which behavior is only one of the many dimensions to be addressed for obesity's suitable comprehension. Biological factors such as chronic low-grade systemic inflammation triggered by obesity [9], alterations of the intestinal microbiome [10], and brain insulin resistance [11] have been widely described as protagonists in the pathophysiology of obesity, which are known to impact the brain and the minds of patients with obesity. Such impacts are reflected, for instance, in the ability to control food consumption and adhere to physical activity programs [8]. It is possible that these factors have an even broader participation in how they modify the mind of people with obesity, altering their cognition [12], emotions [13], motivation [14], self-regulatory processes [15], and even their ability to identify emotions and other mental states in others [7].

Neuroimaging studies show that bariatric surgery can reverse anomalous recruitment and connectivity patterns in different brain areas related to both the processing of pleasure and reward associated with eating, and brain areas associated with cognitive control [16, 17]. This strongly suggests that bariatric surgery may help normalize several neuropsych pathological processes favoring DEB such as binges, emotional eating (EE), and food addiction (FA). Potential mechanisms for regulating brain activity by bariatric surgery include, in addition to improving inflammation, changes in the expression of dopaminergic receptors in key areas such as the ventral striatum, putamen, caudate, thalamus, and hypothalamus, as well as post-surgical changes in the concentration of peptides such as ghrelin, GLP-1, and peptide YY [18]. Findings like these are, however, still controversial. Therefore, the complexity of the mechanisms through which obesity and bariatric surgery can affect the mind and behavior requires that the mental health professional working with bariatric patients have a broad knowledge about the countless variables at stake, which, when not properly controlled, may threaten the surgical results.

The processing of emotions seems to be affected by obesity, favoring BED, which interferes in the results of BPDDS and all other surgical techniques. Indeed, patients with obesity frequently say that their emotions drive or determine their eating behaviors. These patients usually state that they consume food—usually caloric ones—in order to relieve emotions—typically the unpleasant ones.

Emotions are defined as short-term affective responses triggered by environmental stimuli, situations, or events with reinforcing potential [19]. They have different motivational functions and contribute to the control of basic behavioral systems in animals and humans. Emotions may affect all eating behavior, including motivation to eat, affective responses to food, food choices, chewing, speed of eating, amount of food ingested, and even metabolism and digestion [19]. Thus, emotions and eating behavior are closely linked; however, the nature of this connection is not yet fully understood. Hunger is indeed a potent emotional modulator. In fact, hungry animals and humans tend to be more alert and irritable and diverse stimuli elicit different emotional responses in individuals with and without hunger [20]. Nevertheless, there is an individual variation in how emotions may affect eating behavior. Several experiments have shown that individuals restricting food in order to decrease or maintain weight eat more in response to fear and negative moods than individuals who do not [19]. These studies also show that emotional eaters tend to consume more sweet and fatty foods in response to emotional stress, and compulsive eaters tend to have binges when facing negative emotions [19]. Negative emotions need to be regulated and it is possible that, in at least a percentage of individuals with obesity, they will be anomalously regulated with caloric foods. Emotion regulation (ER) is a multidimensional construct encompassing the ability to respond to personal and social demands with acceptable and flexible behaviors and emotions, as well as the ability to postpone and even suppress spontaneous reactions when this is necessary or convenient. ER is achieved through psychological processes such as monitoring, appreciating, and changing the magnitude of emotional reactions [21].

Many patients compare their relationship with food with that displayed by addicts to psychoactive substances, a similarity with an irresistible intuitive appeal, since individuals who consider themselves addicted on food present behavioral phenomena such as cravings, feelings of loss of control, excessive consumption, tolerance, and even signs of food withdrawal. Indeed, obesity and addictions share neurobiological processes that result in compulsive consumption, which are consequences of problems on the suitable functioning of reward processing circuits, where dopamine plays an essential role.

The particularly reinforcing character of food in obesity characterizes its *addictive dimension* [22]. The neurobiological factors traditionally studied in both conditions include three interconnected brain systems that control eating behavior: the hypothalamus (which responds to internal signals about the energy balance); limbic structures such as the amygdala, the hippocampus, the insula, the orbitofrontal cortex (OFC), and the nucleus accumbens or ventral striatum (which are involved in learning/memory and coding the incentive or salience value of food and other environmental stimuli); and the prefrontal cortex (related to cognitive control and self-regulation) ([23]). Impairments in the ability to exert self-control are critical psychopathological elements in any addictive behavior. Self-control can be defined as the set of efforts that an individual makes to modify thoughts, feelings, and behaviors, in order to reach long-term goals or interests. Such efforts allow the coordination of lower-level automatic or implicit cognitive processes, ensuring that our behavior is in line with our aspirations [24]. Individual differences in the functioning of these three systems explain why some people are more inclined to weight gain and substance use. Such differences may stem from inheritable traits; for instance, people who prefer more concentrated sugar solutions are more likely to have a family history of alcoholism [25]. In this sense, a fundamental neuropsychological variable is impulsivity, which can be defined as a predisposition for rapid and unplanned reactions to internal or external stimuli, without concern for their negative consequences, and which results from impaired unconscious information processing [26]. Impulsivity occurs in conditions where conscious processes of reflection and self-control are impaired, being common in mania, addictions, attention deficit hyperactivity disorder, personality disorders, binge eating disorder, and obesity, among many others [23, 26]. Neurobiological processes leading to obesity and addictions result from the interaction between a tendency to produce responses of greater magnitude to potential rewards of the environment (what is called *reward sensitivity*) and damage to self-control, which explains why more impulsive individuals are also more vulnerable to weight gain when exposed to obesogenic environments [23].

Several authors have studied how psychological variables such as emotional overload, ER, impulsivity, anxiety, depression, temperament, and reward sensitivity may negatively affect bariatric surgery outcomes. For instance, Benzerouk et al. [27] studied candidates for bariatric surgery over 1 year, showing that emotional deficits lie behind binges presented by many individuals of this population, who could benefit from programs composed of ER strategies in order to avoid postoperative less than desired loss of weight. In the same sense, Lavender et al. [28] showed significant correlations between emotional dysregulation, emotion intensity, negative urgency, cognitive control, reward sensitivity, and eating pathology over 7 years in adults submitted to RYGBP and laparoscopic adjustable gastric band. Efferdinger et al. [29], in turn, evaluated ER strategies in patients before and 6 months after RYGBP or Sleeve gastrectomy and, despite not showing a significant relationship between ER strategies before and after surgery, they recorded greater patient satisfaction with their ER strategies 6 months after surgery, as well as that their greater satisfaction was associated with postoperative improvement in psychosocial functioning. Williamson et al. [30] examined the moderating effect of ER on symptoms of attention deficit and hyperactivity disorder (ADHD), impulsivity-hyperactivity, inattention, and reward sensitivity, in a cohort of bariatric patients (90% undergoing Sleeve gastrectomy), showing that worse ER strategies are associated with more modest weight loss. These findings reinforce those of other authors, who have documented impairments in ER strategies perpetuating DEB in patients with other psychiatric conditions, whether they are bariatric [31, 32] or not [33].

Individuals with obesity may display higher scores on instruments measuring alexithymia and greater difficulty in identifying emotions than lean individuals. Alexithymia is a transdiagnostic dimension expressing impairments in the abilities to identify and describe one's own emotions, associated with an externally oriented cognitive style [21]. Individuals with obesity and greater alexithymia tend to regulate unpleasant emotions with food, particularly if they show higher scores on instruments measuring externally oriented thinking [34]. Externally oriented thinking is characterized by a style of perceiving and thinking that is disconnected from one's emotions and, therefore, characterized by a low tendency to reflect on conflicts and unpleasant feelings [35]. Therefore, these patients have a more concrete thinking, as well as a low capacity for introspection and may respond poorly to insight psychotherapies.

Individuals with alexithymia may have deficits in the interpretation of bodily signals from the periphery which, when processed by the cerebral cortex, give rise to conscious feelings or emotions [36]. It is also possible (and quite likely) that the interoceptive deficits seen in alexithymia would be not restricted to those specifically linked to emotions, but also involve non-affective interoceptive deficits, such as difficulties in interpreting signs of hunger, proprioception, tiredness, and temperature. In this sense, Brewer et al. [37] investigated whether alexithymia is specifically associated with affective interoception or with a more generalized interoceptive impairment. The authors evaluated the subjects' ability to discriminate between affective and non-affective interoception, concluding that alexithymia encompasses a more generalized interoceptive impairment, where there is a high degree of perceived similarity between affective and non-affective interoception. In this sense, one could imagine that people with alexithymia would have greater difficulty in differentiating anger or tiredness from hunger, which, in turn, would facilitate the recruitment of DEB as emotional regulators.

In addition to alexithymia, other problems in emotion recognition have been described in individuals with obesity. Deficits in emotion recognition and in recognition of the others' facial affect have been documented in children and adolescents with obesity [38, 39]. Such deficits may reflect primary impairments in the identification of one's own emotions, according to the Simulation Theory of Emotion Recognition [40]. This theory proposes that we use our own mental states to infer those of others. We judge not only how other people feel, but also how they think and what they want, through the interpretation of their actions and their facial expressions, for instance. Emotions, particularly the basic ones (happiness, surprise, fear, disgusted anger, and sadness) present us with characteristic facial expressions [41]. Faces are a salient stimulus for our species, since they inform us about identity, gender, age, emotions, and even complex social attributes of our conspecifics [42]. Brain areas associated with the processing of emotions expressed by other human faces include the insula, the OFC, the amygdala, the superior temporal sulcus, and the superior temporal gyrus [43]. OFC seems to contextualize the emotional information, as well as to modulate the activity of the amygdala, which, in turn, directs the gaze to strategic face areas for the identification of emotions [44]. Insula is known to be involved in the processing of interoceptive information and, through its activity of elaborating interoceptive maps of the individual, it may additionally assist in the elaboration of others' interoceptive maps through the observation of their postures, attitudes, and movements [45], in an interoceptive mirroring mechanism. In this way, the insula could be identified as a brain area also associated with the simulation of the mental states of others and even with mechanisms of empathic simulation, which involve cognitive mirroring.

The difficulty in identifying, naming, and reflecting on their own emotional states present in patients with obesity and alexithymia putatively lie behind problems in regulating these states through strategies such as cognitive reappraisal or expressive suppression. Such problems may lead to ER through food, alcohol, and other substances and behaviors with addictive potential, such as gambling, shopping, social media, and pornography.

The most commonly used psychological interventions designed to address ER and DEB in patients with obesity include acceptance-based therapies, dialectical behavioral therapy (developed to reinforce the ability to deal with stress in order to decrease the frequency of dysfunctional behaviors [46]), and cognitive-behavioral therapy, performed individually or in groups [47]. Although these intervention programs include self-monitoring and other basic aspects of self-regulation, psychotherapeutic or rehabilitation strategies specifically addressed to ER have not been sufficiently studied so far in bariatric populations.

An area of increasing interest for mental health professionals working in multidisciplinary team is the relationship between personality traits and bariatric surgery outcomes [48]. This area reflects the role that individual factors such as temperament play in increasing the chances of DEB. Traits such as low *conscientiousness* (the ability to organize and control [49]), poor *impulse control*, and high *neuroticism* (tendency to experience negative mental states [49]) have been associated with an increased risk for obesity, while the trait *persistence* (ability to pursue a goal despite obstacles and frustrations) has been considered a predictor of good postoperative results [48].

10.3 Important Psychiatric Aspects on the Evaluation and Follow-Up of Candidates for Bariatric Surgery

Individuals with morbid obesity are significantly more likely to have any mood disorder, anxiety, substance use, or personality disorders, as well as higher levels of stress, depression, "food cravings," DEB, low self-esteem, and worse quality of life [50].

DEB seem to be behavioral markers of bariatric surgery undesirable outcomes and, in fact, patients with binges tend to have worse mid- and long-term postsurgical results. Binges are defined as episodes of food intake more intense than is commonly tolerated by most people, associated with a sense of loss of control over the amount of food eaten, and with feelings of guilt or shame [51].

Another major concern for psychiatrists and psychologists evaluating and treating bariatric patients is the popular phenomenon of Transference of Addictions (TA). This term suggests that, being no longer able to binge eat, some bariatric patients would abuse alcohol, other substances, as well as behaviors with addictive potential, such as gambling, shopping, or pornography. However, it has not yet been established whether these cases result from increased substance use or from engaging in addictive behaviors by individuals who had already been experiencing problems like these before surgery, from relapses in individuals with substance and/or behavioral dependence, or whether they represent new cases of problematic use of substances or addictive behaviors [52]. Due to their importance in the evaluation and follow-up of bariatric patients, these topics will be discussed in detail below.

10.4 Impulsivity and Compulsivity

Patients with obesity frequently report compulsive eating behaviors, which need to be properly evaluated and treated, mostly in candidates for bariatric surgery, since the maladaptive eating behaviors included by the patients under the term “compulsive” represent risks of undesirable postsurgical outcomes. “Compulsivity” is a nonspecific term, without a diagnostic meaning, being widely used both by patients and by untrained professionals in the diagnosis of eating disorders.

Patients who identify themselves as compulsive often experience Binge Eating Disorder (BED), Night Eating Syndrome (NES), Emotional Eating (EE), Food Addiction (FA), and/or grazing. All of these conditions somewhat include impulsive and/or compulsive components, similar to that which individuals with substance and behavioral addictions show. Such components comprise increased motivation to consume palatable foods and greater pleasure related to the consumption of such foods, gradual increase in the amount of food necessary to maintain satiety, loss of control over food consumption, greater use of time in obtaining and/or consuming food, stress and dysphoria when they are on diets or unable to eat as they usually do, eating quickly or too much in the absence of hunger, overeating despite its adverse physical and psychological consequences, and feelings of guilt, demoralization, or depression associated with eating [53, 54]. Impulsivity and compulsivity are behavioral phenotypes, or endophenotypes [53]. They are hereditary and variable in the general population [55]. Impulsivity is defined as the predisposition for rapid and unplanned reactions to internal or external stimuli, without concern for its negative consequences, and which results from impaired unconscious information processing [26]. In a more colloquial way, an impulsive person acts without thinking. Impulsive people show flaws in conscious processes of reflection and self-control, as well as a tendency to produce responses of greater magnitude to potential rewards of the environment (reward sensitivity) [23, 26]. Compulsivity, in turn, is defined by impairments in the ability to interrupt an ongoing behavior when it is necessary [53].

Individuals with obesity may "decide" to eat without reflection (due to their impulsivity) and, once they start, they have a hard time stopping eating (due to their compulsivity), even though they acknowledge that they should do it. Impulsivity and compulsivity result from failures of the top-down control exerted by the dorsolateral prefrontal cortex over structures such as the ventral striatum and the dorsal striatum, associated, respectively, with impulsivity and compulsivity. Impulsivity and compulsivity recruit different neuronal circuits: the former, a learning system through reward and motivation located in the ventral striatum; the latter, a more dorsal striatal circuit, related to habit development [53, 56]. In some substance additions and also in obesity, the consumption of a caloric and palatable substance is initially mediated by the ventral striatum and, therefore, started impulsively. The repetitive use of that substance or palatable food—primarily subject to voluntary but impulsive control—causes a migration of neuronal activity from ventral circuits to more dorsal striatal circuits, through neuroadaptation and neuroplasticity processes, what causes loss of control over the consumption [53]. Such cellular modifications may correlate with obesity-induced inflammation. In this sense, young women suffering from obesity may have significantly worse scores on measures of attention and impulsivity when compared to women without obesity, a phenomenon that may be mediated by low-grade systemic inflammation associated with obesity, since younger individuals are not usually exposed to other mechanisms related to cognitive decline in obesity, such as hypertension, metabolic dysfunction, and cardiovascular abnormalities, which are known to alter brain structure. Additionally, cognitive impairments commonly observed in young women with obesity may indicate the beginning of an early and persistent cognitive decline associated with obesity itself.

10.5 Binge Eating Disorder

BED is the most prevalent eating disorder, even though it is underdiagnosed and undertreated [57]. BED is essentially defined by the recurrence of binges, as defined above. Patients with BED do not show binges associated with inappropriate compensatory behaviors as in bulimia (for instance, the use of laxatives and/or diuretics, induction of vomits, or exaggerated physical exercises). BED is common in obesity, although not all patients with obesity suffer from this condition. People with obesity and BED usually have more psychiatric comorbidities and are more refractory to conventional treatments for psychiatric comorbidities [54]. When compared to individuals with obesity without BED, patients with obesity and BED have a greater sense of lack of control, greater reward sensitivity, impulsivity associated with eating stimuli, as well as feelings of guilt and shame associated with intense binges [57].

BED is a relatively common disorder, with a lifetime prevalence in the general population of 1.4%, although its prevalence may increase greatly among individuals with obesity, without noticeable differences between genders [58]. Comorbidities with other psychiatric disorders are common, such as depression, anxiety, substance abuse, and even personality disorders [58, 59]. Between 64% and 79% of BED patients have some psychiatric comorbidity throughout their lives, with mood and anxiety disorders being the most prevalent [59]. Individuals with BED also have disturbing concerns about food, weight, and body image, in addition to deficits in emotion identification and ER, as well as several interpersonal problems [7]. As discussed above, negative emotions and non-adaptive ER strategies play an important role in the initiation and maintenance of BED, particularly negative feelings associated with interpersonal relationships, such as romantic disappointments and loneliness [7, 58]. High levels of depression are related to more severe binges; for instance, binges are usually more often associated with lower mood and lower energy levels. Nonetheless, emotions other than depression and sadness tend to lie behind the compulsivity of patients with BED: anger, frustration, guilt, irritability, fury, resentment, and envy, emotions very present in interpersonal contexts, which would be less tolerated by patients with BED or would be experienced by them in a different, more aversive way.

10.6 Night Eating Syndrome

NES is characterized by recurrent episodes of night eating, which can be defined either by eating after waking up at night or by excessive consumption of food after an evening meal, causing stress or impaired functioning and is not explained by other mental disorders [54]. The condition frequently affects individuals with morbid obesity and may be explained as a circadian rhythm dysfunction where there is a dissociation between sleep and eating [60]. Other symptoms include morning anorexia, a strong need to eat between dinner and bedtime and/or during the night or dawn, as well as the belief that it is not possible to sleep without eating [61].

The prevalence of NES in the general population is usually low (between 0.5 and 1.5%) and tends to increase in individuals with obesity (in this population it may reach up to 25%) [61]. Sixty percent of the candidates for bariatric surgery may display NES, whose symptoms usually overlap with those of other eating disorders. Patients with obesity, NES, and other eating disorders are also at increased risk for mood disorders, anxiety, and sleep disorders [62]. Although individuals with NES appear to have similar patterns of onset, end, and duration of sleep when compared to healthy individuals, they wake up an average of 3.6 times per night and engage in eating behaviors in order to fall asleep again [61].

NES typically begins in early adulthood and is long-lasting, with periods of remission and relapses, frequently associated with stressful life events [62]. Some authors suggest that the motivation to eat differs in individuals with NES when compared to that of those with BED, since night eaters eat in order to being able to sleep [62]. NES must be differentiated from Sleep-Related Eating Disorder, a parasomnia in which there are episodes of involuntary food and drink intake during sleep [62].

10.7 Emotional Eating

The relationship between emotions, ER, and DEB was discussed in detail above. ER impairments are usually associated with various psychiatric conditions, such as depression, bipolar disorder, anxiety disorders, borderline personality disorder, and eating disorders [33]. Further evidence is emerging that not only eating symptoms such as binges but also restrictive behaviors common in anorexia nervosa serve as dysfunctional alternatives to regulate or suppress unpleasant emotions. Women with bulimia nervosa, BED, and anorexia nervosa report greater difficulties in perceiving their emotions, greater tendency to avoid them, as well as poorer ability to manage them, when compared to healthy women [33].

10.8 Food Addiction

FA is a term encompassing a set of behaviors related to the consumption of palatable foods that is very similar to those observed in substance disorders. From a scientific perspective, however, the mere similarity of some eating behaviors with substance use disorders would not allow their labeling as an addiction [63]. Some researchers claim that, despite the similarity that certain eating behaviors have with substance addictions, such as the presence of cravings, loss of control, excessive consumption, tolerance, abstinence, stress, functional impairment, and even the findings of alterations in mesolimbic dopaminergic systems in patients with FA [64, 65], the addictive substance putatively present in palatable foods has not yet been identified [63], which would not authorize the use of the term *food addiction*. To date, it is not possible to ensure that a specific nutrient, be it sugar or a combination of sugar and fat, acts directly on the brain, triggering reward-motivated behaviors [63]. On the other hand, evidence that obesity causes important impacts on the activity of different brain areas [66], including those related to reward processing, as well as the fact that the great majority of individuals fulfilling FA criteria (about 88%) are obese [67], bring even more controversy to the topic. It is still not possible to identify precisely whether the changes observed by neuroimaging studies in the connectivity and activity of brain areas related to reward and cognitive control in FA are in fact due to food or specifically associated with obesity.

Obesity and addictions share neurobiological processes that result in compulsivity, which, in turn, are consequences of impairments of brain reward areas functioning. As discussed above, the particularly reinforcing character of food in obesity characterizes its additive dimension [22]. Impairments in the ability to exert self-control are essential psychopathological elements in any addiction. Self-control allows the coordination of lower-level, more automatic cognitive processes, adapting behavior to objectives [24]. The similarity between addictions and obesity is not exclusively phenomenological and psychobiological, but also involves family history, beginning in adolescence or early adulthood, chronic evolution with relapses, and even the possibility of spontaneous resolution [68].

10.9 Grazing

Grazing, picking, nibbling, and snack eating are synonyms defining the behavior of continuously eating small portions of food [69]. A review of different conceptualizations of grazing [69] concluded that the criteria most frequently endorsed by experts include its repetitive character, the consumption of small amounts of food and the lack of planning. The loss of control was not considered by all authors as a behavioral dimension of grazing, since, for some, loss of control would differentiate BED from grazing. Grazing appears to be more frequent in bariatric patients who had BED preoperatively, and some authors hypothesize that it is a subsyndromal BED.

10.10 Addiction Transfer After Bariatric Surgery

There is a belief that a phenomenon called "addiction transfer" would be propitiated by bariatric surgery, that is, operated patients, no longer able to abuse food, would be prone to start abusing alcohol, other substances, and addictive behaviors, such as gambling, shopping, Internet, or pornography.

However, it is not well established whether these events result from increased substance use or from engaging in behavior with high addictive potential by individuals who already had problems like these before surgery or whether, in fact, they are new cases of problematic use of substances or addictive behaviors [52].

Substance and behavioral addictions are defined by their cardinal components: salience, mood changes, tolerance, abstinence, conflict, and relapse [70]. These components are as important from the diagnostic point of view as quantitative variables such as the amount of alcohol or caloric foods used per day or the time spent on social networks or consuming pornography on the Internet. Salience refers to the importance a substance or addictive behavior has in a patient's life, becoming what is most important to him. Addictive substances or behaviors induce emotional arousal or relieve aversive feelings, demand increasing amounts of a substance (or longer amounts of time involved with addictive behaviors) to achieve the same effect of arousal or relief (tolerance), and may develop withdrawal symptoms if exposure to the drug/behavior decreases (abstinence). Patients with addictions frequently experience situations of personal or interpersonal conflict related to their addiction and usually report relapses after trying to resist it [70]. Risk factors for the development of addictive behaviors include genetic factors (e.g., children of parents with alcoholism are 2 to 4 times more likely to develop alcoholism), lack of parental/family support, and the presence of psychosocial stressors. Personality traits such as nonconformity, novelty seeking, impulsiveness, low self-esteem, aggressiveness, emotional lability, inattention, antisocial behaviors, and stubbornness are common in addictions, however, there is still no consistent evidence that an "addictive personality" actually exists [70]. Therefore, given the nosological and etiological complexity of substance and behavioral addictions, the idea that bariatric surgery "creates" new dependents may seem a little simplistic. The emergence of new cases of chemical dependencies after surgery may be just an illusion of cause and effect. For instance, the percentage of patients who admit to continuing to consume alcohol or having trouble controlling alcohol use after surgery is much higher than that of those who acknowledge having problems dealing with alcohol consumption before surgery [52]. This could reflect either a worsening of alcohol use patterns occurring after surgery (and supposedly being induced by it) or (more likely) simply the fact that patients who have alcohol-related problems omit them in the psychiatric evaluation. Except in patients with chronic and severe alcoholism, in which physical signs of the disease are apparent, the identification of problematic use of alcohol and substances can be a real challenge, since the evaluation of problems related to substance use is influenced by limits imposed by the self-report. However, despite the notion shared by most mental health professionals working with bariatric surgery candidates, that problematic alcohol use is risk factor for undesirable outcomes associated to the procedure, some authors have demonstrated better rates of weight loss among some patients with a past of abuse of substances in relation to those without a previous history of these disorders [52]. It is assumed that these surprising results are explained as a result of using the same skills employed in solving problems with substances to deal with life changes after bariatric surgery. This contradicts the idea of TA, a phenomenon still widely discussed among experts. Many of them do not admit its existence and argue that, for there to be a transference of addiction, it is first necessary to accept that in obesity there is an addition to the food and second that this addition takes on a different form after surgery. Furthermore, the lack of consensus between the meaning of addiction makes the discussion even more confusing. For many, the meaning of addiction is similar to compulsivity, a vague term [71], widely used by laypeople, which include various types of behavior, from drinking to gambling or compulsive buying, while for experts it comprises a medical term regarding substance problems, which must be defined in a standardized way [71], covering the cardinal components discussed above. Biochemical evidence suggesting a "kinship" between food and addictive substances compulsivity involves, for instance, the role of an alleged dopamine deficiency in the brain of people with obesity, perpetuating DEB, which compensates for the decreased activation of dopaminergic circuits

[72]. Many neuroimaging studies show that people with obesity have brain responses to food intake or even visual or auditory food cues that are very different from those presented by thin individuals. These responses involve several regions of the brain, already discussed above.

10.11 Final Considerations

Patients undergoing BPDDS benefit from weight loss and maintenance after surgery. However, they need to be properly evaluated regarding pre- and post-operative presence of DEB, which usually put the medium- and long-term outcomes of the procedure at risk. DEB can result not only from difficulties in emotional processing, particularly in ER processes, but also from personality variables, which can be predictive of both weight gain (low awareness, poor impulse control, and high neuroticism), as well as success after surgery (high persistence).

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Chapter 11
Nutritional, Behavioral, and Support for Duodenal Switch

Lillian Craggs-Dino

11.1 Introduction

The decision to opt for the duodenal switch (DS) as a treatment option for obesity and related comorbidities does not come easy for patients. In some cases, this decision may take months to years to commit to. Prevailing patient concerns include how their diet will change, the requirement of life-long vitamin and mineral supplementation, what nutritional side effects they may experience, and if they have the nutrition knowledge and motivation needed to make behavioral and lifestyle changes necessary to their reach goals. It is paramount to successful patient outcomes to include a registered dietitian as part of the interdisciplinary bariatric team. The indispensable role of the registered dietitian is to optimize the nutritional status of the patient prior to surgery and to continue assessment, education, and support after surgery to facilitate healthful patient goals. Continued rapport and follow up with the bariatric team, including the registered dietitian, reduces the risk of nutritional complications, and in cases where nutritional deficiencies have occurred, the expertise of the dietitian is utilized to mitigate these conditions. Building a strong relationship and rapport through nutrition counseling and goal setting with patients who have undergone the DS plays a pivotal role in reaching and maintaining long-term success.

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11.2 Nutritional Pre-optimization and ERABS

More recent attention focuses on the critical importance of pre-operative nutritional optimization of all bariatric surgery candidates. This aligns with enhanced recovery after bariatric surgery (ERABS). ERABS is an adaption of the enhanced recovery after surgery (ERAS) protocol that was initially written for colorectal surgery [1]. ERABS is a pro-active, multi-modal, interdisciplinary, evidenced-based strategy to improve surgical outcomes by enhancing perioperative physiology [2]. ERABS is shown to decrease the length of hospital stay, decrease complications, enhance the quality of postoperative recovery, reduce recovery time, it is cost effective, and improves quality of care [2]. While ERABS includes medical and surgical pathways, Fig. 11.1 shows notable nutrition-related pathways to include as part of the pre-optimization of patients undergoing the duodenal switch [1, 2].

The two major categories of nutrition-related ERABS are explained further and include:

1. Pre-optimization (a.k.a. pre-habilitation)
2. Pre-operative information and counseling

11.2.1 Pre-optimization (Pre-habilitation)

Goals of pre-operative optimization (pre-habilitation) are to reduce the risks associated with surgery, increase quality of postoperative recovery, reduce length of stay (LOS), decrease unnecessary costs, and ultimately, positively improve postoperative

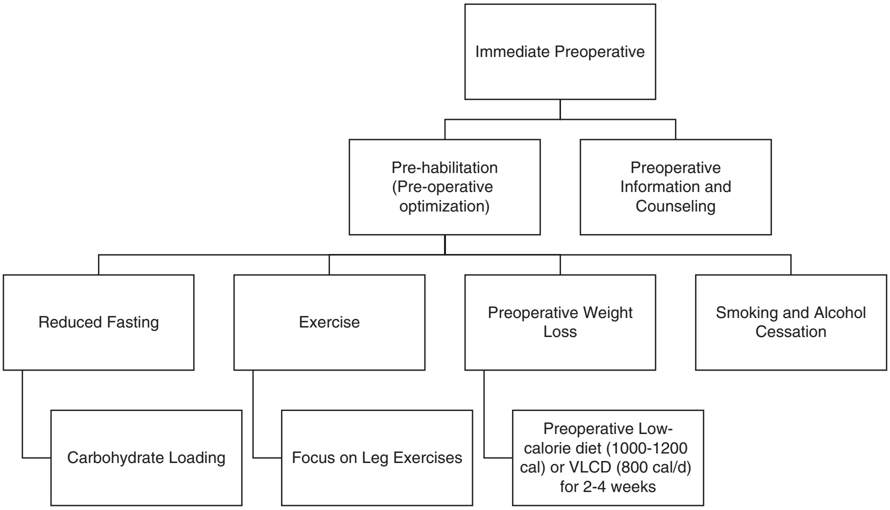

Fig. 11.1 Enhanced recovery after bariatric surgery (ERABS) [1, 2]. Optimizing the nutrition status and knowledge of patients undergoing the DS

patient outcomes [1, 2]. Obesity, as a form of malnutrition, is widely known and researched. Worldwide, micronutrient deficiencies prevalently seen in bariatric surgery candidates include the fat-soluble vitamins A, D, E, and K; water-soluble vitamins B1, B6, B12, C, and folic acid; and minerals iron, copper, zinc, calcium, phosphorus, and selenium [3–8]. Nutritional markers such as levels of hemoglobin, hematocrit, ferritin, albumin, transferrin, parathyroid hormone, and others are also shown to be affected [4–6]. Research shows the presence of micronutrient deficiencies prior to surgery pose a higher risk of having similar deficiencies post-surgery, especially in the more malabsorptive surgical procedures like DS [8, 9] and underscores the importance of pre-optimization through nutrition assessment and nutrition counseling.

Patient optimization for DS surgery covers a wide range of domains, all of which the interdisciplinary bariatric team should address. Figure 11.2 depicts each domain.

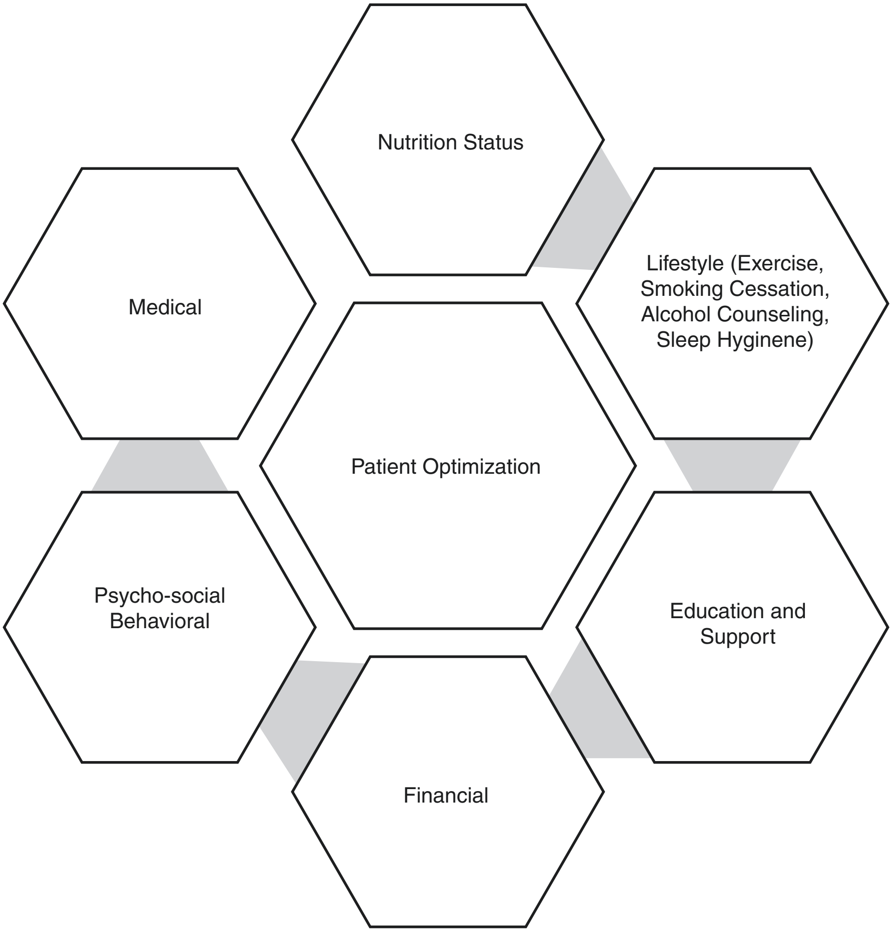

Fig. 11.2 Domains for optimization prior to DS surgery [10, 11]

The medical domain would be matters specific to the patient's medical history or surgical risk that should be optimized [10]. Other domains such as optimizing nutrition status can be adapted specifically for bariatric surgery [11]. Dietitians can positively influence each domain as a critical team member. Pre-optimization of nutrition status would include an in-depth assessment of the patient's nutritional status, including anthropometrics and dietary intake [11]. Factors that influence dietary intake such as food preferences, eating habits and patterns, access to nutritious foods, and food security are all data points of information to collect. Categories specific to nutrition optimization are explained further and depicted in Fig. 11.3. Healthful lifestyle considerations such as smoking cessation, alcohol counseling, proper sleep hygiene, and physical activity also plays an important area to optimize prior to surgery [10, 11].

11.2.2 Optimizing Nutrition Status

Nutrition status is best determined through a comprehensive nutrition assessment that occurs pre-operatively and continues thereafter surgery. Nutrition assessment is defined as a systematic method of collecting and interpreting information that is used to make decisions on nutritional care [12]. The purpose of a nutrition assessment is to guide and apply evidence-based medical nutrition therapy (MNT), nutrition counseling, and nutrition education to optimize the patient's nutrition status and nutrition knowledge prior to and after surgery. Positively influencing dietary choices, eating patterns, and lifestyle choices prior to surgery gives the patient a

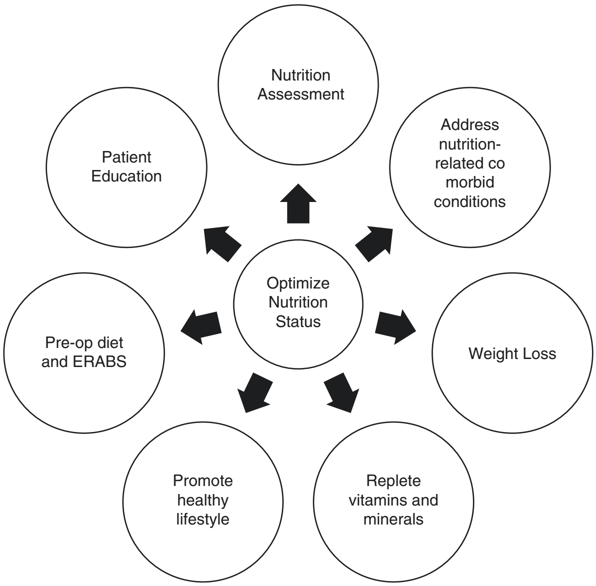

Fig. 11.3 Specific categories for nutrition optimization [10, 11]

head-start to achieve positive outcomes postoperatively, and instills the knowledge needed of how to reconcile the patient's nutritional responsibility with that of having the DS surgery.

The nutrition assessment has five domains with which to collect specific information [13]: Domain 1: Food and Nutrition History; Domain 2: Anthropometrics; Domain 3: Biochemical and Diagnostic Data; Domain 4: Nutrition Focused Physical Assessment (NFPA); Domain 5: Patient History. Figure 11.4 shows examples of what information is collected under each of the five domains applicable for patients having the DS. While all information collected in a nutrition assessment is important, for patients undergoing the DS, it is of significance to assess the patient's support system, especially of close family and friends. Research shows that families that are engaged together have a positive influence on the surgical patient [14].

In addition, the patient's financial concerns and food security should also be addressed prior to surgery. Patients should be educated on potential economic demands that may occur after surgery. For example, one nutrition-related responsibility after the DS requires the intake of life-long vitamin and mineral supplements and most likely some sort of protein supplementation. The patients should be informed of this responsibility. A study by Price et al. [15] showed greater than 17% of bariatric surgery candidates had food insecurity and over 27% were marginal for food security. This information is relevant because postsurgical dietary adherence may be compromised in those patients who do not have the financial means to purchase these products. Suggestions for financial support programs can be researched and offered on an individual basis.

As previously discussed, micronutrient deficiencies are prevalent in bariatric surgery candidates. This becomes relevant for a patient undergoing the DS since vitamin and mineral deficiencies, especially the fat-soluble vitamins, is an inherent

Food Nutrition Hx	Anthropometric	Biochem/Diag	NFPA	Patient Hx
Weight history Types of diets followed in the past Food preferences Food security Eating pattern Eating behaviors Food allergies and intolerances	Height Age Current weight WC* WHR** EOSS*** Body type BMI Body composition Lowest and highest weight	Nutrition related labs Select vitamin and minerals Nutrition related diagnostics	General Vitals Skin Nails Hair Head, Neck, and Face Eyes Oral Cavity Presence of edema Upper and lower extremities	Ethnicity Cultural considerations Socio-economic status Support system Medical history Medications Physical findings Psychosocial Family hisory Exercise patterns Smoking and alcohol use

Fig. 11.4 Five domains of nutrition assessment for DS [13]. *WC = waist circumference; **WHR = waist-hip ratio; ***EOSS = Edmonton Obesity Staging System

concern with the DS and bariatric surgery in general. Therefore, it is paramount that vitamins, minerals, and nutritional markers are screened to correct deficiencies prior to surgery. Suggested nutrition-related parameters, and vitamin and mineral biochemical screening are listed in Table 11.1 as suggested by current clinical practice guidelines [16]. A patient-centered approach to repletion of micronutrient deficiencies prior to surgery should take place to minimize exacerbation of these deficiencies post-surgery. Recommending a daily complete multivitamin/multimineral supplement that contains 100% the daily value (DV) of most micronutrients will help prevent deficiencies. Requiring patients to begin supplementation in the pre-operative period will instill the daily habit and reinforces the behavioral aspect that they will continue after surgery.

11.2.3 Pre-operative Weight Loss and Nutrition Counseling

The American Society for Metabolic and Bariatric Surgery (ASMBS) published a statement that obligatory insurance-mandated weight loss is not supported by evidence and in fact, the requirement is arbitrary, discriminatory, unethical, and may cause unnecessary delay or denial of a life-saving treatment option for the disease of obesity and associated comorbid conditions [17]. ASMBS also supports the understanding that obesity is a chronic disease, and patients may go through periods of weight loss and regain when following conventional diet and lifestyle programs. Patients who meet the body mass index (BMI) requirement at their initial consultation with the bariatric surgeon should be the determining BMI for surgery, despite if patients exhibit short term weight loss prior to surgery that may put the patient below the required BMI of 35 [17].

While successful weight loss should not be a prerequisite for bariatric surgery, the condition of obesity itself poses a risk factor for postoperative complications

Table 11.1 Minimal pertinent nutritional biochemical screening for DS [16]

Micronutrient (Vitamins)	Micronutrient (Minerals)	Nutritional markers
Vitamin A (plasma retinol)	Iron	Complete Blood Cell Count (CBC)
Vitamin D (25 OH-D)	Selenium	Complete Metabolic Panel (CMP)
Vitamin E (plasma alpha tocopherol)	Zinc	Lipid Panel
Vitamin K (PT)	Copper	A1c
Vitamin C (serum)		Ferritin, Total Iron Binding Capacity, % Saturation, Transferrin
Thiamin (whole blood)		MMA[a]
Folic acid (RBC or serum)		Hcy[b]
B12 (serum)		

[a] Methylmalonic acid
[b] Homocysteine

such as increased risk for infection, blood clots, greater intraoperative blood loss, and longer operating time [18]. Dietitians can optimize the health of bariatric surgery candidates with the application of a non-diet approach strategy, whereby the focus is not on the weight or weight loss per se but rather non-weight successes and lifestyle changes.

A non-dieting approach is an alternative paradigm that emphasizes body acceptance at any weight. When optimizing patients prior to DS surgery, applying the health at every size (HAES) philosophy can be useful. HAES deviates from the traditional thoughts about "healthy weight" as defined by anthropometrics measured by the scale, BMI, and body fat percentages [19]. The HAES paradigm embraces body diversity and acceptance with hopes to minimize weight bias and stigma and promotes a holistic view of one's health and ability to be active. This health-focus rather than weight-focus can be promoted as patients move forward with bariatric surgery to help patients take a non-scale approach to their weight loss journey. Patients are taught that bariatric surgery is a "tool" and therefore, reconciling HAES with the DS can promote that health, not weight loss, is the primary goal.

Dietitians and other team members can apply the three concepts of HAES to help guide patients. These include 1: self-acceptance; 2: physical activity; and 3: normalized eating [19]. Self-acceptance instills that beauty and worth exhibits at any size or shape and moves away from the pre-occupation of body image, weight, and "dieting" that often leads to lower self-esteem, depression, and holds the potential for disordered eating patterns [20]. Physical activity encourages movement from pleasure-based activities rather than imposing strict exercise guidelines. It is noted that even ERABS encourages the importance of leg exercises to reduce risk of blood clots [1]. Normalized eating teaches the patient to eat intuitively and mindfully [21].

11.2.4 Liver-Shrinking Diet and ERABS

Dietitians play an essential role to implement and oversee the very low-calorie diet (VLCD), commonly coined the "liver-shrinking diet," surgeons order for the purpose of reducing fatty liver to aid in the technical aspects of surgery. While VLCD is also used in medically supervised weight loss programs for the purpose of weight loss, utilizing them in this case for DS surgery would be to reduce liver size. VLCD has shown to reduce liver size by 23% or more [22].

However, the minimal energy prescription of the VLCD (less than 800 calories per day), poses a hardship for patients and challenges adherence. Patients often experience physical symptoms such as fatigue, headache, hypoglycemia, and malaise. In addition, concerns that the VLCD may lower lean body mass that will ultimately affect functional capacity and cardiovascular health has been raised [23–25]. Concerns have also been presented that the VLCD may affect tissue healing and negatively influence bowel anastomosis by reducing expression of mature collagen necessary for wound healing. However, this has not been confirmed. In a randomized-controlled trial, Chakravartty et al. [22] compared bariatric surgery candidates following a VLCD diet for 4 weeks to a control group who followed a normal diet. Results showed a reduction in liver volume in the intervention group, and a reduction in collagen gene expression. However, there was no evidence that this reduction in collagen expression led to poorer wound healing or infection. In addition, there was no difference seen between the group that followed the VLCD and the control in terms of operating time, blood loss, length of stay, or incidence of complications [22]. Therefore, this gives challenge to the reasoning behind imposing the VLCD on preoperative patients. Dietitians should collaborate with both surgeon and patient to decide if the "VLCD liver-shrinking diet" is necessary for pre-optimization.

In lieu of prescribing a VLCD, a systematic review of the effectiveness of a low-calorie diet (LCD) as a viable option to pre-operative optimization and liver volume reduction is explored [26]. An LCD is defined as a calorie intake between 800 and 1200 calories per day and would be a more realistic energy intake to adhere to. The systematic review showed that an LCD reduced liver volume by 12–27% (mean 16%). The largest decrease in liver volume was seen when the duration of the LCD was 2–4 weeks [26]. Adherence and tolerance to the LCD was also higher. ERABS supports facilitating a low-calorie diet (LCD) or a VLCD prior to surgery. With respect to pre-surgery optimization, surgeons should consider patient perspectives when prescribing either a VLCD or LCD for purposes of reducing liver volume and refer patients to dietitians to help with strategies and suggestions to adhere to the diet. The day before surgery, ERABS has suggested carbohydrate-loading to minimize electrolyte imbalance, hypoglycemia, and dehydration [1].

11.2.5 Pre-operative Information and Counseling

The second category of nutrition-related ERABS is pre-operative information and counseling. This category is especially important because it correlates to positive patient outcomes. Research shows that a predictor of post-surgery weight gain and poor dietary and behavioral lifestyle practices correlates to the absence of dietary guidance and poor nutrition knowledge [27], underscoring again the importance of pre-operative information and counseling. Registered dietitians are adept at providing nutrition education for the purpose of teaching patients how to reconcile the concepts of nutrition and lifestyle changes with their bariatric tool and influencing the patient's knowledge and understanding of their post-op nutritional responsibilities. Pre-operative counseling and education includes instructing patients on the importance of proper eating mechanics, cooking techniques, healthy foods, and supplements. Bariatric nutrition myths are also debunked. The program's nutritional protocol should be reviewed at length and include how the diet will be advanced, potential nutrition complications, and solutions. Patients should be encouraged to attend support group meetings and their post-op follow-ups.

11.3 Potential Nutrition Complications

Potential nutrition complications and risks are well documented after the DS. Vitamin and mineral deficiencies are quite common post DS surgery and throughout years after surgery. Slater et al. [28] showed that fat soluble vitamins A, D, and K show deficiency in 69%, 63%, and 69%, respectively, at 4 years. Studies also show that despite adherence to recommended supplementation, vitamin and mineral deficiencies persist with DS even at 9 years [28], underscoring the utmost importance of long-term follow-up and aggressive dietary monitoring. Absorption of certain water-soluble vitamins are also disrupted by DS surgery. These include vitamins B1 (thiamin), B6, B12, C, and folic acid [29]. In addition, trace minerals iron, zinc, and copper are at risk for deficiency years after DS [29]. An essential component of pre-operative information and counseling the dietitian should impart includes the importance of life-long vitamin and mineral supplementation and the reasons why. It is not enough to just give a list of recommended supplements and dosages. Patients should have a clear understanding of why it is necessary and to prevent devastating deficiency diseases such as Wernicke's encephalopathy (vitamin B1 deficiency), metabolic bone disease (calcium, vitamin D, vitamin K deficiency), microcytic anemia (iron, copper deficiency), megaloblastic anemia (vitamin B12, folic acid deficiency), and neuropathies (B-vitamin deficiencies), just to mention a few.

There are many barriers cited for poor adherence to supplement regimens. These include forgetting to take them, affordability, side effects, difficulty finding recommended supplements, confusion on instructions given by practitioner, and aversion to taste with regards to chewable vitamins [30]. With these cases, mitigating strategies should be discussed with patients. In addition, the review of commercial supplements should be discussed to ensure the product meets the recommendations made by the provider and that the product is not mislabeled or adulterated [16]. Table 11.2 shows suggested vitamin and mineral recommendations according to

Table 11.2 Minimal vitamin and mineral recommendations for DS [16]

Micronutrient	Dosage
Thiamine (B1)	≥12 mg, daily
Cobalamin (B12)	1000 mcg, monthly
Folate	400–800 mcg, daily; 800–1000 mcg, daily if childbearing age
Vitamin D	3000 IU, daily
Vitamin A	10,000 IU, daily
Vitamin E	15 mg, daily
Vitamin K	300 mcg, daily
Calcium	1800–2400 mg, daily
Iron	45–60 mg, daily
Zinc	16–22 mg, daily
Copper	2 mg, daily

current clinical practice guidelines, however, considerations for higher dosages or route of administration (i.e., injection versus oral) should be assessed within the context of a patient-centered approach after a full nutrition assessment is performed.

Common to all bariatric surgeries, patients may experience food intolerances and aversions, inability to meet protein needs, dehydration, nausea, vomiting, bowel changes, and dumping syndrome. More specifically to patients with DS, protein calorie malnutrition (PCM) is a high risk, secondary to increased loss of endogenous nitrogen exacerbated by the dramatically reduced energy and protein intake [31]. Frequent loose bowel movements also contribute to malnutrition. Patients with DS can experience embarrassing odorous gas, halitosis, steatorrhea, and abdominal bloating [32]. While nutrition guidelines suggest protein intake of 1.5–2.0 g/kg body weight and 50 grams of carbohydrate in the early postoperative period [16], more importantly, dietitians provide a patient-centered approach to give strategies and suggestions on how to meet dietary needs and ameliorate symptoms.

11.4 Encouraging Dietary Behavioral Changes

The role of the dietitian on the interdisciplinary bariatric team goes beyond merely giving food and nutrition advice and correcting vitamin and mineral deficiencies. Dietitians provide on-going rapport, support, and guidance necessary to facilitate positive behavioral changes in diet and lifestyle. Research shows patients with bariatric surgery are motivated and appreciative of on-going specialized nutrition care and resources [33]. It is incumbent upon bariatric programs to address and meet the desires and needs of each patient.

While dietitians are not behavior therapists or psychologists, nutrition counseling and education can employ techniques of behavior therapy within the context of facilitating diet and lifestyle changes. Fabricatore [34] describes behavior therapy techniques used to influence elements of lifestyle that require change such as diet and exercise habits. See Fig. 11.5 for strategies used to facilitate lifestyle changes. Each are explained below.

These strategies include:

1. **Self-monitoring:** Self-monitoring is the cornerstone of weight management programs including bariatric surgery because it serves to hold the patient accountable and responsible through the development of self-regulatory skills [35]. For patients with DS, patients should be encouraged and taught how to self-monitor food, fluid, and supplement intake, as well as physical activity, weight, and non-weight successes. With the advent of technology, there are many apps and online programs that can help patients with the ease of self-monitoring. Information gleaned from self-monitoring records will also assist practitioners in making meaningful recommendations to facilitate continued progress toward goals.

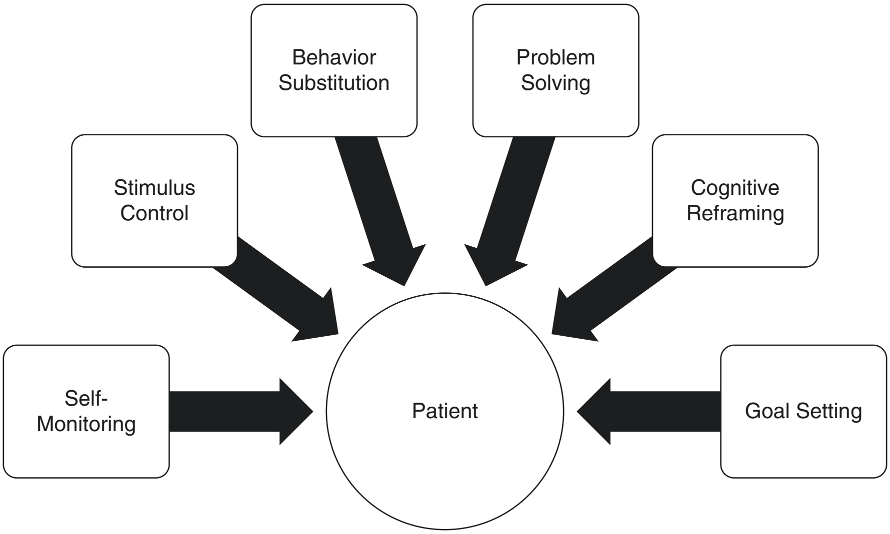

Fig. 11.5 Strategies for facilitating lifestyle change [34]

2. **Stimulus control:** While bariatric surgery changes the patient's physiological cues of hunger, appetite, and cravings [31], patients should be taught strategies to control their external environments, and in doing so, reduce the hedonic food temptation and desires. One suggestion is to discuss together how to eliminate access to noxious foods and snacks. One way would be by not purchasing them and offering healthier alternatives.
3. **Behavior substitutions:** Post-operative weight regain and negative outcomes is often associated with disinhibited eating, or negative eating behaviors [27]. Dietitians can influence behavior substitutions by giving suggestions of non-food activities that can facilitate changes in eating habits. For example, if a patient typically eats in response to stressful emotions, talking with patients to engage in non-food activities such as going for a walk, reading a book, or journaling are all examples of behavior substitutions. Using the technique of motivational interviewing, facilitating dietary and lifestyle change is met when patients are motivated and engaged in active adjustments [36].
4. **Problem solving:** Dietitians can give support and re-education to patients with DS who may be experiencing nutritional challenges. For example, if patients have consistent food intolerance or vomiting, re-educating patients on eating slowly and chewing food properly may mitigate these challenges. Re-education is key to understanding how to problem-solve. Research shows that the time span between when a patient has the pre-operative nutrition education and when they get surgery influences the patient's nutrition knowledge [37]. The longer the time span between the initial education class and surgery, the lower the nutrition knowledge [37]. Therefore, bariatric programs should consider refresher classes and additional individual guidance to lessen this challenge.

5. **Cognitive reframing:** Cognitive reframing assists patients with dispelling distorted, dysfunctional, or negative thoughts. Weight bias and stigma is a pervasive experience of patients who suffer with obesity [38]. There is a significant negative effect of weight-related stigma on dietary adherence after bariatric surgery [38]. Through support and effective communication, the bariatric team can help facilitate changing the patient's beliefs about "successful" weight loss and lifestyle changes to affect continued positive behavioral outcomes.
6. **Goal setting:** Setting realistic goals is a part of any intervention that focuses on lifestyle change. In a pilot study by Jassil et al. [39], the researchers investigated the influence of an 8-week combined supervised exercise with nutritional-behavioral intervention program after bariatric surgery. All patients were taught the principles of SMART (specific, measurable, attainable, realistic, and timely) goal setting and encouraged to use this model in relation to making lifestyle changes. Results showed implementing a structured and supervised nutritional and behavioral program that incorporated goal setting improved functional capacity, and influenced positively both the exercise intensity, food choices, quality of life, and weight loss.

11.5 Conclusion

Patients desiring DS are best served by first optimizing nutrition status and educating and counseling pre-operatively. Pre-optimization of nutrition status begins at the start of the bariatric journey and continues throughout the duration and is best delivered by the dietitian who is the nutrition specialist. The main goal of pre-optimization is to identify and correct any micronutrient and other nutrition-related deficiencies, while also educating the patient as to their dietary and lifestyle responsibilities after surgery. Dietitians, as an integral part of the interdisciplinary bariatric team, are the nutrition experts adept at facilitating dietary and nutrition-related lifestyle change through motivational interviewing, goal setting, on-going rapport, and support.

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Chapter 12
Preoperative Endoscopy

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12.1 Introduction

Bariatric surgery remains the most effective sustained weight loss option for patients with obesity and the number of procedures performed has significantly increased over the years. The main current surgical techniques are sleeve gastrectomy, Roux-en-Y gastric bypass (RYGB), biliopancreatic diversion/duodenal switch, and single anastomosis duodeno-ileostomy with sleeve.

A preoperative evaluation is important for surgical treatment success. A complete evaluation of the cardiovascular, pulmonary, metabolic, and gastrointestinal systems is recommended, as well as follow-up with a nutritionist and psychologist. Abdominal ultrasound exam can be used to assess for biliary tract pathology, liver steatosis, fibrosis, and presence of nonalcoholic steatohepatitis [1].

The role of routine preoperative esophagogastroduodenoscopy (EGD) before primary weight loss surgery remains controversial [2].

Many bariatric surgery centers routinely perform EGD prior to bariatric surgery to potentially identify and treat lesions that may affect the surgery or even cancel the procedure entirely, mainly for the following reasons:

- The symptomatic evaluation has limited value for the diagnosis of gastroesophageal reflux disease (GERD) [3].
- Obesity represents a risk factor for several GI diseases that can be detected by EGD [4].

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- The presence of severe esophagitis or Barrett's esophagus should be considered a contraindication for sleeve gastrectomy due the high risk of postoperative GERD [5–7].
- The EGD should rule out malignancy of the stomach before gastric bypass, as the remnant stomach will no longer be accessible to endoscopic surveillance [8, 9].

12.2 Role of Esophagogastroduodenoscopy Prior to Bariatric and Metabolic Surgery Procedures

While some surgeons perform routine preoperative endoscopy, others recommend it when the stomach or duodenum will be excluded, such as after RYGB or duodenal switch/biliopancreatic diversion, or in the presence of clinical symptoms [10, 11]. The preoperative EGD can identify patients with asymptomatic anatomic findings that may result in an alteration of the surgical approach or delay in surgery [12, 13].

The European Association for Endoscopic Surgery recommends that all patients should undergo EGD before bariatric surgery and especially before RYGB [14]. The Society of American Gastrointestinal and Endoscopic Surgeons recommends that EGD may be used if suspicion of gastric pathology exists [15]. The American Society of Metabolic and Bariatric Surgery (ASMBS) recommends that all clinically significant gastrointestinal symptoms should be evaluated prior to bariatric surgery with imaging studies, upper gastrointestinal series, or EGD [16]. The American Society for Gastrointestinal Endoscopy (ASGE) suggests that the decision to perform preoperative endoscopy should be individualized in patients scheduled to bariatric surgery after a thorough discussion with the surgeon, taking into consideration the type of bariatric procedure performed [17].

12.2.1 Abnormal Findings

The main abnormal findings that cause delay or cancellation of surgical treatment for obesity are arteriovenous malformation, Barrett's esophagus, bezoar, cancer, duodenal diverticulum, duodenal ulcer, duodenitis (severe), esophageal diverticulum, esophageal dysmotility, esophageal stricture, esophageal varices, esophagitis (Los Angeles Grade C/D), gastric polyps, gastric varices, gastritis (severe), hiatal hernia (HH) >2 cm, mass lesion, ulcer, and submucosal lesion [18].

In 2020, Chang et al. [19] published a retrospective study of 613 patients with the aim of determining the frequency of abnormal findings in routine preoperative endoscopy before bariatric surgery. Most patients had pre-endoscopy clinical symptoms (61.3%). The most frequent abnormal findings included esophagitis (26.5%), hiatal hernia (27.1%), gastric ulcer (4.9%), and biopsy-proven Barrett's esophagus (4.6%). The patients with preoperative symptoms were more likely to have abnormal findings on endoscopy. Of the total cohort, 18.4% had changed their planned operation after endoscopy results (Table 12.1).

Wiltberger et al. [20] showed alterations in 76% of preoperative EGDs. The main findings were gastric or duodenal ulcers (53%)—mostly superficial and all deep ulcers were related to *H. pylori* infection; erosive esophagitis (23%)—mostly Los Angeles grade A; hiatal hernia (21%) usually small in size; gastric polyps (8%); and gastric adenocarcinoma (1%).

In a systematic review and meta-analysis, Bennett et al. [21] showed the abnormal findings in routine preoperative endoscopy before bariatric surgery. The main endoscopic alterations were gastritis (37.6%), hiatal hernia (21.1%), and esophagitis (14.4%). *H. pylori* was present in 36.2% (biopsied if suspicious) and 20.2% (routine biopsies) of cases. The proportion of EGDs resulting in a change of surgical approach was 7.8%. Changes in medical management were seen in 27.5%, but after eliminating *H. pylori* eradication, this was found to be only 2.5% (Table 12.2).

Table 12.1 Pathologic findings in asymptomatic and symptomatic patients in the entire study cohort performed by Chang et al. [19]

	Asymptomatic	%	Symptomatic	%	Total	%	*P* value
Number of patients	387	61.3	244	38.7	631		
Esophagitis	91	23.5	76	31.1	167	26.5	0.034
Hiatal hernia	89	23.0	82	33.6	171	27.1	0.0035
Gastric ulcer	22	5.7	9	3.7	31	4.9	NS
Duodenal ulcer	1	0.3	1	0.4	2	0.3	NS
Barrett's	16	4.1	13	5.3	29	4.6	NS
Duodenal mass	3	0.8	1	0.4	0.4	0.6	NS
Helicobacter pylori	33	8.5	21	8.6	54	8.6	NS
Total number of abnormal findings	255	65.9	203	83.2	458	72.6	<0.00001

Table 12.2 Abnormal findings in routine preoperative endoscopy before bariatric surgery in the meta-analysis performed by Bennett et al. [21]

Pathology	%	Number of studies reporting	Number of patients (total)
Gastritis	37.6	31	7.598
Hiatal hernia	21.1	39	9.723
Esophagitis	14.4	37	9.129
Bulbitis/duodenitis	5.2	20	5.974
Gastric ulcer	3.6	25	6.356
Barrett's esophagus	2.1	19	5.802
Gastric intestinal metaplasia	2.2	5	1.126
Duodenal ulcer	1.8	16	3.547
Gastric cancer	0.4	12	3.586
Esophageal cancer	0.2	5	1.278
HP (biopsied if suspicious)	36.2	8	1.652
HP (routine biopsies)	20.2	23	5.650

Table 12.3 Abnormal findings in routine preoperative endoscopy before bariatric surgery in the meta-analysis performed by Parkish et al. [18]

EGD findings	Number of patients ($N = 4511$)	%
Gastritis	1562	34.6
Hiatal hernia	889	19.7
Helicobacter pylori	888	19.7
Esophagitis (all grades)	786	17
Duodenitis	226	5
Gastric ulcer	97	2
Duodenal ulcer	14	0.3
Barrett's esophagus	45	0.1
Carcinoma	4	0.08

In a systematic review and meta-analysis performed by Parikh et al. [18], the patients were grouped based on EGD findings: Group 1—findings that did not significantly change management; Group 2—findings that delayed, altered, or canceled surgery. Overall, 92.4% (n = 6.112) of the patients had a normal EGD or findings that did not change clinical management (group 1) and 7.6% (n = 504) had findings that delayed or altered surgery (group 2) (Table 12.3).

A position statement by IFSO showed that abnormal EGD findings are likely to be found in at least 55.5% of patients prior to bariatric surgery. The most common abnormal findings were gastritis, hiatal hernia, and esophagitis. Conditions that would lead to modification or delay of surgery were less commonly found, with 16.5% findings that led to modification or delay of the planned procedure and 0.2% that had surgery cancelled [22].

12.2.2 Testing and Treatment of H. pylori

There are conflicting data for preoperative testing and treatment of *H. pylori* related to surgical outcomes.

Marginal ulceration after RYGB is diagnosed in 1% to 16% of patients and preoperative *H. pylori* infection is twice as common among the patients who had marginal ulceration (32%) as among those who had not (12%) ($p = 0.02$) [23]. Patients tested for *H. pylori* have a lower incidence of postoperative marginal ulcers (n = 5, 2.4%) than patients who do not undergo this screening (n = 354, 6.8%, $P < 0.05$) [24].

The incidence of postoperative perforation is higher in patients who do not undergo screening/treatment for *H. pylori* (5% vs. 0%; $P = 0.09$) [25]. Although most studies show the benefit of *H. pylori* screening and treatment in patients who will undergo RYGB, Papasavas et al. [26] did not show an association between *H. pylori* infection and marginal or gastric ulcers. The evidence is unclear regarding the benefit of *H. pylori* eradication prior to sleeve gastrectomy [27].

ASGE suggests that testing and eradication of *H. pylori* before bariatric surgery should be individualized [17] and the European Association for Endoscopic Surgery (EAES) concluded that no recommendation can be made for an ordinary routine *H. pylori* eradication or no eradication prior to bariatric surgery on the basis of available evidence [28].

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Chapter 13
Postoperative Care

Léonie Bouvet

13.1 Introduction

The experience of our group with biliopancreatic diversion with duodenal switch (BPD-DS) goes back to the early 1990s [1]. Years of experience with the care of patients undergoing malabsorptive surgery has led to the development of multiple time-tested postoperative protocols.

Even in experienced hands, laparoscopic BPD-DS has a slightly higher rate of perioperative complications when compared to sleeve gastrectomy or gastric bypass [2]. This difference is partly explained by the complexity of the technic and proportionally longer operative time. It also relates to the fact that such procedures are usually offered to patients with higher BMIs (>50 kg/m^2) and more severe comorbidities. On the other hand, standardized postoperative pathways contribute to decrease the complication rate and allow for early recognition of complications.

Implementation of postoperative enhanced recovery protocols that take into consideration the particularities of BPD-DS is a central component of safe perioperative care. This chapter will review the different aspects of postoperative management following laparoscopic BPD-DS.

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13.2 Multidisciplinary Team

As for many aspects of the bariatric surgery process, postoperative management of patients undergoing BPD-DS is facilitated by the involvement of an experienced multidisciplinary team. It includes bariatric surgeons and dedicated nurses, dieticians, and pharmacists. Internal medicine specialists are also routinely implicated in the perioperative care, especially for diabetic patients.

13.3 Postoperative Unit

After undergoing laparoscopic BPD-DS, most patients can safely be discharged from the postanesthesia care unit to the regular floor on a dedicated bariatric floor. Patients with sleep apnea that are adequately treated with noninvasive positive pressure ventilation make no exception [3]. Use of intensive care units is exceptional and limited to particular intraoperative events, or to patients with severe cardiopulmonary comorbidities.

13.4 Analgesia

Multimodal analgesia is a cornerstone in pain control after BPD-DS. In addition to intraoperative strategies, it contributes to reducing opioid use and their side effects. Postoperative analgesic medication protocols include regular doses of nonsteroidal anti-inflammatory drugs (NSAIDs) and acetaminophen. Every patient is also prescribed a proton pump inhibitor (PPI) for gastric protection and control of early gastroesophageal reflux symptoms.

13.5 Diet

On the day of surgery, patients are given intravenous fluids and sips of water are permitted 2 h after extubation. Nausea is frequent after surgery, and liberal use of intravenous antiemetic medication is routine, particularly for patients undergoing one stage BPD-DS due to the sleeve component. Clear liquids diet is initiated on postoperative day 1 and advanced to full liquids diet the next day. All patients are evaluated and counseled by a clinical dietician during their hospital stay. The importance of high levels of protein intakes is reinforced and patients are counselled on different protein supplements that can be safely added to their diet even at an early stage. The different steps of postoperative diet progression are summarized in Table 13.1. Patients are also given elaborated documentation with examples of

Table 13.1 Postoperative diet progression

	Type of diet	Duration
Step 1	Clear liquids	POD 1
Step 2	Full liquids	1 week
Step 3	Pureed	1 week
Step 4	Minced	2 weeks
Step 5	Tender	1 week
Step 6	Regular	Remaining

appropriate meals for every step. The same dietary progression is used either for the first stage or second stage BPD-DS. Unsurprisingly, diet progression is easier for second stage BPD-DS patients [4] but the recent duodenoileal anastomosis warrants the same careful progression of texture. Food intolerance is rare, but failure to progress to the next step should lead to reevaluation by the dietician or the bariatric surgeon to avoid early protein malnutrition.

13.6 Thromboprophylaxis

Deep venous thrombosis (DVT) and pulmonary embolism (PE) are the leading causes of major morbidity and mortality after bariatric surgery. In a study reporting 1000 consecutive cases of BPD-DS, incidence rate of PE was 0.4% following laparoscopic procedures and caused the only perioperative mortality (0.1%) [5]. After bariatric surgery, the majority of venous thromboembolism (VTE) events occur after the patients are discharged home, with an average time of diagnosis of 11.6 days [6]. Thromboprophylaxis is therefore mandatory in the early perioperative period and extended postdischarge therapy for high-risk patients have been recommended [7].

Sequential compression devices are initiated intraoperatively and kept until the patients resume adequate ambulation, usually on postoperative day 1. Early ambulation is routine and starts with the help of caregivers on the day of surgery. By postoperative day 1, patients are expected to ambulate in the hallway by themselves.

One dose of unfractionated subcutaneous heparin is given on the first evening after surgery and low-molecular-weight heparin is started on postoperative day 1. Doses are adjusted for patient's BMIs with the majority of patients receiving Dalteparin 7500 IU daily [8]. For patients who weigh greater than 180 kg, or with previous history of DVT or PE, doses are increased to 10,000 IU daily. Dalteparin is preferred to other low-molecular-weight heparins because daily injections are sufficient for most high BMI patients.

Given that the great majority of BPD-DS patients will be considered high-risk for VTE on risk calculator scales, all patients at our institution are prescribed low-molecular-weight heparin upon discharge for a total of 20 days. This regimen has not led to an increase in postoperative bleeding events.

13.7 Investigations

Accordingly with enhanced recovery protocol principles, any routine use of surgical drains, urinary catheter, and nasogastric tube are avoided. Current literature states that it does not prevent perioperative complication and can delay recovery [9–11]. Frequent vital signs and urinary output are recorded. Usual blood work on postoperative day 1 and 2 includes complete blood count, creatinine, and ions. Interestingly, postoperative bleeding rarely occurs following either one-stage or two-stages BPD-DS compared to sleeve gastrectomy alone. This is likely because delayed bleeding complications are associated more with the sleeve component. As the sleeve is performed at the beginning of the operation in BPD-DS, it allows for a second look of the hemostasis at the end of the procedure.

No routine leak test is done, as they do not prevent complications, can be falsely reassuring, and can cause delays in diet initiation [12]. Every patient is assessed at least once daily by an experienced bariatric surgeon. Any unexplained tachycardia or pulmonary distress should raise suspicion for anastomotic or gastric leaks. CT-scan with intravenous and oral contrast is the examination of choice to identify a leak for stable patients. Nonetheless, even with a reassuring CT scan, diagnostic laparoscopy should be performed in worsening patients.

13.8 Adjustments of Comorbidity Treatments

The improvement of obesity-related diseases after BPD-DS outstands the results of any other bariatric surgery. A meta-analysis by Buchwald et al. reported resolution of hypertension in 81%, improvement of dyslipidemia in 99%, and improvement or remission of type 2 diabetes mellitus (T2DM) in 98% [13]. Second stage BPD-DS results are similar to one-stage in regards to correction of obesity-related comorbidities.

13.9 Antihypertensive Medication

The principal mechanisms through which obesity-related hypertension occurs is excess plasma volume expansion and increased cardiac output with a concomitant decrease in natriuresis due to excess body mass. Accordingly, mechanisms through which weight loss helps resolve hypertension are well described [14]. Nonetheless, more recent data suggests that immediate postsurgical changes in gut hormones are likely to contribute to hypertension control. This is also supported by the increased remission rate of hypertension following metabolic surgeries when compared to purely restrictive procedures. Independently of weight loss, glucagon-like peptide 1 (GLP-1), ghrelin, leptin, and peptide YY (PYY) alterations seem to influence hypertension remission following BPD-DS.

These more recent findings further support holding or reducing anti-hypertensive therapy, starting in the immediate postoperative period. Cessation of diuretics, angiotensin-converting-enzyme inhibitors (ACE inhibitors), and angiotensin receptor blockers (ARBs) is done preferentially to avoid the risk of acute renal failure secondary to decreased fluid intake following surgery. In patients with persistent hypertension upon discharge, calcium channel blockers (CCBs) are either continued or added to reach good tension control. Known cardiac diseases also warrant the represcription of cardioprotective molecules like beta-blockers.

13.10 Dyslipidemia Medication

BPD-DS has a sustainable effect on the metabolic syndrome, including dyslipidemia. Marceau et al. reported a decreased total cholesterol, low-density lipoprotein cholesterol (LDL), and triglycerides, with high-density lipoprotein cholesterol (HDL) remaining stable after a mean follow-up of 7.9 ± 4.6 years [15]. This supports cessation of dyslipidemia medication after BPD-DS with the exception of patients in which statins are also indicated for further treatment of known atherosclerosis disease.

13.11 Diabetic Medication

Malabsorptive bariatric procedures improve T2DM using multiple pathways, most of them preceding significant weight loss [16–18]. These metabolic influences are initiated immediately after surgery by caloric restriction, increased GLP-1 levels, decreased nutrient absorption, changes in bile acid, incretin effect, and modification of intestinal microbiome [19]. A recent study evaluating the early perioperative mechanisms of glycemic control after BPD-DS confirmed that caloric restriction increases insulin sensitivity and secretion [20]. Therefore, rapid resolution of hyperglycemic state is observed in the immediate postoperative period supporting the dramatic reduction or cessation of diabetic medications. To avoid postoperative hypoglycemia, insulin secretagogues, sodium-glucose cotransporter-2 inhibitors, and thiazolidinediones are discontinued. Similarly, insulin doses should be significantly reduced. To reach tight glycemic control, frequent glycemic measurements and use of subcutaneous rapid-acting insulin adjustment protocols are routine after BPD-DS. Changes in diabetes treatment at the time of discharge are made proportionally to the severity of T2DM. For example, patients with severe T2DM will usually resume taking metformin or incretin-based therapies once they are tolerating liquid diet. Control of hyperglycemia in the early postoperative stage will sometimes necessitate reintroduction of basal long-acting insulin, at reduced doses. Thus, diabetologists are implicated in the postoperative care of any patient with a more complex treatment regimen. In a study addressing long-term results for insulin-treated T2DM after BPD-DS, 97% of patients were off insulin and 68% were in complete remission. Mean time to reach remission was 40.4 months [21]. Therefore, frequent follow-up for diabetes treatment downstaging are warranted in the weeks, months, and even years after BPD-DS.

13.12 Contraceptive Counselling

After BPD-DS, pregnancy should be postponed for at least 2 years. Weight should be stabilized and nutritional parameters proven normal on routine post-bariatric blood works. Pregnancy occurring within 2 years of surgery are at increased risk of gestational complications.

For female patients, fertility is increased following bariatric surgery. Furthermore, oral contraceptives are no longer reliable after BPD-DS due to malabsorption. To avoid incidental early pregnancy after surgery, discharge counselling should include recommendations for effective contraception for all female patients. Intrauterine devices are the preferred contraception methods after BPD-DS. They can be inserted before surgery without increased risk of VTE.

13.13 Vitamins

Upon discharge, patients are given a prescription for daily vitamins and mineral supplementations. They are advised to introduce these supplements 1 month after surgery, allowing patients a period of adaptation to their reduced gastric volume. Importance of lifelong supplementation is again reinforced. Usual initial prescription doses are summarized in Table 13.2. Vitamin B12 dosage tends to increase on long-term follow-up after BPD-DS even with low dose supplements of 20–40 mcg included within the multivitamin complex. Therefore, vitamin B12–specific supplements are not included in our initial postoperative prescriptions as they rarely need to be added on subsequent follow-up in our experience. Blood works are planned every 4 months in the first postoperative year. Vitamin supplements will be adjusted in time following these routine blood works.

Table 13.2 Initial daily doses of vitamins and minerals supplementations

Multivitamin and mineral complex	2 tablets
Calcium carbonate	1000 mg
Ferrous sulfate	300 mg
Vitamin D3	20,000 IU
Vitamin A	30,000 IU

13.14 Length of Stay

Length of stay after one-stage BPD-DS is slightly longer than for other bariatric procedures. Upon discharge, patients' pain should be adequately controlled by oral analgesia, patients should be able to tolerate their liquid diet, and they should be ambulating by themselves. These criteria can be reached by the majority of patients by postoperative day 2, and even by postoperative day 1 for most second-stage BPD-DS patients.

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Chapter 14
Preoperative Testing and Counseling

Virginia Tan and Abraham Fridman

14.1 Introduction

Bariatric surgery is an effective modality used today to help maintain weight loss and decrease obesity-associated comorbid conditions such as diabetes, heart disease, hypertension, sleep apnea, and different orthopedic disabilities. Common bariatric surgeries done today are sleeve gastrectomy, Roux-en-Y gastric bypass, and the biliopancreatic diversion with duodenal switch (BPD/DS). The biliopancreatic diversion was first described by Scorpinaro in 1979 and still remains one of the most effective procedures for treatment of morbidly obsess patients, especially those who have a body mass index of over 50 kg/m^2. Modifications by Hess and Marceau, sleeve gastrectomy and duodenal switch (BPD/DS), have significantly diminished the more severe complications of BPD such as dumping syndrome, hypoproteinemia, and hypocalcemia [1]. A thorough preoperative work-up is recommended in all patients undergoing this procedure in order to help ensure long-term success. This chapter will describe the preoperative workup needed in patients who will undergo the duodenal switch procedure with biliopancreatic diversion (BPD/DS). (Table 14.1).

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Table 14.1 Preoperative comprehensive work-up

Preoperative comprehensive work-up	
History	Medications Medical and surgical history Weight loss history Smoking history VTE history
Physical exam	Medical Surgical
Psychosocial evaluation	Psychopathology Eating disorders/habits
Laboratory	CBC Chemistry Coagulation profile Renal function Urine analysis Liver function tests Lipid panel Fasting blood glucose Vitamins (B1, B12, D, folic acid, iron, fat soluble vitamins) Zinc and copper
GI evaluation	esophagogastroduodenoscopy (EGD) upper gastrointestinal (UGI) *H. pylori* screening Abdominal ultrasound
Medical subspecialty evaluation	Pulmonary Cardiology Endocrinology
Informed consent	Education Communication Expectations

14.2 History

All patients considering a BPD/DS should undergo preoperative evaluation for different causes of obesity and obesity-associated comorbid conditions. Preoperative evaluation should include a comprehensive medical history, a psychosocial history, and a physical examination.

A complete preoperative history and physical should be obtained on every patient during evaluation for bariatric surgery. Comorbid conditions should be identified at this time; some examples would include diabetes, cardiac disease, gastroesophageal reflux disease (GERD), obstructive sleep apnea (OSA), and hypertension. In addition, weight loss history, commitment to bariatric procedure, and other potential risk factors should be obtained at this time. A physical exam should be performed with focus on any potential medical/surgical contraindications to the planned procedure. A complete medical history and medication list should be elicited and reviewed. Immobility can significantly increase the risk of morbidity and mortality; therefore, patients should be evaluated for any mobility limitations [2].

Patients who are active smokers should be advised to quit at least 6 weeks prior to a BPD/DS procedure [3]. There is not sufficient data to support the exact timeline of smoking cessation prior to surgery. However, smoking cessation should be encouraged in all patients, as studies have shown that smoking is a modifiable risk factor for significant increases in the incidence of postoperative morbidity in bariatric surgery. Smoking cessation could minimize the risk of adverse outcomes in patients [4]. Tobacco cessation should also be encouraged post operatively due to increased risk of poor wound healing and ulcer formation.

Patients interested in bariatric surgery should be consulted to avoid pregnancy preoperatively and for 12–18 months postoperatively. Patients who do become pregnant following bariatric surgery should have routine nutritional surveillance and laboratory screening for deficiencies every trimester, including iron, folate and B12, calcium, and other fat-soluble vitamins. Estrogen therapy should be discontinued before bariatric surgery to reduce the risk of postoperative thromboembolic events (1 cycle of oral contraceptives in premenopausal women and 3 weeks of hormone replacement therapy in postmenopausal women) [5].

14.3 Laboratory Testing

All patients undergoing a BPD/DS should undergo routine laboratory screening. This would include a complete blood count, chemistry, coagulation profile, kidney function, urine analysis, liver function tests, lipid panel, and fasting blood glucose.

Lipid profile and preoperative triglyceride levels correlate with nonalcoholic steatohepatitis and high-density lipoprotein levels negatively correlate with nonalcoholic fatty liver disease. All of this supports the utility of preoperative lipid panels.

Because BPD/DS is a malabsorptive procedure, it will require a more extensive nutritional evaluation, including micronutrient measurements prior to any bariatric surgery procedures [6]. In addition, micronutrient deficiencies persist or could worsen postoperatively, therefore routine nutritional screening, recommendation for appropriate supplements, and monitoring adherence are important [7]. Preoperative nutrition panel for a BPD/DS would include thiamine, vitamin B12, folic acid, iron, vitamin D and calcium, fat soluble vitamins, zinc, and copper [8].

14.4 Psychosocial Evaluation

Psychosocial factors can affect the outcome of bariatric surgeries. Therefore, a thorough psychological evaluation is required before a patient is approved for surgery, usually by a bariatric behavioral health clinician with specialized knowledge and experience with the bariatric surgery population. The role of the psychosocial evaluation is to identify factors that can pose challenges, that can hinder optimal surgical outcomes, and recommendations to the patient and the care team on how to properly address these issues [9]. Because of the importance of the preoperative psychosocial evaluation, most bariatric practices universally include a clinical interview as part of the preoperative workup [10].

A comprehensive history of the patient's weight trajectory over time, including past weight loss attempts, is an important part of the evaluation. This is important because it can reveal important contributors that have affected the patient's weight. In addition, it is important at this time to carefully assess past and current eating disorder symptoms. Disorders such as binge eating disorder, night eating disorder, bulimia, and anorexia nervosa should be all screened for. Eating habits should also be elicited in order to ensure optimal surgery outcomes. This would include eating habits such as "grazing" or "emotional eating." [11].

Patients with severe obesity also tend to exhibit more psychopathology than healthy weight individuals or those with less-severe obesity [12]. Patients who seek bariatric surgery can also have more psychopathology than individuals with obesity in the community [13]. Therefore, screening patients for disorders such as depression, bipolar disorder, anxiety, and schizophrenia should all be identified preoperatively and treated prior to receiving surgery. Patients should be well informed, motivated, and willing to engage in the necessary postoperative dietary and behavioral changes needed for bariatric surgery.

14.5 GI Evaluation

The role of a routine upper gastrointestinal (GI) endoscopy before a bariatric surgery is a controversial topic. While the European Association for Endoscopic Surgery recommends it in all patients, Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) recommends endoscopies only in patients where gastric pathology is suspected [14]. A systematic review by Bennett et al. showed that endoscopic findings resulted in a change in surgical management in 0.4–7.8% of patients, depending on the interpretation and application of the surgeon. Therefore, they concluded that it would be reasonable to not have a routine preoperative endoscopy in the absence of suspicion for gastric pathology [15].

In operations that exclude anatomy, like the BPD/DS, a preoperative endoscopy can be performed because many abnormal endoscopic findings are asymptomatic. In this case, an endoscopy would be preferred as it can visualize and biopsy lesions if needed [16].

Evaluation can also include *H. pylori* testing as a possible contributor to persistent gastrointestinal symptoms after bariatric surgery [5]. *H. pylori* prevalence can vary from 8.7 to 85.5% in different populations [17, 18]. Evidence overall does not support routine screening, but in high prevalence areas routine screening is recommended.

14.6 VTE/Deep Venou Thrombosis (DVT)

History of venous thromboembolic events (VTE) or pulmonary embolism (PE) should be obtained in all patients. The overall risk of VTE after surgery was 0.42% via the BOLD Database. Most VTE events occurred after discharge (73%). VTE was more frequent when the procedure was performed open as opposed to a laparoscopic approach [19]. An extended course of thromboprophylaxis after bariatric surgery is a safe and effective strategy for VTE prevention [20]. A longer duration of chemoprophylaxis is recommended for patients who are at a higher risk of postoperative VTE. Inferior venous cava (IVC) filter placement before surgery is not shown to prevent pulmonary embolisms and might lead to increased complications [21].

14.7 Cholelithiasis/Abdominal US

Surgically induced weight loss is associated with an increased risk, up to 32–42%, for developing cholelithiasis [22]. Routine administration of ursodeoxycholic acid, simultaneous cholecystectomy during a bariatric procedure, and performance of a cholecystectomy following a bariatric surgery are the mainstays of treatment for these patients [23]. The risk factors for gallstone formation in the postoperative bariatric surgery patient include diminished bile acid and phospholipid secretion, high biliary cholesterol secretion, and gallbladder stasis [24].

Timing of cholecystectomy and bariatric surgery is complicated. Bariatric surgery increased risk for gallbladder pathologies due to massive weight reduction, which is associated with altered gastrointestinal anatomy, which can make the cholecystectomy more challenging. However, simultaneous cholecystectomy and BPD/DS is associated with increased morbidity in patients with obesity [24].

Warschkow et al. published a meta-analysis that showed concomitant cholecystectomy during bariatric surgery would not be recommended. This is based on the fact that the rate of subsequent cholecystectomy after laparoscopic roux-n-y gastric bypass (LRYGB) is low (6.8%) and that the main cause for subsequent cholecystectomy was uncomplicated biliary disease. They also found that around 95% of the subsequent cholecystectomies were performed and had little complications (0.1%) [25]. A case can be made that since the access to the biliary tree after a BPD/DS is more difficult, a preoperative or concomitant cholecystectomy should be performed to minimize the risk for a more complicated procedure in the future.

Nevertheless, patients who are symptomatic and have signs that indicate gallbladder pathology should undergo a transabdominal ultrasound. Ultrasound is still the conventionally utilized technique in order to assess gallstone formation though US might have limited sensitivity in the obese patient [26]. Though there is controversy surrounding preoperative gallbladder evaluation prior to bariatric surgery, data supports evaluation in symptomatic patients and subsequent cholecystectomy [27].

14.8 Medical Subspecialty Evaluation

14.8.1 Pulmonary

Included in the preoperative evaluation, chest radiograph and standardized screening for obstructive sleep apnea with confirmatory polysomnography if screening tests are positive [5]. OSA is an important aspect of the preoperative workup for patients considering bariatric surgery because OSA is associated with increased postoperative complications [28]. OSA is also very prevalent in patients prior to bariatric surgery with up to 38% of patients having undiagnosed OSA [29]. Standard preoperative management of OSA with continuous positive airway pressure (CPAP) is recommended.

Included in the preoperative evaluation should also be pulmonary evaluation for other pulmonary pathology such as asthma, dyspnea, chronic obstructive pulmonary disease (COPD), and obesity hypoventilation syndrome (OHS). OHS is an independent risk factor for more severe desaturations and is also associated with OSA [28]. If severe disease is confirmed, patients should have preoperative arterial blood gas measurements and pulmonary function tests [5].

14.8.2 Cardiology

Patients undergoing bariatric surgery have a high prevalence of known and unknown cardiopulmonary diseases [30]. Therefore, it is recommended to do some cardiac testing preoperatively. Patients with a known heart disease may require formal cardiology consultation before surgery. Noninvasive cardiac testing beyond an electrocardiogram is determined by the patient's risk factors and history/physical exam. If a patient is at risk for heart disease, evaluation for use of B-blocker should be done. A paper by Thompson et al. shows that B-blocker continuation on the day of and after surgery was associated with fewer cardiac events and lower 90-day mortality [31].

14.8.3 Endocrinology

Type 2 diabetes mellitus (T2D) is one of the risk factors contributing to postoperative complications in patients undergoing BPD/DS. Preoperative glycemic control should be optimized using a diabetes comprehensive plan using diet, exercise, and pharmacotherapy. Targets for perioperative glycemic control include having a hemoglobin A1c value of 6.5–7.0% or less, a fasting blood glucose level of <110 mg/dL, and a 2-h postprandial blood pressure glucose concentration of <140 mg/dL [5]. Studies have also found that a shorter duration and better control of diabetes prior to surgery corresponds to a higher rate of remission [32].

14.9 Informed Consent

Informed consent of bariatric surgery is a dynamic process of education and comprehension in addition to the disclosure of risks and benefits [33]. Prior to surgery, the patient must be made aware of the full implications of bariatric surgery, since the surgery will have lasting impacts on their life moving forward [34]. Educational objectives, active teaching and learning processes, and assessments are recommended and should be communicated at a sixth to eighth grade reading level [34, 35]. Multimedia tools for informed consent and patient education show promise for improving comprehension. However, the mainstay of informed consent will still be personal counseling that allows for the patient to ask questions and express concerns [36]. Informational seminars can be useful at the beginning of the preoperative workup for a patient but education should be continued throughout the whole preoperative period. Studies have shown that candidates for bariatric surgery understand its benefits but still can have unrealistic expectations of weight loss. Therefore, setting realistic expectations prior to surgery is an important aspect of the preoperative evaluation and education process [37]. Thorough discussion of the need for long-term follow-up, vitamin supplementation, and long-term lifestyle change is required in order to achieve post-operative success. Consent should also include experience of the surgeon within the specific procedure offered, and whether the hospital is an accredited institution should be mentioned.

The basic elements of informed consent should include the nature of the illness and the natural consequences of no treatment, the nature of the proposed operation, including the estimated risks of mortality and morbidity, the more common known complications, and any alternative forms of treatment, including nonoperative techniques. The patient should understand the risks as well as the benefits of the proposed operation [35]. Patients can sometimes forget significant elements of their preoperative teaching and education, including risks of serious complications. Therefore, discussion about the risk of serious complications should happen again immediately prior to the proposed operation.

Ultimately, the privilege of consent lies with the patient alone. Therefore, it is prudent and safer to have a well-educated and informed patient prior to the procedure.

14.10 Conclusion

Preoperative work-up for BPD/DS is essential in the subsequent success and happiness of the patient and operation. It is important to have practice standards so that patients can be approached in a standardized fashion with evidence-based guidelines preoperatively to optimize care. Having a standardized preoperative protocol will limit errors of omissions and ensure that patients all received high quality care while also maintaining efficiency and avoiding unnecessary testing.

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Chapter 15
Risk Assessment and Reduction

John Cole Cowling and Erik Wilson

15.1 Risk Assessment

Risk assessment of the bariatric surgery patient begins with a comprehensive, in person clinical consultation with several objectives. The first is to get to know the patient, as well as their family or other member of their social support structure who will be helping the patient achieve a healthier lifestyle. In getting to know the patient, the surgeon begins to build the rapport that will be necessary to gain the patient's trust for what will be a long-standing clinical relationship that will span many visits over a multi-year time period to address a chronic health condition.

Second, the surgeon should conduct a traditional history and physical exam, focusing on not only the pertinent details of the patient's history of obesity and efforts to lose weight through diet, exercise, and medical treatment but also a detailed review of their past medical and surgical history, social history including tobacco, alcohol, or other substance use, their current work or important hobbies that may be impacted by surgery and the necessary recovery, and a detailed review of their medication list. Patients should also be assessed if they are up to date on age-specific cancer screening such as mammograms and colonoscopies. [1] By reviewing this information, the surgeon can quickly glean patient-specific risk factors that may impact their ability to safely undergo and recover from a complex surgical intervention and achieve the intended outcomes of weight loss and remission of their associated medical comorbidities.

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Particular interest should be given to a history of cardiovascular or cerebrovascular events; coagulation disorders; pulmonary health including smoking, COPD, and obstructive sleep apnea; history of gastrointestinal disorders; and previous abdominal and intestinal operations. Hepatic and renal disease and autoimmune disorders that might be treated by steroids or immune modulators should also be asked about.

A physical exam should include the patient's current height, weight, and body mass index (BMI) among other vital signs. An exam might detect previously unknown cardiovascular or pulmonary risk factors such as signs of congestive heart failure or arterial disease that should be evaluated and addressed before undergoing anesthesia. An exam might also identify abdominal pathology such as masses, hernias, or excessive abdominal surgical history that may complicate the ability to safely gain access to the abdomen or mobilize limbs of the intestine. Similarly, the presence of jaundice or other signs of severe liver dysfunction may preclude the patient as a surgical candidate.

Lastly, an assessment can begin to be made of the patient's degree of frustration imposed by their morbid obesity and psychological readiness to undergo surgical weight loss, as well as their prior knowledge about or research of the available operations and the involved recovery. In fact, many patients will come to the office having already done a great deal of online research about surgical weight loss or will have known someone who has already undergone surgery and may have some preconceived biases about the operations of choice. This preoperative research is beneficial, as a well-informed patient who has a solid understanding of the scope of weight loss surgery can reduce the risks of non-compliance or poor follow-up. This is a good opportunity to clear up any misconception about bariatric surgery functioning as a cosmetic intervention.

15.2 Risk Reduction

In our practice, risk assessment and reduction is achieved by evaluating and optimizing modifiable patient-specific risk factors to achieve a safer surgical outcome, even at the expense of delaying surgery when necessary. Here, we will address some commonly evaluated conditions.

15.2.1 Smoking

Any patient with a smoking history is counselled on the need for cessation and offered resources to assist them in stopping tobacco use before surgery, typically by referral to their primary care provider. Our goal is to have the patient be free of smoking for at least 4–8 weeks before surgery to allow time for the effects on wound healing and inflammation to reverse [2]. We confirm their cessation with a preoperative nicotine screen usually 1 week before surgery, but some advocate for a cotinine test 1–2 days prior [3] and there is evidence that smoking is underreported, especially preoperatively, suggesting we should be more aggressive in screening [4]. A recent National Surgical Quality Improvement Program (NSQIP) review of over 133,000 patients undergoing sleeve gastrectomy and Roux-En-Y gastric bypass found that 9.3% of the patients were smokers and suffered substantially worse 30-day outcomes, including risks of readmission, death, and respiratory complications [5]. Another NSQIP review of sleeve gastrectomy patients demonstrated increased risk of intubations and 30-day mortality in smokers [6]. Patients can be reassured that an effort to stop smoking should have little impact on their long-term weight loss. In a review of sleeve and gastric banding patients, pre- or post-operative smoking status was not associated with any significant difference in weight loss in long-term follow-up [7]. Moser found no significant difference in weight loss after sleeve gastrectomy, regardless of smoking status at 6, 12, and 24 months [8].

15.2.2 Substance Abuse

Bariatric surgery patients may also have a higher lifetime risk of substance abuse and the physiologic changes after surgery may put them at increased risk of alcohol abuse [9]. We consider active alcohol abuse or alcoholism to be a contraindication to bariatric surgery of any kind, including duodenal switch, and these patients are referred for rehabilitation and detoxification. Although data exists for duodenal switch, there is concern in the gastric bypass patient that alcohol absorption may be accelerated and reach higher concentrations in the blood, putting patients at increased risks of alcohol use disorder after surgery [10]. Patients are counselled about the risks of post-operative substance use disorders.

Patients with a history of opioid abuse and recovery should be given non-opioid analgesics in the perioperative period and utilize local anesthetic blocks to control pain [11]. Enhanced recovery (ERAS) protocols are already becoming widespread in bariatric surgery and can be applied to the duodenal switch patient.

15.2.3 Psychosocial Evaluation

Most third-party payers require psychosocial evaluation to determine that the patient does not have any untreated mental disorders or eating disorders as a condition of insurance approval. We refer patients to a local psychologist for this evaluation and follow any recommendations made. This topic is discussed in more detail in a prior chapter.

15.2.4 Cardiopulmonary Assessment

Although preoperative cardiopulmonary assessment is not typically a provision of insurance approval, consideration should be given to cardiac evaluation and screening of obstructive sleep apnea and obesity hypoventilation syndrome.

A good place to start, aside from a physical exam as mentioned above, is to assess the patient's functional status. This is done by evaluating a patient's ability to perform activities of daily living and is measured in metabolic equivalents (METs), which can be calculated using the Duke Activity Status Index. Perioperative cardiac risks are increased in patients unable to perform 4 METs [12].

The Revised Cardiac Risk Index is one of several available risk assessment tools to evaluate perioperative cardiac risk in patients undergoing non-cardiac surgery such as duodenal switch. The calculator gives one point and deems a patient high risk for any of the following: ischemic heart disease, cerebrovascular disease, congestive heart failure, insulin therapy for diabetes, serum creatinine level > 2 mg/dL, or planned high-risk surgery [13]. For patients in these categories, consideration should be given for referral to a cardiologist for consideration of preoperative stress testing, particularly if unable to perform 4 METs [14]. Patients on beta-blockade and statins should have these medications continued in the perioperative period.

The presence of obstructive sleep apnea (OSA) can similarly be assessed using questionnaires such as STOP-Bang [15] and the Berlin Questionnaire to evaluate for factors like snoring, daytime sleepiness, and measured neck size to determine if the patient may benefit from referral for polysomnography, which is the gold standard for diagnosing OSA and will quantify the number of apnea and hypopnea events per hour as the apnea-hypopnea-index (AHI). Several studies have demonstrated a significant prevalence of OSA in the bariatric surgery patient population of >60%. A recent expert consensus panel recommended preoperative and perioperative CPAP in patients with moderate to severe OSA, defined as an AHI > 15 and to have patients bring their own machine and mask to the hospital for the postoperative period. Patients should also be monitored with continuous pulse oximetry in the early postoperative period until sedatives and opioids minimized [16].

15.2.5 Chronic Steroid Immunosuppression

Some patients presenting for evaluation may be on chronic steroid immunosuppression for a variety of conditions. While there is no definitive study in the duodenal switch patient, reviews of gastric bypass and sleeve gastrectomy patients suggest an increase in postoperative complications. Kaplan found that patients on chronic steroids undergoing sleeve gastrectomy and gastric bypass had a 3.4 times increased risk of dying at 30 days postop and 2 times increased risk of serious complications [17]. Andalib found an almost 7 times increased risk of 30-day mortality and similar twofold risk of major morbidity in sleeve and gastric bypass patients who were steroid dependent at the time of surgery. Also, there was no difference in 30-day complication rates between sleeve and gastric bypass, suggesting that sleeve is not a safer alternative in this population [18]. Hefler found an increased risk of 30-day complications, bleeding, and anastomotic leak in immunosuppressed patients also undergoing sleeve and gastric bypass but appeared to show worse outcomes in the bypass cohort [19]. While the long-term effect of bariatric surgery and weight loss may reduce the inflammatory state of certain rheumatic diseases [20], caution should be used in offering stapled operations to patients on chronic steroid immunosuppression, likely including duodenal switch.

15.2.6 Preoperative Weight Loss and Liver Volume Reduction

The concept of a preoperative diet to reduce the liver volume and moderate the technical challenges of bariatric surgery is controversial. Risk reduction may be achieved with a preoperative liver volume reduction diet that may result in improved exposure of the gastric cardia and reduce the risk of bleeding from an oversized liver. Visceral adiposity may also be reduced [21]. Very low calorie diets (VLCD, 450–800 kcal/day) and low calorie diets (LCD 800–1200 kcal/day) have been studied. Van Nieuwenhove studied a 2-week VLCD in gastric bypass patients and found a decreased perception of difficulty of the surgery but no difference in bleeding or outcomes [22]. Edholm also found improvement in the perceived complexity of gastric bypass in 15 patients following a 4-week LCD and resulted in a reduction of liver volume by 12% as measured by MRI [23].

The optimal time and degree of caloric restriction is unknown. A systematic review concluded that VLCD are effective for volume reduction but found no association between degree of liver volume reduction and the length of a preoperative diet or degree of caloric restriction and that diets of <1500 kcal/day are likely sufficient for liver volume reduction [24].

It is also unclear if preoperative weight loss reduces postoperative complications. Ekici found no significant difference in early postoperative outcomes or weight loss at 1 year in patients having sleeve gastrectomy after a 4-week 1000 kcal/day diet [25]. A randomized trial of gastric bypass patients found no difference in bleeding or postoperative outcomes [22]. Tan also found no difference in postoperative complications in bypass and sleeve patients with <5% or >5% weight loss after a VLCD [26]. There may also be a detrimental effect to wound healing with a prolonged preoperative VLCD of 4 weeks [27].

While we do not know of any studies evaluating preoperative weight loss specifically in the duodenal switch population, there is likely at least some benefit to achieving liver volume reduction with a 2-week LCD to mitigate the technical challenges of an enlarged fatty liver, especially during the sleeve creation portion of the operation.

15.2.7 Hospital and Programmatic Support of Bariatric Surgery

Surgery should be done within a comprehensive accredited bariatric program with access to nutritional consultation both pre and postoperatively and with adequate support staff to assist the patient in preparing for surgery and to monitor the patient in postoperative recovery. Additionally, surgery should be performed in a hospital setting with the resources to care for the inherent high-risk complexities of these morbidly obese patients. Some third-party payers require that these surgeries are performed in high-volume centers of excellence.

A plan should be made and literature provided to the patient that details all aspects of the postoperative recovery. In our practice, this includes educating the patient on the expected time they will be in the hospital recovering and how much time they should plan to be out of work while recovering at home. In our practice, this is generally 1–2 weeks, depending on the physical nature of their employment or daily activities. Additionally, we provide information on the postoperative diet, which involves liquids for 2 weeks, followed by a gradual advancement through pureed and soft foods over the course of weeks 3–6, and that emphasizes daily protein intake of 60–80 grams and avoidance of carbohydrate dense and fatty foods. Additionally, patients must have a firm understanding of the risk of malnutrition and short and long-term vitamin deficiency and the inherent need for and financial considerations of lifelong vitamin supplementation. In our practice, we require close follow-up after surgery at 1 and 6 weeks, 3, 6, 9, 12, 18, and 24 months, and then yearly thereafter and perform routine monitoring of both their weight loss and any side effects. We also engage in regular laboratory monitoring of hematologic, metabolic, and hepatic function and monitor vitamin and mineral levels. Patients must be committed to the time and travel burden necessary to make these follow-up appointments.

Maybe the most important aspect of risk reduction is a comprehensive experience and plan prior to surgery that addresses the technical challenges of the surgery including safe dissection and division of the duodenum, safe and reproducible anastomotic technique and efforts to streamline the operation to minimize operative time and increase efficiency. It is our opinion that this can be achieved by attending specialized training courses and lectures with experienced duodenal switch surgeons, practicing the technique in cadaveric models ahead of surgery and having an experienced proctor or assistant present during the early and crucial phases of the learning curve. It makes intuitive sense that a surgeon who decides to perform duodenal switch should have adequate experience in both sleeve gastrectomy and anastomotic weight loss surgery (e.g., Roux-en-Y gastric bypass) prior to adding duodenal switch to the surgical armamentarium offered to patients in his or her practice. Whether a single or double anastomosis procedure is performed, prior experience in sleeve creation and bowel anastomosis will be crucial in safely performing these technically advanced operations.

Despite every effort made to assess and reduce the risks to the patient of undergoing duodenal switch, operative and perioperative complications are inherent to the nature of surgery. We believe that giving informed consent of the risks of surgery is crucial to the ethical practice of surgery. Patients must understand the real risks of bleeding, anastomotic leak, stricture and ulcer, deep venous and mesenteric venous thromboembolism, incisional hernia, bowel obstruction, malnutrition, and even myocardial infarction, stroke, or death.

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Chapter 16
Airway Evaluation and Management

Joshua F. Chacon

16.1 Obstructive Sleep Apnea History and Management

When evaluating obstructive sleep apnea (OSA) history, there are key details that provide insight of how to manage the patient preoperatively. The ASA OSA task force has provided a thorough assessment [1] and recommendations for patients suffering with this disorder. Given that the morbidly obese patient will likely present with complications from OSA perioperatively, one should consider tailoring the anesthetic technique to minimize these complications including: easy access CPAP, easy access of reversal agents, adjustable beds to at least 30+ degrees, access to wedge pillows, short acting inhaled anesthetics, consideration of awake extubation, minimizing narcotics and barbiturates, use of multimodals including regional, inpatient O2 monitoring overnight before discharge, and pt. education regarding the use of CPAP at home if narcotics are used on discharge.

Upon extubation, most of the morbidly obese patients undergoing bariatric surgery will require some supplemental oxygen. Depending on their OSA morbidity scores, these patients can quickly become hypercarbic and become less responsive in the recovery units. Strict instructions should be given to the post-anesthesia care teams to minimize the complications of hypercarbia and hypoxia by appropriately utilizing CPAP machines to facilitate an optimal respiratory status.

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16.2 Possible Difficult Laryngoscopy

When evaluating the morbidly obese patient for a general anesthetic, special attention should be placed on the patient's Mallampati score, neck mobility, Hx of difficult laryngoscopy, surgical Hx, patient cooperation, and equipment available for the anesthetic team for induction.

Whether the anesthetic plan dictates an awake intubation or intubation under general anesthesia with/or without videoscopes, proper patient positioning should be used to maximize the likelihood of first pass success in securing the airway. Proper positioning includes placing the patient in the sniffing position with or without wedge pillows. To ensure appropriate positioning, the tragus is anterior to the shoulder to facilitate alignment of the oral, pharyngeal, and laryngeal axes.

Before a laryngoscopic attempt is performed, per anesthesia guidelines, the anesthesia machine should be checked, suction should readily available, vital sign monitors placed and reviewed, video laryngoscope readily available, laryngeal mask airway (LMAs) readily available, and reversible agents readily available. Seeing that intubation is notoriously difficult with morbidly obese patients, it is advisable to have an experienced laryngoscopist in the anesthesia team to both assist and secure the airway.

Induction of general anesthesia is one of the most dangerous anesthetic events in these patients. Therefore, visual attention is recommended at bedside by OR staff and anesthesia team. The OR staff should be familiar with some of the anesthetic equipment if both the MD and certified registered nurse anethetist (CRNA) are unable to leave the immediate care of the patient. The equipment that is often needed in an emergency include: bougie, LMA, video laryngoscope, endotracheal tubes, cricothyrotomy kit, and laryngoscope blades. It is advisable for the OR staff to familiarize themselves with the equipment to minimize the anxiety that comes in an emergency while trying to identify and assist with the airway devices. Once the airway is placed, the staff should wait until there is confirmation of end tidal CO_2 and the device is secured to the patient before manipulation is done to the patient or the operative bed.

If intravenous general induction is part of the anesthetic plan, it is preferred to use short-acting medications that allow optimal visualization of the vocal cords. With the advent of video laryngoscopes, it is common practice to opt for this route as the preferred method to visualize the vocal cords and subsequently securing the airway with an endotracheal tube. In the event of an unexpected difficult intubation, it is advisable to follow the American Society of Anesthesiologist Difficult Airway Algorithm [2].

16.3 Possible Difficult Mask

When evaluating the morbidly obese, it is of most importance to assess the likelihood of difficult mask ventilation. Some of these factors include body mass index >26 kg/m^2, age older than 55 years of age, macroglossia, beard, lack of teeth, history of snoring, increased Mallampati grade > III, and lower thyromental distance <5 cm. Identification of two or more of these factors [3] allows anesthesia providers to appropriately predict the level of difficulty of mask ventilation.

Most morbidly obese patients have two or more of the above criteria that predicts the possibility of experiencing a difficulty in mask ventilation. Therefore, we encourage anesthesia personnel to provide adequate preoxygenation and utilize short acting medications for the induction of general anesthesia. Additionally, we encourage having readily available backup help, LMAs, and more than one anesthesia provider in the room for the induction of general anesthesia. As always, follow the American Society of Anesthesiologist Difficult Airway Algorithm in the event of difficult mask ventilation.

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Chapter 17
Patient Positioning and Positioning for Bariatric Surgery

Joshua F. Chacon

17.1 General Considerations for Patient Positioning

A coordinated approach among the surgical team and anesthesia providers allows for quick patient positioning and helps to reduce malposition. The ideal patient position is one in which the spine is in alignment and patient extremities are as close to neutral positioning as possible. Care must be taken to pad points of pressure with the goal of protecting peripheral nerves or skin from hard surfaces, poles, and other positioning devices.

IV sites and IV tubing (including invasive lines such as arterial or central access) should be checked to ensure they are free of tension and are not applying pressure to the skin and should be reassessed for flow to gravity once the patient is positioned. In addition to checking the IV(s), other monitors should be assessed for proper function, to make sure they are free from tension, and not run across the patient's body in a way that can lead to injury. For example, the pulse oximetry cable should be checked to ensure that the finger (or toe) it is attached to is in neutral position and that the pulse oximetry cable is run under patient limbs, ideally along the bedside to prevent nerve injury or ischemic injury to the extremities it runs along. EKG leads should be reassessed to ensure they are providing adequate signal. The individual EKG wires should be run under extremities they cross and checked to ensure they are not crossing over the neck. It is also important to make sure that the EKG leads are not placed in the surgical field (if possible). Lastly, the blood pressure cuff should be checked to ensure that it has not migrated and that the tubing does not cross over limbs in the same fashion as the IV tubing and other monitors. These checks are performed primarily by the anesthesia staff but other OR members are encouraged to speak up if they see anything amiss or at risk for causing injury to the patient.

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17.2 Considerations for Selected Positions and Changes in Physiology

17.2.1 Supine

Supine positioning is the most common position used for surgery and often is the starting position of choice for bariatric surgery. The patient is positioned on the table face up with the head, neck, and spine in alignment as seen in Fig. 17.1. The arms can be positioned in multiple variations with the recommended range of abduction <90° to prevent injury to the brachial plexus or ideally adducted next to the body. In addition, the hand and forearms can be placed in a range of rotation, with the palms facing inward in a neutral position (often the most preferred position due to minimal stretch of the ulnar nerve) or supinated so the palms are facing upward [2]. Supinated position of the hands and forearms still carries risk of stretch injury [3]. Careful attention should be paid to the bony prominences such as the elbow, sacrum, and heels, which should be adequately padded to prevent pressure injury from ischemia [4]. In addition to the above injuries, low back may be exacerbated in patients with this health issue. Monitors and IVs should be assessed for

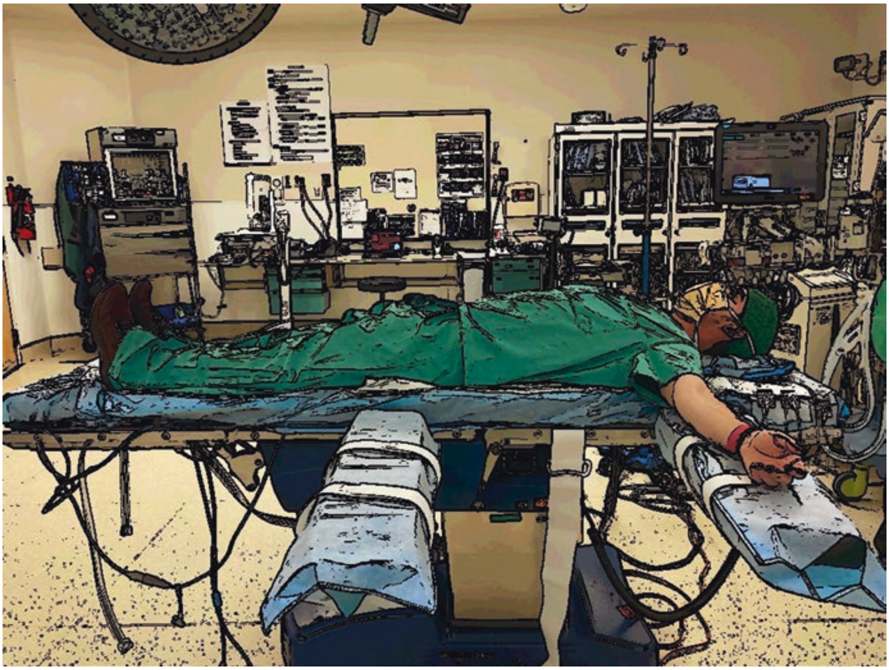

Fig. 17.1 Supine position. Note that the organs are at the level of the heart, the arms are abducted less than 90° at the shoulders, and forearm/hands are in a natural position, minimizing the stretch on the associated nerves. Photo credit: Austin McCarthy, original content

function, tension, and if possible should be run below the extremity to prevent injury. This position maintains most organs at the level of the heart which offers favorable hemodynamics.

There are multiple variations of the supine position that are frequently employed during bariatric surgery to promote surgical exposure and/or patient physiology.

Trendelenburg—in this position, the bed is tilted so that the head is lower compared to the feet as shown in Fig. 17.2. This helps to improve visualization of multiple structures in the abdomen including the gallbladder, appendix, and pelvic structures. Prior to initiating this position, it is important to ensure that proper devices are in use to prevent sliding: the patient is strapped to the bed, either via chest strap or waist strap; there is a bed gripper under the patient, or the use of shoulder braces. It is not recommended to use shoulder braces unless necessary due to increased risk of brachial plexus injury [5].

There are a myriad of physiologic changes associated with the Trendelenburg position. This position initially leads to an increase in venous return from the lower extremities that functions as an autotransfusion which leads to increased cardiac output; however this effect is temporary [6]. The weight of the abdominal organs and effect of gravity on the diaphragm cause a reduction in the lung volumes, increased work of breathing, and increased airway pressures which leads to more rapid desaturation, increased shunting, and during prolonged procedures can lead to

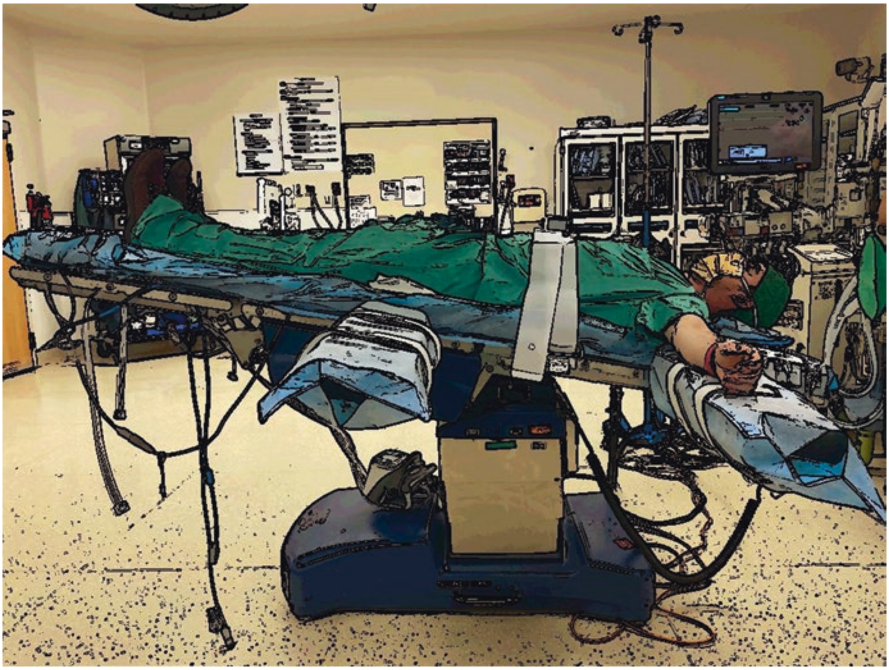

Fig. 17.2 Trendelenburg position. Note that the head is below the level of the heart and a safety strap is in place to prevent the patient from sliding. Photo credit: Austin McCarthy, original content

head and neck edema. Also of note is that for patients who have or are at risk for increased intracranial or intraocular pressure, this position should be used with extreme caution or not at all (most sources indicate this position is contraindicated when intracranial hypertension is present). When exiting this position, although the increased venous return is temporary, one should expect some degree of venous pooling in the lower extremities and thus a drop in blood pressure.

Reverse Trendelenburg—in this position, the patient is tilted so that the head is raised above the level of the heart as shown in Fig. 17.3. This position helps to improve visualization of upper abdominal structures due to the effect on gravity pulling abdominal structures toward the pelvis. Prior to initiating this position, it is important to ensure that proper devices are in place to prevent sliding: patient is secured with a safety strap; a bed gripper is beneath the patient; and use of a foot board is recommended if steep reverse Trendelenburg (greater than 30°) is to be used.

There are multiple physiologic changes that occur with the reverse Trendelenburg position. Since the head is above the level of the heart, the abdominal organs are shifted caudally, which helps to improve airway pressures and decrease the work of breathing. There is a loss of preload due to venous pooling in the lower extremities associated with this position so hypotension can be expected. Due to the reduction in preload, it is important to monitor blood pressures carefully, as cerebral perfusion

Fig. 17.3 Reverse Trendelenburg. Note that the head is above the level of the heart and the patient is held in place by a safety strap. Photo credit: Austin McCarthy, original content

relies on adequate blood pressure and the BP cuff is usually at the level of the heart and therefore pressure is higher at the cuff site. If invasive monitoring is used, it should be zeroed at the level of the Circle of Willis to adequately detect the blood pressure in the brain.

Lawn/beach chair position—in this position, the hips and knees are flexed using the leg portion of the bed, which helps to reduce strain on the low back as noted in Fig. 17.4. The upper body section of the bed can also be adjusted between 0 and 90° depending on the needs for the surgery. Although it does not provide optimal surgical positioning for bariatric surgery, in selected patients with low back pain or at risk of airway swelling it is used prior to induction and after surgery completion as the patient is waking up. This can also be considered a variation of the sitting position as described below.

17.2.2 Semi-fowler/fowler's

In this position, the upper body section of the surgical bed is raised anywhere between 5 and 90°, which causes the patient to flex at the hip. This is also referred to as the sitting position. Although this position is not used much for bariatric

Fig. 17.4 Lawn chair/beach chair position. Note the flexion of the hips and slight bend at the knees, which helps to reduce strain on the low back. Photo credit: Austin McCarthy, original content

surgery, it can be used to improve the bariatric/obese patient's respiratory mechanics and access to the airway both prior to inducing general anesthesia and when waking up from general anesthesia. Since the flexion of the torso occurs at the hip, patients are at risk of stretch injury to the sciatic nerve and if present, worsening of their back pain symptoms.

17.2.3 Lithotomy

In this position, the patient begins supine and as part of a coordinated effort the legs are raised simultaneously above the level of the head with the hips flexed and legs abducted from midline using various positioning devices. Commonly used devices include candy cane stirrups or support poles with well-padded boots to protect the patient's legs. Once the legs have been positioned, the foot end of the bed is lowered, allowing access to the perineum. This position is ideal for urologic, gynecologic, or peroneal/rectal surgeries.

In most textbooks, it is recommended the hips should be flexed between 80 and 100° and the legs abducted between 30 and 45° from midline. However, more recent case reports have identified multiple cases of sciatic nerve palsy when the hips are flexed past 90°, so aiming for hip flexion less than 90° is recommended to prevent this injury [3]. In addition to sciatic nerve palsy, special attention should be paid to the lateral femoral nerve, as abduction of the legs against the bed or positioning devices can lead to injury of this nerve, and thus minimizing the degree of abduction and appropriate use of padding is recommended [3]. The peroneal nerve is also at high risk for injury if attention is not paid to avoid pressure on the lateral fibular head. Although much attention has been paid to the lower extremities, the upper extremities are at risk of malposition as well. Since the bed is broken/lowered at the leg level, if the arms are tucked the fingers must be positioned correctly to prevent crush injury when the leg section is raised at the end of the surgery—it is recommended that the fingers be visible to prevent this injury. Additionally, if lithotomy and Trendelenburg are planned to be used, extra attention should be paid to the shoulders to ensure that there is no compression of the brachial plexus, especially if shoulder braces are used to prevent the patient from sliding.

This position carries with it physiologic changes similar to the Trendelenburg position. Lifting the legs above the level of the head temporarily increases venous return [6]. Flexion of the hips increases pressure on the intrabdominal organs and displaces them toward the diaphragm, which in turn reduces lung compliance. This leads to a decrease in lung volumes and increases airway pressures. In patients with increased abdominal mass (obese, gravid uterus, tumor), these effects can be very pronounced and can lead to cardiovascular collapse if one does not remain vigilant.

17.2.4 Lateral Decubitus

In this position, the position is rotated on their side, allowing better access to the thorax, hip, and retroperitoneal organs. The dependent, or down, side is padded and the knee of the dependent side flexed to reduce stretch of the associated nerves. Often, padding or pillows are placed between the knees to prevent ischemia from bony contact. The dependent arm is placed on a padded board while the non-dependent, or up, arm is positioned crossing the body with either pillows, a padded mayo stand, or some other device such as a padded stand attached to a pole. Keeping both arms abducted less than 90° at the shoulder is important to prevent injury to the brachial plexus. Addition of an axillary role on the dependent side is also important to prevent compression of the brachial plexus and axillary artery. Perfusion of the dependent arm can be assessed by measuring the blood pressure or placing a pulse oximetry monitor—low BP or poor O2 signal can indicate compression of the axillary artery and warrants further investigation to prevent injury.

17.2.5 Robotic Surgery

Since its introduction over 30 years ago, robotic surgery is becoming more popular as a method for minimally invasive surgery. Robotic surgery was initially used mostly for gynecologic and urologic surgery but has expanded in recent years to include abdominal, thoracic, and head and neck surgery. Many of the principles that apply to laparoscopic surgery also apply to robotic surgery with some additional considerations as detailed below.

The majority of bariatric surgery is performed in the supine position or some variation thereof. Since the majority of robotic surgeries have historically been urologic or gynecologic, the majority of data centers around Trendelenburg or Lithotomy position. However, as bariatric surgery is becoming more popular, other positions are seeing more use, namely, the reverse Trendelenburg position and for certain cases lateral decubitus (such as complex hiatal hernia surgery requiring approach through the abdomen and thorax). For bariatric surgery, steep reverse Trendelenburg (30–45°) often provides optimum exposure of the stomach, diaphragm, and other organs such as the duodenum and jejunum. Prior to positioning the surgical robot over the patient, it is important to reassess the position to ensure that the patient has not migrated, that all monitors and IV lines remain functioning well, and that no parts of the patient's body are in contact with positioning devices in a way that can cause harm.

Robotic surgery, as well as laparoscopic surgery, changes multiple physiologic parameters. Hemodynamic changes are caused by insufflation of the abdomen with CO_2, which leads to compression of the venous system, reducing preload and thus cardiac output. In addition to the changes experienced by the vascular system, the pulmonary system sees an increase in airway pressures and loss of tidal volumes due to collapse of the alveoli.

These physiologic changes associated with robotic and laparoscopic surgery can be further worsened depending on the patient position. In Trendelenburg position, airway pressures will be further increased and lung volumes further decreased. With the addition of CO_2 that is absorbed by the body during insufflation, blood CO_2 levels rise and it can be difficult to increase the minute ventilation to adequately ventilate the patient. The benefit of autotransfusion will be minimized secondary to insufflation pressures that decrease venous return. In reverse Trendelenburg, venous return is further reduced, often leading to hypotension. Although airway pressures are improved slightly compared to supine or Trendelenburg, they still are elevated compared to non-Robotic or open surgery. As such, mechanical ventilation can still prove to be challenging [7].

17.3 Summary

In summary, positioning is a team-based exercise that proper knowledge, vigilance, and execution can lead to improved patient outcomes, increased operating room efficiency, and decreased risk of injury. Although the positions described above are not all encompassing, these are the positions most frequently encountered in bariatric surgery. Additionally, it is important to recall the physiologic changes associated with the specific positions and the type of surgery that is being performed.

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Chapter 18
Intraoperative Monitoring of the Morbidly Obese Patient

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18.1 Pulse Oximetry

Pulse oximetry utilizes light absorption to quantitate the amount of oxygen-bound hemoglobin. Pulse oximetry uses 2 small light emitting diodes (LEDs), red (660 nm) and infrared (940 nm). Oxygenated hemoglobin absorbs more infrared light and allows red light to pass through. Deoxygenated hemoglobin absorbs red light allowing infrared to pass through. The LEDs fire approximately 30 times per second, and a receiver measures the amount of light that passes through. This ratio provides a measurement of blood oxygenation.

Multiple physiologic and pathophysiologic conditions that often accompany morbid obesity necessitate accurate pulse oximetry [2]. The morbidly obese patient is more likely to have obstructive sleep apnea, in addition to an increased basal oxygen consumption and potential respiratory disease. As such, these patients are highly likely to desaturate and become hypoxemic more quickly. These patients also have a lower resting oxygen saturation at baseline, making appropriate preoxygenation prior to the induction of general anesthesia significantly more important.

18.2 Electrocardiogram

Given the risk of hypoxemia and the high likelihood of coexistent cardiac disease or dysfunction, the morbidly obese patient population is undoubtedly at higher than average risk for intraoperative myocardial ischemia. Given these concerns it is especially important to monitor the EKG correctly [3, 4].

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When discussing lead placement it is important to identify which leads to monitor and why to select them. When looking for ischemic changes, lead V5 alone will detect 75% of ischemic episodes in men 40–60 years of age [4]. Adding lead V4 increases this to 90%, and the combination of leads II, V4, and V5 add up to a 96% detection rate.

Meanwhile lead II, when correctly placed, is most appropriate for accurate evaluation of p-waves. For those reasons, when utilizing a 5-lead setup, leads V5 and II are the most commonly monitored, allowing for ischemic and electrophysiologic problems to be identified in a timely fashion.

18.3 Blood Pressure

Accurate and consistent blood pressure monitoring is essential in safe anesthetic care. In the morbidly obese patient obtaining these measurements can be challenging.

Noninvasive blood pressure monitoring utilizes the oscillometric technique. When the cuff is correctly placed on the patient's arm, it is inflated with air until arterial flow past the cuff ceases. Then the pressure in the cuff is gradually released. Sensors in the cuff detect the oscillations of intraarterial flow. As the cuff pressure declines, the oscillations increase in amplitude to a maximum, which represents the mean arterial pressure (MAP). This MAP value is the only pressure actually measured, at the point of maximal amplitude.

The system can then use an algorithm using the measured MAP value to calculate a systolic and diastolic pressure. Each manufacturer has its own method, meaning there may be considerable variation between systems. A study in lean and obese patients found inaccuracies regardless of body weight or arm circumference [5].

Non-invasive blood pressure (NIBP) readings are further complicated in the obese patient. Finding an appropriately sized blood pressure cuff can prove a difficult endeavor. Often, even if the cuff can appropriately fit the circumference of the arm, the conical shape of the morbidly obese arm makes reading inconsistent [6]. Undersized cuffs typically underestimate the blood pressure for the morbidly obese patient. Various studies have evaluated the accuracy of blood pressure cuffs on both the forearms or on the legs. A study from 2002 showed that NIBP measurement with a cuff placed at the wrist routinely measured the blood pressure higher than upper arm values. That study concluded that compensation can be performed by subtracting 10 mmHg from the measured values or simply by elevating the wrist about 15 cm and taking the BP at face value.

Aragahi et al. enrolled a group whose mean BMI was approximately 32. They found that both oscillometric and traditional auscultatory methods were unreliable compared to intraarterial measurement. Noninvasive blood pressure measurements consistently underestimated systolic pressure and overestimated diastolic pressure. Multiple studies have proposed equations to calculate an accurate blood pressure value by forearm cuff, however there is little to no agreement between various researchers [7]. Forearm pressures appear to be consistent, but not equivalent to more accurate pressure measurements. Leg blood pressure cuff readings appear even more unreliable. Overall, there is no consistent correlation. NIBP readings in the morbidly obese patient show significantly different values (some increased and some decreased) that are neither consistent nor equivalent to more accurate blood pressure measurements.

18.4 Arterial Line

Arterial line placement is often considered the gold standard for accurate blood pressure measurement. While arterial measurement may pose a more accurate value, there are both risks to placement and challenges with the morbidly obese patient.

Body habitus and the amount of subcutaneous tissue in the morbidly obese patient may make arterial line placement technically challenging. If and when access is obtained, often a longer catheter must be inserted in order to provide secure placement in the artery. Risks of arterial line placement include temporary vascular occlusion, thrombosis, ischemia, hematoma, localized infection, and even sepsis. Rare complications include severe nerve or artery damage, and critical ischemia requiring surgical intervention.

In general, arterial line placement is reserved for patients with significant cardiovascular comorbidities and is rarely used for routine monitoring of the bariatric patient.

18.5 End Tidal Carbon Dioxide Monitoring

Use of the modern gas analyzer has multiple advantages for the morbidly obese patient. Prior to induction of general anesthesia, preoxygenation can be quantitatively measured by end tidal oxygen values. Optimum preoxygenation can provide a larger margin for safety during any apnea that occurs prior to intubation [8].

Morbidly obese patients are more likely to have sleep apnea and comorbid pulmonary complications. Appropriate end tidal carbon dioxide monitoring can help avoid significant hypercapnia that often occurs in the morbidly obese patient.

18.6 Temperature

Maintaining body temperature during surgery has well documented benefits in terms of healing, coagulation, recovery, and avoiding infection. In the morbidly obese patient avoiding hypothermia prevents increasing metabolic demands on the body, which can be crucially important given the likelihood of comorbid cardiovascular disease. Forced air warmers, blankets, bed warmers, and intravenous fluid warmers may all aid in maintaining body temperature.

18.7 Additional Monitors

18.7.1 Noninvasive Cardiac Output Monitors

Many companies have produced noninvasive means of measuring cardiac output (CO). However, the efficacy in using these devices in the morbidly obese patient population is questionable and has not been formally validated. Studies comparing CO calculated by either noninvasive means versus thermodilution via pulmonary artery (PA) catheter have shown poor correlation [9]. Tejedor et al. in the *Journal of Critical Care* did a case series that showed noninvasive means reported higher values compared to PA catheter, more than half of patients studied showed greater than 20% variation above PA catheter value.

PA catheter placement, while the gold standard for CO measurement, is not without significant risk including bleeding, infection, cardiac arrhythmia, PA rupture, blood clots, stroke, and even death. While a gold standard for cardiac output monitoring, it may be unnecessary for most morbidly obese patients, unless significant comorbid conditions are also present.

18.7.2 Processed Electroencephalogram

Processed electroencephalogram (EEG) is becoming more common in the operating room, and may play an important role in the morbidly obese patient. Several studies have shown that morbidly obese patients undergoing general anesthesia while utilizing processed EEG monitoring were given lower doses of induction agents and could be safely maintained on lower end tidal concentrations of anesthetic gas. This translated to quicker wake ups and less time spent in the recovery room [10].

As with any anesthetic, appropriate monitoring is essential in providing safe and effective anesthesia care. The morbidly obese patient population has comorbidities that make monitoring both more important and more challenging. By identifying the potential difficulties that may arise, correct monitors can be identified without causing unnecessary risk to the patient. Keeping this in mind will help providers utilize the appropriate monitors to the best of their abilities.

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Chapter 19
Method of Anesthesia: Gas Selection and Adjunct Medications

Amir Samir

19.1 Definition of Morbid Obesity

With patients involved in bariatric surgery being morbidly obese with a BMI over 40, it is important to take into consideration the dosing of both inhalational as well as intravenous anesthetics during such operations.

19.2 Why It Is Important to Dose Inhalational Agents and Other Drugs Differently in Obese Patients

Obesity is associated with increased cardiac output and blood volume which in turn affect the rate of clearance and elimination of anesthetic drugs [1]. The increase in body weight and fat content in such patients leads to an increase of the volume of the distribution of lipophilic drugs [2]. Also drug clearance is higher in obese patients due to the enhancement of their renal and hepatic metabolism (Table 19.1).

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Table 19.1 Factors affecting pharmacokinetics in obesity [3]

Volume fat mass	
	Increased fat mass
	Increased lean body mass
	Increased total body water
	Increased blood volume
	Increased cardiac output
	Organomegaly
Protein binding[a]	
	Possible increased lipoproteins (e.g., cholesterol or triglycerides)
	Altered alpha1-acid glycoprotein
Drug metabolism	
	Increased activity of some CYP P450 enzymes[b]
	Increased phase II drug metabolism via glucuronidation and sulfation
Excretion	
	Increased renal blood flow
	Increased GFR
	Increased renal tubular secretion and reabsorption
Individual organ system comorbid conditions	

Pharmacokinetics for many drugs have not been well studied in obese patients, and depend on the degree of lipophilicity or hydrophilicity, protein binding, and mechanisms of metabolism and excretion. The increased value of distribution can prolong the half-life of elimination, particularly for lipophilic drugs and prolonged infusion, despite increased drug clearance. Alterations in body composition and physiologic parameters vary with the degree of obesity, and may be affected by comorbidities that are commonly associated with obesity (e.g., diabetes mellitus, hypertension, cardiovascular disease, fatty liver disease) or other etiologies

CYP cytochrome; *GFR* glomerular filtration rate

[a] The effects of obesity on various plasma proteins have not been well established, and may very among patients. Serum albumin is generally unchanged in obesity

[b] Effects of obesity on the CYP enzymes is variable among the different enzymes. Obesity increases activity of CRP2E1, but studies on the effects of obesity on other isozymes are inconsistent

19.3 Anesthesia Gases Used for Bariatric Surgery

1. *Carrier gases:*

   (a) Oxygen and air mix are the most common carrier gas compositions used in bariatrics. Initially during induction, 100% oxygen is used for preoxygenation as obese patients tend to desaturate faster due to lower functional residual capacity, decreased chest wall compliance, and increased intrabdominal mass, all of which can lead to rapid desaturation even during short periods of apnea [4]. Once the airway is secured, the composition should be changed to a mix of oxygen and air with the goal of keeping the fractional inhaled oxygen, FiO2, less than 60%. This will avoid any oxygen toxicity such as pulmonary toxicity and ocular damage [5].

(b) Nitrous oxide is usually used as a supplemental anesthetic agent to both lower the fraction of inspired oxygen (FiO2) and potentiate the effect of inhalational agents by affecting the brain centers in the brain and the spinal cord and stimulation of GABA receptors. However, NO is relatively contraindicated for bariatric surgery and other laparoscopic procedures. This mainly due to the fact it has the ability to expand in air containing spaces that may lead to bowel distention that may interfere with the surgeon performing the bariatric procedure. It may also be associated with the development of neuropathy and pernicious anemia [6].

(c) Air is used mainly to dilute the concentration of oxygen in order to lower the fraction of inspired oxygen and lower the chances of oxygen toxicity.

2. *Volatile gases:*

Volatile gases are used for induction and maintenance of anesthesia in the operating room. They are liquid at room temperature and require special vaporizers in order to change to an inhalational gas form. They provide both amnesia and immobility to the patient.

- **Mechanism of action**: They act mainly by depressing the central nervous system through augmenting the effect of GABA on its receptors. It causes immobility by acting via action on the spinal cord [7].
- **Minimum alveolar concentration**: It is the concentration of gas in the alveoli at which 50% of patients would show a motor activity in response to surgical stimulation [8].
- **Volatile agents related physiological changes in obese**: Increased work of breathing, increased oxygen consumption, and increased carbon dioxide production. Those changes lead to increased oxygen requirement along with early desaturation.

Table 19.2 covers the factors that affect anesthetic requirements.

(a) **Desflurane:** This is the most commonly used inhalational agent for patients that are obese and or have obstructive sleep apnea. This is mainly due to the fact that it has low oil to gas partition coefficient, which leads to decreased uptake by the adipose tissue and as a result avoiding prolonged emergence from anesthesia [9]. It also has a very low blood to gas partition coefficient that helps with rapid induction and rapid recovery.

Table 19.2 Factors that affect anesthetic requirements

Factors that increase anesthetic requirements	Factors that decrease anesthetic requirements
• Chronic ETOH • Infant (highest MAC at 6 months) • Red hair • Hypernatremia • Hyperthermia	• Acute ETOH • Elderly patients • Hyponatremia • Hypothermia • Anemia (Hgb < 5 g/dL) • Hypercarbia • Hypoxia • Pregnancy

Disadvantages:

- Very high pungency and marked airway irritation that may lead to cough, breath-holding, or laryngospasm. Therefore, it is not suitable for inhalational induction that may be needed in obese patients with expected difficult airway.
- Sympathetic stimulation leading to tachycardia and hypertension especially at high concentration.
- Needs a special electric heated vaporizer. This along with high cost of desflurane may make it less available in some countries.

(b) **Sevoflurane:** It is the second best gas to be used for obese patients. It is favorable due to its sweet smelling and low pungency, which makes it suitable for inhalational induction for difficult airway patients. It also has low blood to gas partition coefficient, which helps with rapid induction and quick emergence.

Disadvantage:

- High cost due to the higher fresh gas flow required (2 L/min) in order to prevent compound A formation.
- Compound A associated nephropathy.

(c) **Isoflurane:** Older inhalational drug that has a low cost, high potency, and little effect on cerebral autoregulation.

Disadvantages:

- Highly soluble in adipose tissue, which makes it one of the least desired inhalational agents to be used on obese patients.
- Highly pungency, which makes it very unsuitable to use in case of a needed inhalational induction.

(d) **Halothane:** Older agent that is sweet smelling and has low cost. However, Halothane is no longer available in North America due to its side effects, especially Halothane hepatitis.

Disadvantages:

- Highly soluble in blood and fat tissue, which results in slow induction and prolonged emergence.
- Hepatic toxicity and halothane hepatitis.

Inhalational agents delivery (Ventilation) (Table 19.3)**:** Different techniques of ventilation have been used for obese patients with success. Obesity is not associated with increased lung volume and therefore increased tidal volume is not indicated. Atelectasis is very common in bariatric patients and the use of higher positive end expiratory pressure (PEEP) may be required as well as a high alveolar recruitment maneuver to keep the alveoli patent. This helps with improving the patient's oxygenation. However, such high pressure may lead to increase in the intrathoracic pressure causing lowering of the venous return and in turn lower cardiac output and blood pressure [10].

Table 19.3 Types of inhalational gas agents

Inhalation anesthetic agents					
Generic name	Nitrous oxide	Halothane	Isoflurane	Sevoflurane	Desflurane
Brand name	N/A	Fluothane	Forane	Ultane	Suprane
Chemical formula	N_2O	$C_2HBrClF_3$	$C_3H_2ClF_5O$	$C_4H_3F_7O$	$C_3H_2F_6O$
Odor	Slightly sweet	Sweet	Sweet	Sweet	Sweet
Color	Colorless	Colorless	Colorless	Colorless	Colorless
Pungency	None	Moderate	High	Low	Very high
Solubility:blood:gas partition coefficient	Very low: 0.46	Very high: 2.40	Moderately high: 1.40	Low: 0.65	Very low: 0.45
Redistribution:brain:blood partition coefficient	1.1	1.9	1.6	1.7	1.3
Potency:oil:gas partition coefficient	Very low: 1.4	Very high: 224.0	High: 97.0	Moderately high: 42.0	Low: 18.7
Minimu alveolar concentration (MAC) = ED_{50} for response to surgery	105.0%	0.8%	1.2%	2.0%	6.0%
MAC-awake/MAC-awake = ED_{50} for response to voice/touch	68.0%	0.4%	0.5%	0.6%	2.5%
Blood pressure effect	Negligible	Dose-dependent hypotension	Dose-dependent hypotension	Dose-dependent hypotension	Dose-dependent hypotension
Vascular effect	Negligible	Negligible	Vasodilation	Vasodilation	Initial vasoconstriction, later vasodilation
Inotropic effect	Negligible	Negative	Slightly negative	Slightly negative	Initial positive, later negative
Chronotropic effect	Negligible	Bradycardia	Tachycardia	Tachycardia >1 MAC	Tachycardia

(continued)

Table 19.3 (continued)

Inhalation anesthetic agents					
How supplied	Pressurized bottled gas	Bottled liquid	Bottled liquid	Bottled liquid	Bottled liquid
How delivered	Flowmeter	Vaporizer	Vaporizer	Vaporizer	Electric heated vaporizer
Fire risk	Supports combustion	Non-flammable	Non-flammable	Non-flammable	Non-flammable
Notes	Nausea/emesis	Nausea/emesis; bradycardia/asystole; inhalational induction; no longer used in US	Nausea/emesis; potentially significant tachycardia	Nausea/emesis; inhalational induction	Nausea/emesis; airway irritation; initial sympathomimetic

19.4 Drug Dosing for Obese Patients

Dosing guidelines are not very clear and therefore it is important to titrate medications to effects. Drug clearance is usually higher in obese vs non-obese patients. Medications are classified based on their required dose into ideal body weight dosing, lean body weight dosing, and adjusted body weight dosing. The latter is calculated by AdjBW = IBW + 0.4 [TBW − IBW].

Volume of distribution of lipophilic medications is increased in obese patients due to increase up by the adipose tissue while is decreased for hydrophilic drugs. Drug clearance is slightly higher in obese patients due increased renal and hepatic metabolism. Elimination of drugs depends on both the volume of distribution and clearance and since both are altered by obesity, elimination is altered as well.

19.5 Emergence from Inhalational Anesthesia

Patient should be completely awake, following command, with no residual muscle relaxant effect. Deep extubation is relatively contraindicated as patients have an increased risk of aspiration as well as difficult ventilation and reintubation. The head should be elevated to avoid aspiration and improve the tidal volume. Prolonged surgical procedures may be associated with airway edema and narrowing of the airway and careful removal of the endo tracheal tube should be done after performing a leak test and with available personnel and equipment in case reintubation is necessary.

19.5.1 Adjunct Medications

(a) Succinylcholine: Obesity is one of the leading causes of difficult intubation. Therefore rapid sequence intubation should be considered to avoid the possibility of “cannot intubate, cannot ventilate” scenario. Succinylcholine provides rapid muscle relaxation that allows for quick security of the airway and thus preventing that scenario as well as helping prevent aspiration that is associated with obesity.

(b) Induction agents such as Propofol, ketamine, etomidate, and thiopental are best doses based on the adjusted body weight to avoid over or under dosing of those drugs.

(c) Narcotics that tend to be highly lipophilic are better dosed based on ideal body weight to avoid excess adipose tissue uptake and redistribution back into the blood at later time.

(d) Fluid management with euvolemic is the target. Judgement on volume status should be done through multiple monitors such blood pressure, central venous pressure, urine output, and stroke volume variation [11].

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Further Reading

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Chapter 20
Regional Anesthesia in Bariatric Surgery

Andre Teixeira, Adam El Kommos, and Marisabel Linares Bolsegui

20.1 Introduction

Pain following bariatric surgery can be quite troublesome, causing suffering, prolonged recovery, and increased healthcare costs [1, 2]. There are several comorbidities common in patients with obesity, such as obstructive sleep apnea (OSA), associated metabolic syndrome, and increased susceptibility to opioid medication, that lead to difficulties in pain management [2, 3]. The first goal of regional anesthesia is to **cover the nociceptive and adrenergic stimulation** originating from the manipulation of the gastrointestinal tract and the abdominal wall. **Decreasing the pain in the immediate postoperative period** has substantial importance for the management of patients undergoing bariatric surgery [2, 3], as it may decrease the need for opioids at the critical times of emergence from general anesthetic, extubation, and immediate management in the Post Anesthetic Care Unit (PACU) [1, 3, 4]. The second goal is to guarantee **adequate postoperative analgesia without interference with bowel motility, allowing early alimentation and mobilization**, and recovery, in the same way, reducing the risk of thrombosis and respiratory infections [2]. Achieving these goals can promote an early return to normal life for the patient, allowing the early start of the postoperative weight loss program [2, 3, 5].

The complexity of the bariatric patient dictates the choice of safe anesthetic strategies for pain control. One popular approach includes **regional anesthetic techniques**, which are mainly in **neuraxial form** (spinal and epidural); or a combination of **peripheral nerve blocks** [1], such as ***transversus abdominis plane (TAP) block,*** rectus sheath block, thoracic paravertebral block, erector spinae block, local

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anesthetics administered at the surgical ports or via wound infiltration, and intraperitoneal local anesthetic administration are also possible as a part of multimodal analgesia therapy [5, 6].

A combination of general anesthesia and epidural analgesia can improve analgesia. A combination of general anesthesia and spinal analgesia is another option for open bariatric surgery, continuous spinal analgesia, although rarely performed now, was seen to be effective in intra- and postoperative pain management in patients undergoing open vertical banded gastroplasty (VBG), allowing for earlier mobilization. In some selected patients, even neuraxial anesthesia alone can be a reasonable alternative (e.g., in patients with severe respiratory impairment or with a history of difficult airway) [1].

The potential benefits of regional anesthesia are substantial and have increased the interest in these techniques for obese patients undergoing bariatric surgery [2]. Several metanalysis and systematic clinical trial reviews [4–6] have shown that the implementation **of regional anesthesia provides many advantages and** allows minimal airway manipulation, avoidance of anesthetic drugs with cardiopulmonary depression, attenuated sympathetic responses caused by the surgical insult, and reduced postoperative nausea and vomiting (PONV) [3, 5].. Therefore, patients develop fewer pulmonary complications and achieve greater postoperative pain control than those under general anesthesia, and in turn may decrease the level of stress, hospital stay, and length of recovery after surgery [1]. This likely improves postoperative outcomes and accelerated baseline function return [5]. Regional anesthesia may also reduce perioperative and postoperative opioid requirements, as well as interference with the gastrointestinal tract, allowing the surgical interventions to show their biological effects [1, 3, 6]. Regional anesthesia has also been shown to preserve immune function better than traditional techniques and opioids. Additionally, the risk of deep venous thrombosis and pulmonary embolism is lower with epidural anesthesia than with general anesthesia [6].

It is recommended to perform neuraxial blocks at least 12 h after the administration of low molecular weight heparin (LMWH) to reduce the risk of hematoma. Removal of indwelling catheters should also occur at least 12 h after administration of LMWH [1]. Obese patients require less local anesthetic in their epidural and subarachnoid spaces in order to achieve the same level of block when compared with non-obese controls. This dose requirement is due that obese patients have smaller cerebrospinal fluid volumes than non-obese individuals [3, 5, 6].

20.2 Regional Block

As an alternative to epidural analgesia, infiltrative techniques have gained increasing attention in recent years as they can be safely and easily applied [2, 6]. In the current times, there are several discussions about all the regional techniques in regional anesthesia, two of the most popular are TAP and ESP block.

20.3 Transversus Abdominal Plane Block (TAP Block)

Over the last two decades, regional neuromuscular blocks have gained clinical relevance. Especially **TAP block**, this technique has been increasingly employed in the **multimodal postoperative pain** management after various types of minimally invasive surgeries, including colorectal, biliary, gynecologic, and bariatric surgery [1, 2, 4, 7], First described by Rafi et al. in 2001 [3, 4, 7, 8], the TAP block is the injection of local anesthetics in the transversus abdominis plane, a compartment that can be found between the transversus abdominis and internal oblique muscles [7] contains the **T6-L1 thoracolumbar nerves**, responsible for the sensitivity of the anterior abdominal wall [8, 9]. Additionally, these nociceptive impulses are responsible for initiating segmental spinal reflex responses, increasing skeletal muscle tone, inhibition of phrenic nerve function, and decreasing gastrointestinal motility [6, 10].

This compartment can be accessed through several approaches and anatomical sites: **subcostal** (between anterior abdominal wall between xiphoid process and anterosuperior iliac spine, the anesthetic is deposited between rectus abdominis and transversus abdominis muscles), **lateral** (between the mid-axillary and anterior axillary lines), and **posterior** (at the level of lumbar **triangle of Petit** the area confined within iliac crest, latissimus dorsi, and external abdominal oblique muscle [7, 11], or at the level of the anterolateral aspect of the quadratus lumborum muscle). See Figs. 20.1, 20.2, and 20.3, respectively. Subcostal and posterior approaches are generally preferred over the lateral approach. Because an increased number of dermatomes is anesthetized (4 vs. 3) and higher peak of sensory blockade (T8 vs. T10) [7, 8] (*source:* Tran, D. Q., Bravo, D., Leurcharusmee, P., & Neal, J. M. (2019).

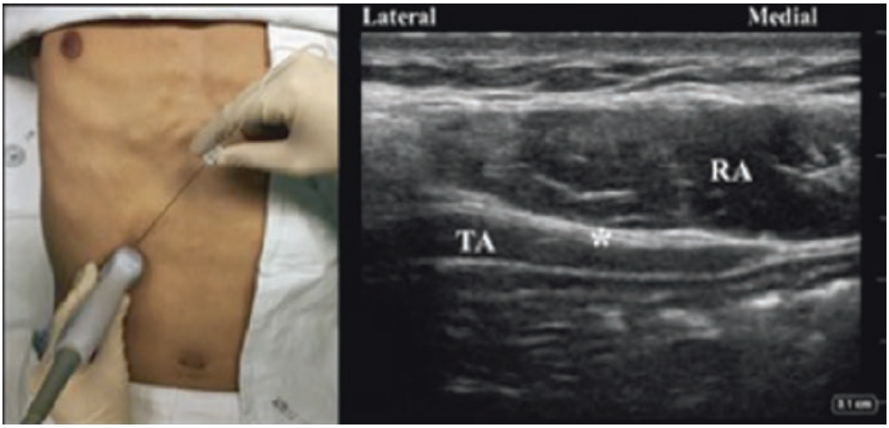

Fig. 20.1 TAP Block US landmark. Ultrasound probe position, needle puncture site, and sonographic image of the subcoastal transversus abdominis plane block. Asterisk indicates needle target; *RA* rectus abdominis muscle; *TA* transversus abdominis muscle

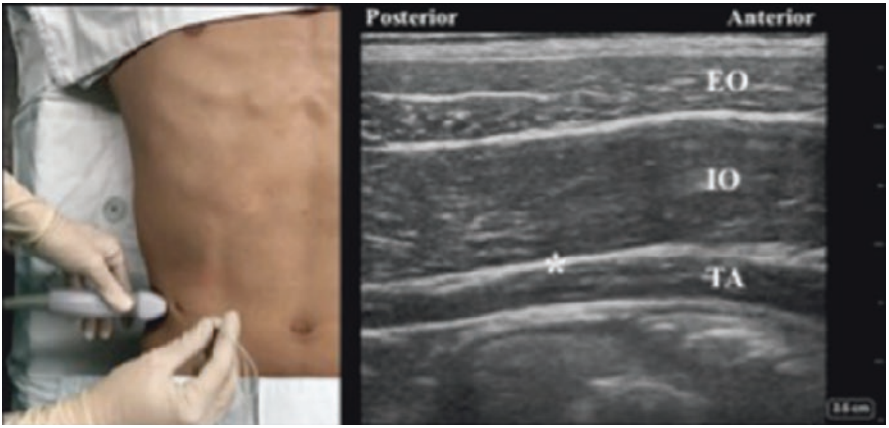

Fig. 20.2 TAP block US landmark. Ultrasound probe position, needle puncture site, and sonographic image of the lateral transversus abdominis plane block. Asterisk indicates needle target; *EO* external oblique muscle; *IO* internal oblique muscle: *TA* transversus abdominis muscle

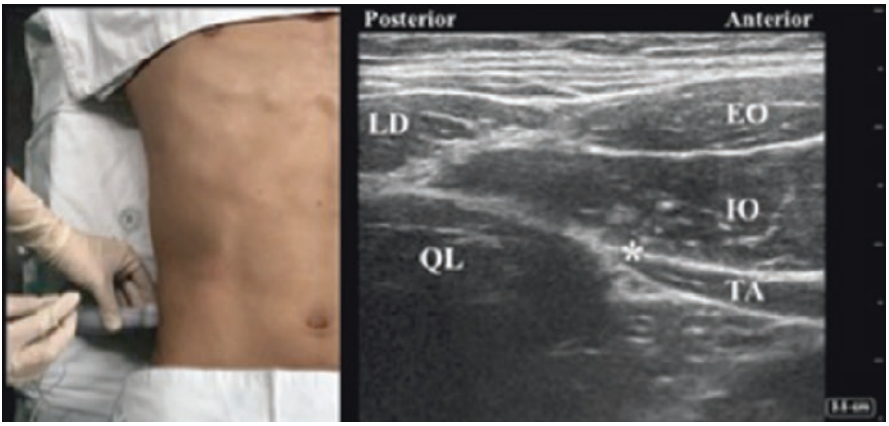

Fig. 20.3 TAP block US landmark. Ultrasound probe position, needle puncture site, and sonographic image of the posterior transversus abdominis plane block. Asterisk indicates needle target; *EO* external oblique muscle; *IO* internal oblique muscle; *LD* latissimus dorsi muscle; *QL* quadratus lumborum muscle; *TA* transversus abdominis muscle. Source: Tran, D. Q., Bravo, D., Leurcharusmee, P., & Neal, J. M. (2019). Transversus Abdominis Plane Block. Anesthesiology, 131(5), 1166–1190. https://doi.org/10.1097/ALN.0000000000002842

Transversus Abdominis Plane Block. Anesthesiology, 131(5), 1166–1190. https://doi.org/10.1097/ALN.0000000000002842) [7].

TAP can be identified with landmarks, USG, or intraoperatively by surgeons (Figs. 20.1, 20.2, and 20.3). The landmark guided technique has been used only for the posterior approach (identification of the lumbar triangle of Petit and recognition of the intermuscular plane between the internal oblique and transversus muscles with tactile pops) [1, 9, 12]. When TAP block was first described, obesity was thought to be one of the contraindications to perform the block because it is difficult to identify the triangle of Petit and other landmarks in obese patients [3, 5, 6], and there was a high risk of visceral injury [7, 9], this fact has led many authors to favor the use of **ultrasound guidance (USG)** that allowed identification of the layers of the abdominal wall even in obese patients, where landmarks are often obscured by the body habitus [7, 8]. Due to the depth of the abdominal wall structures, a low-frequency curved transducer is used to guide needle placement.

Several clinical trials suggest, according to the current knowledge that USG-TAP block must be performed bilaterally by injecting **between 0.2 to 0.5% of bupivacaine or 0.2 to 0.25% of ropivacaine and volumes of at least 15 mL** per side (usually 20–40 mL) [7–9]. It has been described that the use of adjuvants such as dexamethasone, dexmedetomidine, magnesium, and in some cases buprenorphine has increased the duration of the anesthesia, nevertheless, further research is required to better knowledge about dosing, mode of administration, and combination [12].

Considering the pharmacokinetics of the short-acting local anesthetics used, notably bupivacaine (which means elimination half-life is around 9–10 h) and ropivacaine have longer analgesic effectiveness. **The impact of TAP block during the postoperative period decreasing the opioid consumption is predicted to be significant mainly in the first 24 h**. Recently the relatively long-acting liposomal bupivacaine [4, 9] has been employed for TAP block in bariatric surgery patients, which offers the advantage of extended duration of analgesia for up to 72 h [2, 4, 7].

Furthermore, surgeons can perform TAP in the set of a laparotomy or laparoscopic incision, with the deposition of local anesthetic into the TAP under direct vision of the laparoscope. A few trials have compared surgeon- and anesthesiologist-performed TAP blocks, where the surgical technique resulted to be faster, the pain scores were similar but there was lower IV postoperative morphine consumption compared with their anesthesiologist-performed counterpart [7, 9, 12].

20.3.1 Outcomes

USG-TAP block has shown to be a practical, **effective, and safe technique for postoperative analgesia in morbidly obese patients having SPSG with a minimal incidence of complications** [12].

Several clinical trials and meta-analysis review in patients undergoing bariatric surgery has demonstrated a strong association between TAP block and **improved perioperative and postoperative** ***early (0–3 h), and late (3–24 h) pain scores*** (either at rest and on movement) during the first 24 h after surgery [4, 7], ***reduced 24-h postoperative opioid consumption*** *(cumulative IV morphine) and, consequently decreased incidence of related side effects at 24 and 48 h,* [1, 7] *shorter time to ambulation and* reduced incidence of postoperative nausea and vomiting (PONV) [1, 4]. Less need for biphasic intermittent positive airway pressure (BIPAP) ventilation support and lower Richmond Agitation and Sedation Score in the first 6 h [2].

A 2013 systematic review meta-analysis in patients going through laparoscopic sleeve gastrectomy and Roux Y gastric bypass showed that the posterior **TAP block** has a greater reduction in opioid consumption and in rest and dynamic pain scores compared with the lateral approach [1, 2, 4, 7]. Moreover, postoperative **TAP block administration resulted in greater effects decreasing opioid consumption at 24 h compared with *preoperative* block administration** [1, 4, 7, 9]. The literature evaluation has shown statistically significant difference improvement in time to **postoperative bowel recovery, lower sedation score, shortened time to ambulate,** [13] **reduced number of complications of immobilization higher satisfaction scores compared to the control group** [2–4, 7], with very low rate incidence of complications related to the TAP block procedure (e.g., hematoma, visceral injury), symptoms of local anesthetic toxicity or any significant adverse event [4, 7]. All those factors help the faster recovery of patients [2] and likely shorter length hospital stay [10].

20.3.2 Erector Spinae Plane Block (ESPB)

The erector spinae plane block (ESPB) Fig. 20.4 is a relatively new procedure, first described in 2016 [14] as another alternative to conventional thoracic regional anesthetic techniques such as thoracic epidural and paravertebral injections [15, 16]. Clinical studies have demonstrated that the block targets both the *ventral and dorsal spinal rami*, and sympathetic chain. Exploration of the anatomical basis of the block has shown that cranio-caudal local anesthetic spread allows for anesthesia of most of the thoracic cavity [17, 18].

One of the advantages of ESPB compared to more conventional techniques is that this block targets a plane that is far removed from the pleura and neuraxial structures, improving its safety profile Fig. 20.5 [11]. The mechanism of action of ESPB has also been shown to involve both transforaminal and epidural spread, giving the technique an advantage over direct intercostal nerve blockade. In delivery of ESPB, local anesthetic is injected into the fascial plane, **deep to the erector spinae muscle group, to achieve analgesia of the thoracic and abdominal wall**. Anatomically, ESPB targets the tips of the transverse processes, giving it a distinct advantage over retrolaminar block, which targets the laminae and involves injection over the thick spinalis and transversospinalis muscle groups. ESPB can be performed at the level of T5, T6, T7, or T8 transverses processes [14] to target the thoracoabdominal area Fig. 20.6. Since the erector spinae muscle extends inferiorly to the lumbar spine, injection at the lower vertebral level spreads to the lower thoracoabdominal nerves Fig. 20.7. Anatomically, the relatively superficial location of the ESP block, distant from any major blood vessels and nervous structures, also minimizes concerns regarding anticoagulation and the development of a clinically significant hematoma [16].

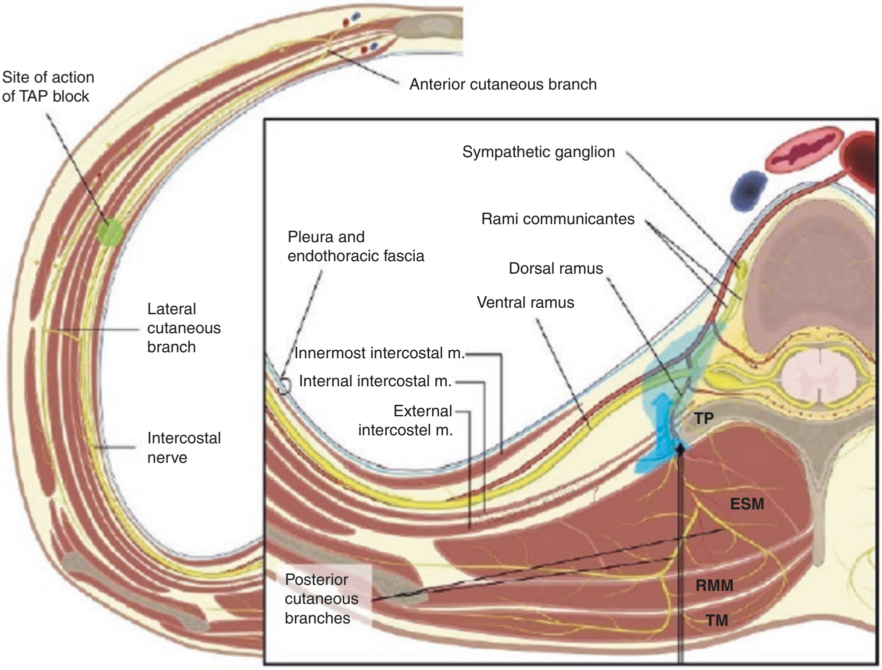

Fig. 20.4 ESP block anatomy. Anatomy of the ESP block. Local anesthetic (in blue) injected anterior (deep) to the erector spinae muscle (ESM) spreads in a cranial direction along this tissue plane. Also enters the thoracic paravertebral space to anesthetize not only the ventral ramus and dorsal ramus of the spinal nerve, but also the white and gray rami communicants that carry the preganglionic and postganglionic sympathetic fibers to and from the sympathetic ganglia. The ESP block thus has the potential to provide both somatic and visceral analgesia to the trunk. Source: Chin, K. J., Malhas, L., & Perlas, A. (2017). The Erector Spinae Plane Block Provides Visceral Abdominal Analgesia in Bariatric Surgery: A Report of 3 Cases. Regional Anesthesia and Pain Medicine, 42(3), 372–376. https://doi.org/10.1097/AAP.0000000000000581

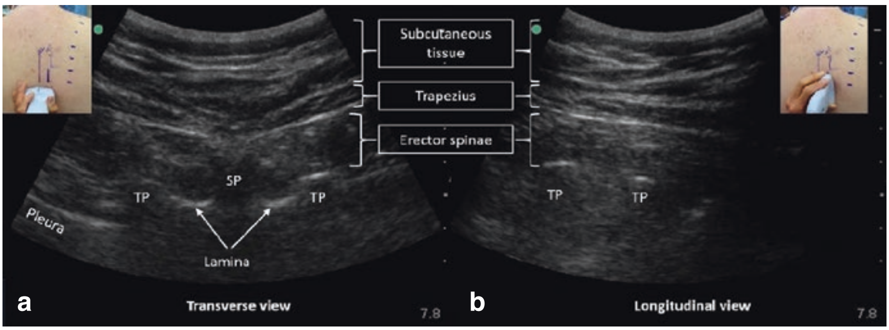

Fig. 20.5 ESP block. Targets a plane that is far removed from the pleura and neuraxial structures. Target transverse process is determined by surface landmarks or using the probe to count up from the 12th rib or down from 1srt rib (**a**, **b**)

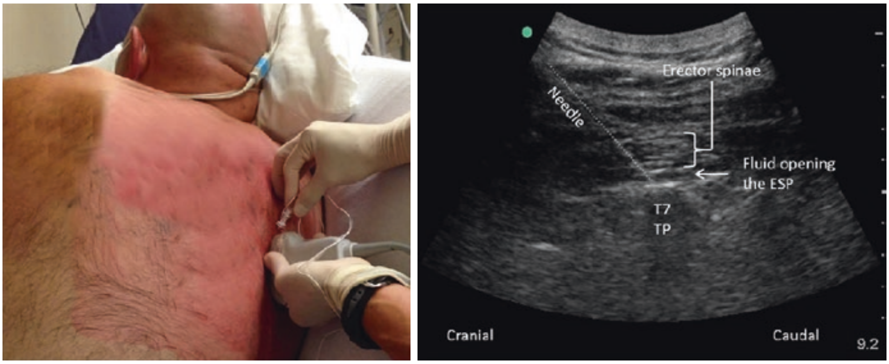

Fig. 20.6 ESP block. Erector spinae approach. Source: Chin, K. J., Malhas, L., & Perlas, A. (2017). The Erector Spinae Plane Block Provides Visceral Abdominal Analgesia in Bariatric Surgery: A Report of 3 Cases. Regional Anesthesia and Pain Medicine, 42(3), 372–376. https://doi.org/10.1097/AAP.0000000000000581

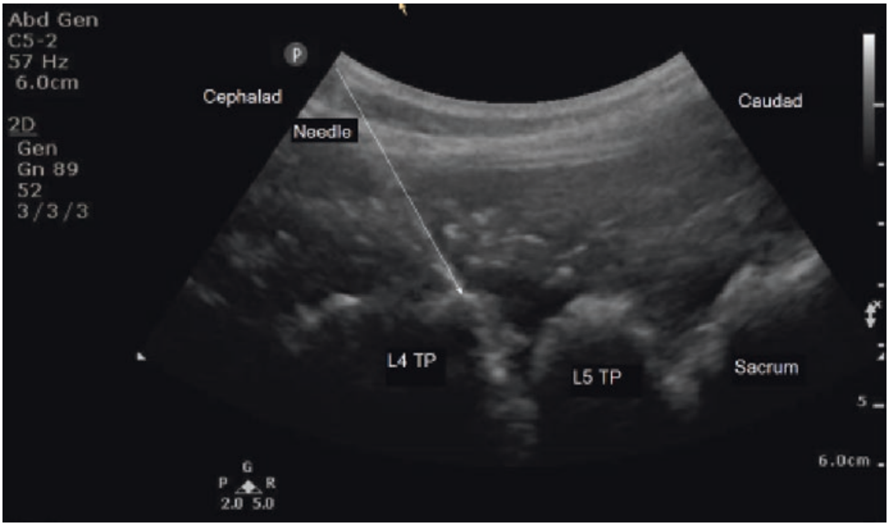

Fig. 20.7 ESP block. Ultrasound image of the erector spinae block performed at L4 transverse process. Source: Harbell, M. W., Seamans, D. P., Koyyalamudi, V., Kraus, M. B., Craner, R. C., & Langley, N. R. (2020). Evaluating the extent of lumbar erector spinae plane block: An anatomical study. Regional Anesthesia & Pain Medicine, 45(8), 640–644. https://doi.org/10.1136/rapm-2020-101523 [11]

In the case report study realized by (Chin et al., 2017), three patients underwent ESP block with 20 mL of 0.5% ropivacaine. The results indicated that ESP block has provided significant relief of upper abdominal pain [10].

These three cases illustrated that the ESP block may hold potential as a **relatively simple regional anesthesia technique, providing both visceral and somatic analgesia in postoperative pain following laparoscopic bariatric**

surgery, however, the authors suggested further clinical investigation, including prospective randomized controlled trials, to clearly establish the potential efficacy of ESP block as an analgesic modality in laparoscopic bariatric surgery [10, 16].

In a clinical trial realized by (Mostafa et al., 2021), which was the first prospective randomized trial to investigate the impacts of ESPB on perioperative analgesia, and pulmonary functions in patients suffering from morbid obesity for bariatric surgery using laparoscopy. Showed that bilateral **ultrasound guided ESPB effectively provided lower postoperative pain score** in the first 8 postoperative hours with decreased perioperative analgesic consumptions. Measured as significant **reduction in postoperative VAS scores for the first 8 h, intraoperative fentanyl consumption as well as the first 24 h postoperative cumulative morphine consumption**. Nevertheless, no significant differences in postoperative pulmonary functions were detected between both groups [14].

20.4 Conclusion

Enhanced Recovery After Surgery (ERAS) protocols suggest the implementation of regional techniques such as USG-TAP and USG-ESP block as part of multimodal analgesia for postoperative pain management, in patients undergoing laparoscopic bariatric surgery. These procedures can have utility when neuraxial techniques or opioids are contraindicated [4, 16]. Multimodal systemic medication and local anesthetic infiltration techniques should be combined, since there is a strong scientific evidence that regional block procedures as TAP or, more recently ESP blockade provides several benefits in the pain management setting, with **less use of opioids compared to traditional techniques and may decrease the level of stress, decrease** incidence of thromboembolic complications, **and length of recovery after surgery, as well as provides** higher rates of patient satisfaction [4, 12]. It has also shown that regional anesthesia preserves immune function better than general anesthesia and opioids [6, 7].

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Chapter 21
Multimodal Analgesia in Bariatric Surgery

Andre Teixeira, Adam El Kommos, and Laura V. Medina Andara

21.1 Introduction

Pain control after bariatric surgery represents a major challenge for the perioperative team. Comorbidities in the bariatric population such as obstructive sleep apnea, hyper-coagulopathies, and metabolic syndromes prevent this patient population from more traditional postoperative pain management strategies. The goals of postoperative pain management in the bariatric population are to provide adequate comfort while fostering early mobilization with minimal respiratory depression. One such strategy that has been recently popularized is multimodal analgesia.

Multimodal analgesia is a pharmacologic method of pain management which combines various groups of medications for pain relief. Its purpose is to target more than one pain mechanism, therefore diminishing adverse side effects of any drug class: especially opioid-induced respiratory complications. Typical drug classes in multimodal analgesia include acetaminophen, nonsteroidal anti-inflammatories, local anesthetics, alpha-2 inhibitors, steroids, calcium channel blockers, and NDMA antagonist. In addition to drug classes, other strategies implored with the multimodal analgesia method include peripheral nerve blocks, local wound infiltration, and neural-axial techniques. However, it is important to also recognize that even with the implementation of multimodal analgesia, there is a role for opiates during the patient's hospital course: primarily as a rescue analgesic in reduced dosing.

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21.2 Opiates

Opioids have been the mainstay for postoperative pain relief in patients undergoing laparoscopic bariatric surgery for many decades and are often critical for perioperative pain management. Opioids mimic the actions of endogenous opioid peptides by interacting with mu-, delta-, or kappa-opioid receptors. The adverse effects of prescription opioids are well documented. Opioids are associated with immunosuppression, opioid-induced endocrinopathy (sexual dysfunction, depression, and decreased energy), hyperalgesia, nausea, vomiting, constipation, physical dependence, delayed gastric emptying, tolerance, and respiratory depression. Hyperalgesia has been demonstrated with exposure to both short- and long-term opioids [1]. Respiratory depression secondary to opiates in the bariatric surgery population is one of the primary reasons why multimodal analgesia is implemented.

21.3 Acetaminophen

Acetaminophen also called paracetamol is one of the most widely used analgesic drugs due to its good tolerance and high safety profile. The exact mechanism of action (MOA) of acetaminophen is not known. Acetaminophen can be administered in various ways; an intravenous (IV) formulation was approved by the US Food and Drug Administration (FDA) in 2010 for mild to severe pain as an adjunct to opioids [2]. Bariatric surgeries can alter the absorption of medications leading to decreased bioavailability, absorption, and effectiveness; thus, IV acetaminophen is the preferred route for these types of surgeries [3]. Acetaminophen has been proven to be beneficial in decreasing the length of hospitalization, opioid consumption, and pain; however, its results are not the same in all the surgeries [2].

Recent trials have been exploring the role of intravenous (IV) acetaminophen in multimodal analgesic therapy in bariatric surgery. Patients who received IV acetaminophen 1 g every 6 h during the 24-h postoperative period consumed fewer intravenous morphine equivalents and had similar pain scores as patients who were treated with opioids alone. These patients also had earlier return of bowel function [4, 5]. Overall, the studies suggest that the use of IV acetaminophen after bariatric surgery is effective in reducing postoperative pain scores and opioid doses in these patients [5]. The use of IV acetaminophen is a rational first-line opioid adjuvant for postoperative pain management in bariatric patients and should be concerned as a scheduled medication [6].

21.4 Nonsteroidal Anti-Inflammatory Drugs (NSAIDs)

NSAIDs include ibuprofen, naproxen, indomethacin, ketorolac, and diclofenac, a class of medication commonly used as an analgesic to reduce myofascial pain, postoperative pain, and chronic pain conditions. NSAIDs are potent analgesics (600 mg of ibuprofen is as efficacious as 15 mg of oxycodone hydrochloride) and act through inhibition of cyclooxygenase and prostaglandin synthesis [5], thus blocking the sensitization of pain receptors by blocking the inflammatory cascade that occurs during surgery.

A randomized controlled trial highlighted by the Safety Program for Improving Surgical Care and Recovery (ISCR) showed that the use of IV ketorolac versus placebo in patients undergoing laparoscopic gastric bypass surgery was associated with lower pain scores, improved ability to cooperate with respiratory physical therapy, and improved postoperative patient satisfaction [7]. However, a study carried out between January 2016 and January 2017 showed that an intravenous administration of 800 mg ibuprofen did not significantly reduce opioid consumption; however, it reduced the severity of pain compared with 1 g of IV acetaminophen in patients under bariatric surgery [7].

The use of NSAIDs is controversial. Like opioids, there are numerous side effects of NSAIDs specific to the bariatric population including gastric irritation, gastric bleeding, platelet dysfunction, increased risk of cardiovascular disease, and worsening renal function [8]. Therefore, caution is advised in selecting the appropriate NSAID for a patient after consultation with the perioperative healthcare providers [5].

21.5 *N*-Methyl-D-Aspartate Antagonists

The *N*-methyl-D-aspartate (NMDA) class of glutamate receptor is involved with nociceptive processing and development of chronic pain. Clinically available NMDA antagonists include ketamine hydrochloride, magnesium sulfate, dextromethorphan hydrobromide, and methadone.

Ketamine is a nonbarbiturate that abolishes peripheral afferent noxious stimulation and may also prevent central sensitization of nociceptors. There are no studies specifically examining the use of intraoperative ketamine alone in patients undergoing bariatric surgery. The administration of a low dose of ketamine and clonidine at induction of anesthesia is associated with earlier extubation and less pain in open bariatric surgical patients [7]. The side effects of ketamine include increased sympathetic activity, elevated intracranial pressure, increased salivation, nystagmus, and hallucinations. Therefore, caution is advised when using ketamine in patients with coronary artery disease, intracranial pathology, and psychiatric comorbidities [2].

There were no studies specifically for magnesium sulfate in bariatric surgery, but other sources have indicated that perioperative magnesium infusion is associated with a decrease in postoperative pain and opioid consumption without clinical toxic effects caused by toxic serum levels of magnesium [5]. As for dextromethorphan, it is not commonly reported as an analgesic after bariatric surgery. If the clinician decides to use dextromethorphan for the bariatric surgical patients, it should be noted that the optimal dosing of dextromethorphan is uncertain, although typical doses used range from 30 to 60 mg orally given preoperatively and postoperatively on a twice a day or TID dosing regimen afterward [7].

21.6 Alpha-2 Agonists

The two common alpha-2 agonists used in clinical practice today are clonidine and dexmedetomidine. They bind to the presynaptic alpha-2 adrenoceptors which inhibit the release of norepinephrine, therefore terminating the propagation of pain signals. Dexmedetomidine has a much higher affinity (approximately 8:1) than clonidine at the alpha-2 receptor site. Both agents may significantly reduce opioid consumption, postoperative nausea/vomiting, anxiety, postoperative shivering, and stress responses intraoperatively [3]. The use of dexmedetomidine has been studied in two recent papers due to its safety profile regarding respiratory depression and better hemodynamic stability [2]. In the setting of bariatric surgery, six studies were highlighted by the taskforce (ISCR) suggesting that a perioperative IV infusion of dexmedetomidine may be associated with a decrease in pain scores and opioid requirements during this period. Patients also had better pain control and a lower incidence of postoperative nausea and vomiting (PONV) without any reported major adverse events [7].

21.7 Calcium Channel Blocker

The release of excitatory neurotransmitters including glutamate and pain-inducing peptides such as substance P from presynaptic sites is stimulated by the opening of activation of voltage-gated calcium channels and calcium influx; therefore, blocking calcium channels can play a significant role in modulating both nociceptive and antinociceptive processes. Gabapentin, pregabalin, zonisamide, ziconotide, and levetiracetam are examples of drugs that block calcium channels as a part of their MOAs and have been used in pain management.

Pregabalin and gabapentin were originally used as anticonvulsant, but recent studies have shown that they can also be used for pain management. Meta-analyses indicate that a single dose of gabapentin or pregabalin administered preoperatively is associated with a decrease in postoperative pain and opioid consumption at 24 h but an increase in postoperative sedation, dizziness, and visual disturbances [9].

There are two small studies examining the preoperative administration of gabapentinoids before bariatric surgery. Both suggest that the administration of preoperative gabapentinoids may result in lower pain levels and less postoperative nausea and vomiting (PONV) although there may not be a decrease in opioid consumption [9].

However, a study conducted to evaluate the effect of a single dose of preoperative pregabalin (75 mg) vs placebo in patients undergoing bariatric surgery showed that a single preoperative dose of pregabalin did not improve pain relief, quality of postoperative recovery, or reduction in opioid consumption [5].

21.8 Lidocaine Patches

The MOA of lidocaine patch is believed to provide analgesia by reducing aberrant firing of sodium channels on damaged pain fibers directly under the patch**.** There is no evidence that lidocaine patches exert any effect in postoperative bariatric surgery [7]; although, in other sources, lidocaine patches (intradermal) are generally well tolerated and compared with other opioids and nonopioid analgesics, it has a very favorable (low risk) adverse effect profile [5] and should be considered for some patients.

21.9 Tramadol

Tramadol produces analgesia via dual opioid (very weak mu-opioid receptor activation) and nonopioid (inhibits serotonin and norepinephrine reuptake) MOAs [5]. Tramadol produces analgesia with a relatively lower risk of addiction, less constipation, minimal cardiovascular adverse effects, and minimal respiratory depression. However, the analgesic efficacy of tramadol for bariatric surgical patients is uncertain. Tramadol has less μ-receptor (opioid) activity than morphine and may be a useful analgesic adjunct because it demonstrates a weak moderate analgesic effect that is significantly improved when combined with acetaminophen [5].

21.10 Local Anesthetic Wound Infiltration and Infusions

Wound infiltration can be performed either as a single injection of local anesthetic (typically at the conclusion of surgery) or as a continuous infusion of local anesthetic through a catheter at the incision site placed by the surgeon prior to skin closure; the last one has been associated with a decrease in morphine consumption, a need for opioid rescue, and significantly lower pain scores within the first hour. Studies available on the field of bariatric surgery investigating the continuous infusion of local anesthetic suggest that this technique may be associated with lower opioid use with no difference in pain score [5]. However, there is not a definitive conclusion due to the limited data on this field.

21.11 Conclusion

Over the years, there has been a greater interest about better postoperative pain management and safety on patients undergoing bariatric surgery. Recently, the Agency for Healthcare Research and Quality (AHRQ), together with other institutions [7], reviewed evidence-based pathways of care to improve outcomes and enhance perioperative care and patient safety including patients undergoing bariatric surgery.

This taskforce and other investigations highlighted the importance of multimodal analgesia in the bariatric population to improve patient outcomes and minimize adverse outcomes. Multimodal analgesia for bariatric surgery should be implemented by the perioperative team by considering the risks and benefits of each drug class and analgesic strategy, alone and in conjunction with one another.

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Chapter 22
Anatomical Considerations

Almino Cardoso Ramos and Eduardo Lemos De Souza Bastos

22.1 Introduction

Even with all the literature support for biliopancreatic diversion with duodenal switch plus sleeve gastrectomy (BPD-DS) and its variant, the single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S), as the most effective procedure among all the bariatric surgical techniques, inducing weight loss and achieving metabolic improvement, these surgical modalities have very few worldwide acceptation with less than 1% of the worldwide weight loss surgery preference [1–3]. This low acceptance could be associated with the hypoabsorptive nature of the procedure with high risks in terms of serious nutritional complications, including anemia and hypoproteinemia, and also the major surgical complexity of the surgery, involving steps in all the four different abdominal quadrants with duodenal dissection, division, and anastomosis, steps considered as very challenging for the majority of the bariatric surgeons. The complete knowledge about surgical anatomy of the stomach, duodenum, jejunum, and ileum is absolutely important in preparation and training for reaching optimum results with duodenal switch-style bariatric procedures. In this chapter, we will highlight the most important anatomical considerations in order to be well prepared for the most complex bariatric/metabolic technical alternative.

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22.2 Sleeve Gastrectomy

In general, the majority of the surgeons start the BPD-DS and SADI-S by the sleeve part of the procedure with the stomach approach being the first target of the surgery. The stomach is a bag-shaped muscular, highly vascularized food reservoir organ with a great capacity of distension that can assume different sizes and shapes, from time to time, depending on the volume and kind of content (liquids or solid food), the posture or position (standing, sitting, or lying down), and the fullness state of the digestive organ [4, 5]. The stomach has a content capacity of about 60–90 mL when empty and totally relaxed but can expand to hold more than 1 L of food, and in great stretch situations, the gastric capacity can achieve up to 4 L of content [6, 7]. The fundus involves the superior third segment of the stomach, including the cardia and the esophagogastric angle (His angle), representing the stomach portion with maximum capacity dilation to accumulate food and also the most important place in production of the major hormone of hunger, the ghrelin [8]. Then there is a tubular right curved part of the stomach, the body, leading to the final triangular shape portion, the antrum, orientated to the right, starting at the level of the *incisura angularis* and finishing in the pyloric channel with the pyloric sphincter [9–11].

Surgeons will start the sleeve gastrectomy part of the BPD-DS or SADI-S by dissection and exposing the esophagogastric angle or dividing the vessels of the greater curve looking for having access for the tubular gastric resection. Considering the first choice, the esophagus comes from the thorax and enters the abdomen passing through the right crus of the diaphragm, via the esophageal hiatus, and has a small 2–3 cm abdominal length portion, finishing in the esophagogastric junction, the cardia [12, 13]. In this abdominal course, it is covered with the peritoneum of the greater sac anteriorly and on its left side, and it is covered with the lesser sac peritoneum on the right posterior side [9]. In the case of starting the sleeve by this upper part, the surgeon will open this peritoneum with electrocauterization or bipolar or ultrasonic energy exposing all the left lateral part of the right crus. Some surgeons will also remove the fat pad, a landmark in the top of the fundus, just close to the esophagogastric junction, while some don't [14–17].

The greater curve of the stomach starts at the level of the apex of the fundus running distally along the left border of the body of the stomach and the inferior border of the antrum and pylorus in a convex trajectory. The lesser curvature starts at the right of the cardia as a continuation of the right border of the abdominal esophagus and runs along the right side of the body and the antrum in a concave trajectory including the *incisura angularis* in the middle [10, 11]. The blood supply of the stomach is very rich, with many vessels overlapping. The lesser curve is supplied by the left gastric artery, coming straight from the celiac trunk and the right gastric artery, a branch from the hepatic artery. The greater curve is supplied by the right gastroepiploic artery arising from the gastroduodenal artery and the left gastroepiploic artery and the short gastric arteries originating from the splenic artery making an extensive arcade. This arcade gives off multiple small arteries to the body and antrum of the stomach. This excellent collateral blood supply of the stomach allows the surgeon to ligate much of the arterial supply without any risk of ischemia [18].

These vascular branches will be divided just close to the gastric wall using bipolar or harmonic energy releasing the greater curve for the tubular gastrectomy with linear 60 mm cartridge stapling. In general, the surgeon will look for the thinnest point in the gastric connection with the omentum to start the dissection. There is no necessity for using metallic clips. Once we open, we will reach the retrogastric space, the *bursa omentalis* or lesser sac, behind the stomach and in front of the pancreas. Now surgeons will take the decision about progressing with the division at first up till the esophagogastric angle, ligating all the short vessels, or moving down up to the pylorus or vice versa (Fig. 22.1). Few peritoneal bands may be identified between the posterior surface of the stomach and the anterior surface of the pancreas, and these adhesions should be removed. With all the greater curve released, the stapling of the stomach can be initiated (Fig. 22.2). It is important to have clear differences of gastric wall thickness according to the different portions of the stomach that will become progressively thicker from the fundus to the antrum and from greater to smaller curve. The average thickness is 1.7 mm, 2.4 mm, and 3.1 mm in the fundus, body, and antrum, respectively, and will orientate the choice of the color of the cartridge based on the range diameter for closing the staples [19, 20].

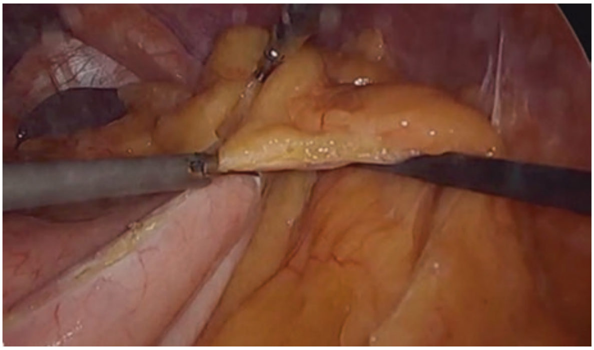

Fig. 22.1 Division of the greater curve: gastroepiploic vessels arcade

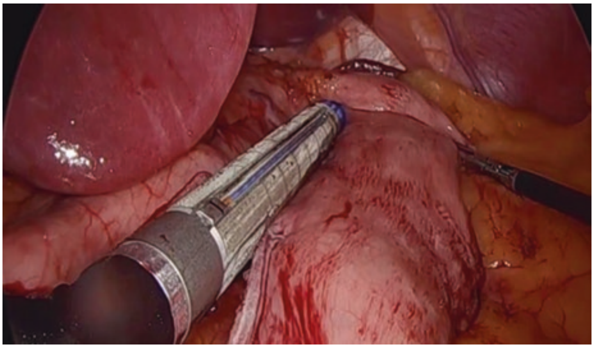

Fig. 22.2 Stapling of the stomach creating the gastric sleeve

Sleeve gastrectomy was initially proposed as part of the BPD-DS, named parietal gastrectomy, with the objective of reducing acid gastric production to decrease the possibility of peptic complications of the procedure such as the anastomotic ulcer. The esophagus is covered with nonkeratinized stratified squamous epithelium, which changes into columnar epithelium in the stomach. The columnar cells in all of the stomach secrete mucin; the main zymogenic cells in the fundus secrete protein-digesting pre-enzyme pepsinogen; the parietal oxyntic cells in the body of the stomach secrete acid and intrinsic factor; and the G cells in the antrum secrete gastrin that can stimulate parietal cells in acid production [21–25].

The celiac trunk arises from the anterior surface of the abdominal aorta at the level of the first lumbar vertebrae. It has a short length, about 1 cm long, and trifurcates into the common hepatic artery (CHA), the splenic artery (SA), and the left gastric artery (LGA). The LGA runs toward the lesser curvature of the stomach and divides into an ascending branch (vascularizing the abdominal segment of the esophagus) and a descending branch for the proximal stomach. The CHA runs toward the right on the superior margin of the pancreas and gives off the gastroduodenal artery (GDA), which runs down behind the first part of the duodenum. After giving off the GDA, the CHA continues as the proper or common hepatic artery (CHA) [10–16].

The right gastric artery (RGA), a branch from CHA, runs along the lesser curvature from right to left and joins the descending branch of the LGA to form an arcade along the lesser curvature between the two leaves of the peritoneum of the lesser omentum. This arcade gives off multiple small arteries to the antrum and body of the stomach [10–16].

The greater curvature arcade is formed by the RGEA and the LGEA providing several omental (epiploic) branches to supply the highly vascularized greater omentum. The splenic artery also gives off three to five short gastric arteries that run in the gastro-splenic (gastro-lienal) ligament and supply the upper part of the greater curvature and the gastric fundus, sometimes collectively referred to as the *vasa brevia*. Few small posterior gastric arteries may arise from the splenic artery. The stomach has a vast network of vessels in its submucosa [10–16].

The left gastric (coronary) vein drains into the portal vein at its formation (by the union of the splenic and superior mesenteric veins). The right gastric and right gastro-omental veins drain into the portal vein. The left gastro-omental vein drains into the splenic vein, as do the short gastric veins [10–16].

The esophageal plexus of vagus (parasympathetic) nerves lies in the posterior mediastinum below the hila of the lungs. It divides into two vagal trunks that enter the abdomen along with the esophagus through the esophageal hiatus in the left dome of the diaphragm. The right (posterior) vagus is behind and to the right of the intra-abdominal esophagus, whereas the left vagus is in front of the intra-abdominal esophagus [10–16].

22.3 Duodenal Approach

The small bowel is the intestinal part placed between the stomach and the colon including three different portions, duodenum, jejunum, and ileum. Talking about the technical steps for BPD-DS and SADI-S, the duodenal dissection looks to be the major anatomic barrier for increasing the international acceptance for these DS bariatric model surgical procedures. Surgeons are a little afraid of working in an area with big vessels, pancreas, and common bile duct (CBD), for duodenal dissection and division (Fig. 22.3), finishing the surgery with a manual duodeno-ileal anastomosis [26].

The duodenum corresponds to the shortest part of the small intestine with about 25 cm and can be divided into four segments: superior, descending, horizontal, and ascending in a "C" shape. The first superior part, or bulb with 5 cm, is connected to the undersurface of the liver by the hepatoduodenal ligament, which contains the proper hepatic artery, portal vein, and common bile duct (CBD); the quadrate lobe of the liver and gallbladder are in front, and the CBD, portal vein, and GDA are behind. The second descending part, or the "C" connection loop with 8–10 cm, which has a double, upper and lower, flexure, is related to the transverse mesocolon and colon in front and the right kidney and inferior vena cava (IVC) behind; the head of the pancreas lies in the concavity of the duodenal "C." The third horizontal part with 5–7 cm runs from right to left in front of the IVC and aorta, with the superior mesenteric vessels, the vein on the right and the artery on the left, anteriorly. The fourth ascending part with 2.5 cm will continue as the jejunum. The duodenojejunal junction or flexure is an abrupt turn at the level of the second lumbar vertebrae and can be identified during surgery just to the right of the inferior mesenteric vein (IMV). It is attached posteriorly by the suspensory muscle of the duodenum or the ligament of Treitz [27, 28]. The GDA, a branch of the CHA, runs down behind the first part of the duodenum in front of the neck of the pancreas and gives off the posterior superior pancreaticoduodenal artery (PSPDA) before it divides into the right gastroepiploic (gastro-omental) artery (RGEA) and the anterior superior pancreaticoduodenal artery (ASPDA) [27, 28].

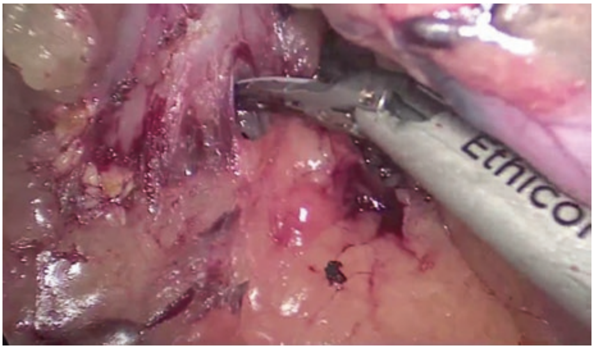

Fig. 22.3 Retroduodenal dissection close to the gastroduodenal artery (GDA)

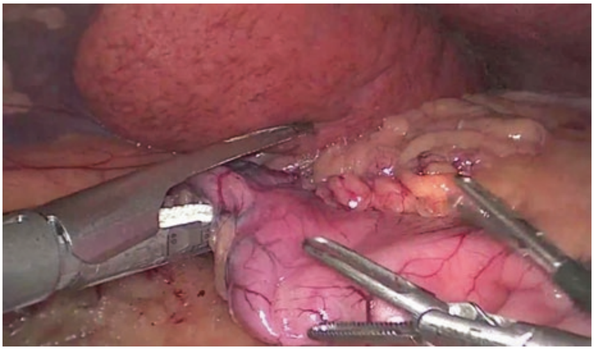

Fig. 22.4 Duodenal division

Once dissected and divided, the first part of the duodenum is mobile and can be used for the duodeno-ileal anastomosis (Fig. 22.4). Duodenal dissection starts in the duodenocolic ligament moving posteriorly in the retroduodenal space having the pancreas behind. This space is a vascular crossing in between the posterior surface of the duodenum and anterior to the pancreas. Next the opposite side in the duodenal hepatic ligament will be opened. Inferior limit will be the gastroduodenal artery [29, 30]. A thin tape can be used to repair and mobilize the duodenum. In this part of the procedure, some surgeons will prefer to divide the right gastric artery in order to reach a better mobilization of the divided duodenal limb. This can be done in between clips or simply by using bipolar or harmonic energy. Now, the duodenum can be transected with linear stapling trying to keep the largest segment as possible (Fig. 22.4). This distal part of the duodenum will be anastomosed to the ileum by manual suture or using linear staple [31, 32].

22.4 Jejunum and Ileum

In continuity with the duodenum, jejunum and ileum are a 4–12-m-long (average 6–7 m) convoluted tube occupying the center of the abdomen and the pelvis, surrounded on the two sides by the right and left colon and above by the transverse colon. The ileum continues into the large intestine (cecum) at the ileocecal junction [33, 34].

The jejunum constitutes about two fifths of the proximal small intestine, and the ileum makes the distal three fifths. No clear demarcation can be noted between the jejunum and ileum; however, there are some references which can help to distinguish the jejunum from the ileum. The jejunum has a thicker wall and a wider lumen than the ileum and mainly occupies the left upper and central abdomen. Mesenteric fat is less abundant in the mesentery of the jejunum, and vessels in the mesentery are, therefore, well seen [31–34].

The ileum has a thinner wall and a smaller lumen than the jejunum and mainly occupies the central and right lower abdomen and pelvis. Mesenteric fat is abundant in the mesentery of the ileum, and vessels in the mesentery are, therefore, not well seen. The mesentery is a double fold of peritoneum attached to the posterior abdominal wall. It is fan-shaped with a root of about 15 cm which covers the entire length of the jejunum and ileum. Between the two leaves of the mesentery are the mesenteric vessels and lymph nodes [31–34].

The superior mesenteric artery (SMA) is the main artery of the small intestine; it comes off as the second branch from the anterior surface of the abdominal aorta 1 cm below the celiac trunk, behind the neck of the pancreas. From there, it descends in front of the uncinate process of the pancreas and the third horizontal part of the duodenum to enter the small intestine mesentery. Multiple jejunal and ileal branches arise from the left side of the SMA. They anastomose with each other to form a series of loops or arcades from which arise the terminal (end) branches, called vasa recta, which supply the jejunum and ileum and lie between the two leaves of the small intestine mesentery. Jejunum has fewer (two to three) series of arcades, and the vasa recta are longer. The ileum has more (four to five) series of arcades, and the vasa recta are shorter [31–34].

From the right side of the SMA arise ileocolic, right colic, and middle colic arteries. The ileocolic artery or one of its branches gives off the appendicular artery. The ileal branch of the ileocolic artery anastomoses with the terminal ileal branch of the SMA. The left branch of the middle colic artery anastomoses with the ascending branch of the left colic artery (which in itself is a branch of the inferior mesenteric artery).

Jejunal, ileal, ileocolic, right colic, and middle colic arteries are accompanied by the same named veins, which drain into the SMV [31–34].

The superior mesenteric vein (SMV) lies to the right of the SMA in front of the uncinate process of the pancreas and the third part of the duodenum. The union of the vertical SMV and the horizontal splenic vein forms the portal vein (PV) behind the neck of the pancreas. The inferior mesenteric vein (IMV) lies to the immediate left of the duodenojejunal (DJ) flexure and joins the junction of the splenic vein (SV) and SMV. The PV runs up (superiorly) behind the first part of the duodenum in the hepatoduodenal ligament (HDL) behind (posterior to) the bile duct on the right and the proper hepatic artery (HA) on the left. The portal venous system (SV, SMV, and PV) has no valves [31–34].

From the point of view of nutritional balance and nutrient's absorption, the proximal jejunum and distal ileum are more important; the distal jejunum and proximal ileum (mid-small bowel) can be more easily sacrificed or bypassed without much disturbance of absorption and risk of malnutrition [34]. Also, in this kind of surgery, keeping the first part of duodenum in alimentary bowel transit will collaborate in improving micronutrient nutritional balance.

Once we have finished sleeve gastrectomy and duodenal division, the next step of the surgery will be identifying the ileocecal valve and progress carefully mobilizing and counting the length of the total alimentary limb length for BPD-DS or common channel in the case of the SADI-S technique, proceeding with the subsequent duodeno-ileal anastomosis (Fig. 22.5) that will finish this procedure or moving with ensuing ileal section and jejunoileal anastomosis in the case of BPD-DS [14–17]. Suture of the intestinal mesenteric gaps to avoid internal hernia occurrence would be the closing step of the procedure.

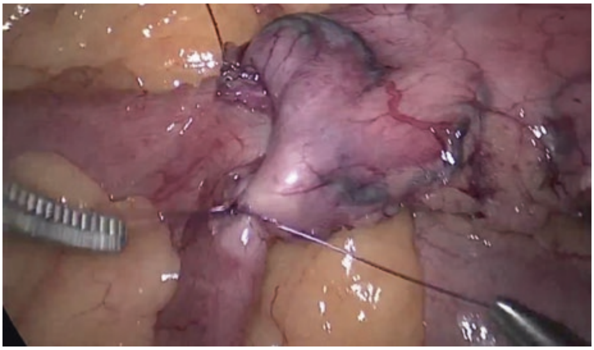

Fig. 22.5 Duodeno-ileal anastomosis

22.5 Summary

BPD-DS or SADI-S is considered the most complex bariatric/metabolic technique. Surgeons more frequently will start the procedure by the gastric approach with the greater curve liberation for proceeding the tubular gastrectomy. Next will be duodenal dissection, and it is considered very important to have an adequate anatomic knowledge of the region mostly over vascular supply, pancreas, and biliary tract. This is not an easy approach for most surgeons. After duodenum dissection and division, the surgical working field will change for the right inferior abdominal quadrant to ileocecal identification and ileal measurement defining the length of the limbs. The last part will be proceeding with the gastrointestinal tract reconstruction by duodeno-ileostomy that will complete a SADI-S procedure or move with the final part of the BPD-DS, the jejunoileal anastomosis.

Key Learning Points

The knowledge and adequate mastery of anatomic relations involving the stomach, duodenum, jejunum, and ileum are essential to practice a safe and effective BPD-DS or SADI-S.

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Chapter 23
Robotic Duodenal Switch and SADI-S: Technical Aspects

Aaron Bornstein and Andre Teixeira

23.1 Introduction

As the incidence of morbid obesity continues to rise within the United States and throughout the world, bariatric surgery offers the most effective and durable solution to combat this ongoing epidemic. While the sleeve gastrectomy and Roux-en-y gastric bypass comprise the most popular weight loss options, the biliopancreatic diversion with duodenal switch (BDP/DS or duodenal switch) and single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) are the most effective weight loss surgeries available. The duodenal switch and SADI-S offer the greatest magnitude of excess weight loss (EWL) and the most significant improvement and resolution of comorbid conditions, in particular type II diabetes and hyperlipidemia. However, despite their superior weight loss and comorbidity resolution, duodenal switch operations typically account for less than 5% of the bariatric surgeries performed worldwide. This is likely due to a combination of factors: patient selection, fear of long-term nutritional complications, and, most importantly, the technical skills required to perform the operation safely. The ability to perform this procedure using the robotic platform eases the technical demands of the operation allowing bariatric surgeons to more freely offer this surgical option [1–5].

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The robotic platform has several advantages from a technical standpoint when compared to standard laparoscopy: improved visualization, improved ergonomics, more precise dissection, and dexterity of the wristed instruments. These advantages allow surgeons to perform more complex operations in a minimally invasive manner. For the BPD/DS and SADI-S, the 3D visualization and dexterity of the robotic arms give the surgeon more control when dissecting around the duodenum and the ability to more easily perform all the anastomoses in a hand-sewn manner. Also, the improved angulation of the robotic stapler, as opposed to the laparoscopic stapler, allows the surgeon to create the sleeve gastrectomy and transect the duodenum with ease. This chapter will be dedicated to the technical aspects involved in performing these two operations using the robotic platform [6–8].

23.2 Biliopancreatic Diversion with Duodenal Switch

23.2.1 Patient Positioning and Port Placement

The patient is placed in the standard supine position with both arms out at right angles on padded arm boards. A footboard is used, and a padded belt is placed across the lower extremities to secure the patient to the table. Peritoneal access is obtained using either a Veress needle followed by an optical trocar or optical 5 mm laparoscopic trocar in the left mid-abdomen near the mid-clavicular line. A 0° laparoscopic scope is used when accessing the abdominal cavity using either approach and then exchanged for the 30° laparoscopic camera to place the remaining trocars. The trocars are placed in a smile shape across the abdomen: 8 mm right anterior axillary line a few fingerbreadths below the inferior edge of the liver, 12 mm right mid-clavicular line near the level of the umbilicus, 8 mm supraumbilical midline, 12 mm left mid-clavicular line near the level of the umbilicus, and 8 mm left anterior axillary line a few fingerbreadths beneath the ribs. The liver is then retracted toward the anterior abdominal wall. This can be done in several different ways at the discretion of the surgeon; routinely, I will place a 5 mm subxiphoid trocar and place a laparoscopic toothed Alice grasper at the superior aspect of the hiatus, thus retracting the liver off of the stomach. Alternatively, a full length 2–0 Ethibond suture placed through the superior aspect of the hiatus and brought out through the abdominal wall on either side of the falciform ligament also works very well.

After the liver has been retracted, I run the bowel laparoscopically starting at the terminal ileum to a point roughly 250 cm proximally, and a suture is placed in the mesentery to mark this point. The suture is also brought through the superior portion of the greater omentum which prevents the bowel from falling down into the pelvis. This can also be done robotically depending on surgeon preference. A marking pen is used to mark the bowel proximal to the suture in order to ensure no twisting of the mesentery when the bowel is brought up to the duodenum for the anastomosis. Once the suture is placed and bowel marked, the patient is placed in

10–15° reverse Trendelenburg, and the robot is brought in from the patient's left side for docking. The instruments used for a duodenal switch from the patient's right to left side are as follows: fenestrated bipolar grasper, assistant trocar/robotic 60 mm SureForm stapler, 30° robotic camera, vessel sealer/robotic monopolar scissor/large needle driver, and tip-up grasper or cadiere. After the robot is docked, I begin with the duodenal dissection.

23.2.2 Duodenal Dissection

Beginning along the greater curvature of the pre-pyloric antrum, a plane is created between the antrum anteriorly and the pancreas posteriorly using the vessel sealer and the fenestrated bipolar grasper. The distal antrum is retracted anteriorly using either a cadiere or tip-up grasper. This plane is continued down to the duodenum, and a retro-duodenal tunnel is created in order to ensure a 1–2 cm cuff of mobilized duodenum. It is important not to be overly aggressive during the retroduodenal dissection which could lead to duodenal stump ischemia and subsequent stump blowout or injury to the gastroduodenal artery posterior to the duodenal bulb which could lead to significant hemorrhage. Once the retroduodenal tunnel is completed, a Penrose drain is placed through the tunnel in order to facilitate placement of the stapler during the transaction of the duodenum. Following the completion of the sleeve gastrectomy, the robotic stapler will be used to transect the duodenum at least 1 cm distal to the pylorus. However, I do not transect the duodenum until after the sleeve gastrectomy portion of the procedure has been completed. It is easiest to bring the stapler in through the left mid-clavicular 12 mm trocar as opposed to the right mid-clavicular site. I prefer to place the anvil side of the stapler through the retroduodenal tunnel given its thinner profile. The previously placed Penrose drain is retracted anteriorly to better expose the retroduodenal tunnel and ensure appropriate placement of the stapling device. Once the stapler has been placed, the Penrose drain is removed to ensure it is not incorporated within the staple line. I prefer to use a white load cartridge, but a blue load is perfectly acceptable when transecting the duodenum. I do not routinely oversew or reinforce the staple line of the duodenum.

23.2.3 Sleeve Gastrectomy

Starting along the greater curvature of the body of the stomach, the lesser sac is entered by dividing the branches of the gastroepiploic arcade using the vessel sealer. The dissection is then carried cephalad along the greater curvature up to the angle of His ensuring that the left crus is clearly identified, no redundant fundus is present posteriorly, and no evidence of a hiatal hernia exists. The inferior portion of the greater curvature dissection is then completed ensuring that a few arcade vessels remain between the duodenal dissection plane and the greater curvature dissection to help avoid any ischemic complications as it relates to the duodeno-ileal anastomosis. After the dissection is completed, the calibration tube is advanced into the stomach with the assistance of the anesthesia provider and positioned along the lesser curvature of the stomach with the tip of the calibration tube in the antrum. The calibration tube is then placed on suction to help maintain its position within the stomach. The SureForm robotic 60 mm stapling device, brought in through the right mid-clavicular trocar, is used to create the sleeve gastrectomy starting with a green load cartridge at the antrum followed by blue loads for the remainder of the gastric sleeve. It is important to note that the overall size of the sleeve gastrectomy created for a duodenal switch is slightly larger than that made for patients who undergo sleeve gastrectomy alone. This is done to help limit any risk for postoperative dysphagia or oral intolerance.

23.2.4 Duodeno-Ileostomy

After the sleeve gastrectomy and duodenal transection have been completed, the suture used to mark the small bowel is located, the loop of the small bowel is brought up to the duodenum in an antecolic fashion, and a posterior suture line is created between the ileum and the duodenum using a suture of your choice; I prefer a 3–0 PDS or Stratafix. For those surgeons who prefer a double-layer anastomosis, this suture will be carried around anteriorly after the inner layer has been completed. Generous enterotomies are created in both the duodenum and ileum using the robotic scissors ensuring that the anastomosis is wide, so as to avoid any concerns for anastomotic stricture. The enterotomies are sutured together using a 2–0 or 3–0 suture, commonly Vicryl. The suture used to create the posterior suture line is then brought anteriorly creating a two-layer anastomosis.

23.2.5 Ileoileostomy

After the duodeno-ileostomy (DI) has been created, attention is then turned to creating the ileoileostomy. This begins by transection of the small bowel just proximal to the DI anastomosis using a white or blue load of the robotic stapler; this will serve as the biliopancreatic (BP) limb of the anastomosis. During this portion of the operation, the robotic stapler is typically brought in through the left mid-clavicular 12 mm trocar. Alternatively, a small window in the small bowel mesentery can be made using the robotic scissors and the stapler brought in via the right mid-clavicular 12 mm trocar. The small bowel is then counted 125 cm distal to the DI anastomosis and sewn to the distal BP limb in order to approximate the bowel loops needed to create the ileoileostomy. The approximated small bowel is then retracted toward the right upper quadrant to allow space for the robotic stapler to enter through the left-sided 12 mm trocar to perform the anastomosis. Enterotomies are created in both the biliopancreatic and Roux limbs using robotic scissors. Using a white load of the robotic stapler, the anastomosis is created. The common enterotomy is closed in one or two layers depending on surgeon preference. I typically prefer to close the enterotomy in a single layer with a 3–0 PDS or Stratafix suture in a running fashion. Once the common enterotomy has been closed, it is time to address the mesenteric defects.

23.2.6 Hernia Defects

There are two hernia defects created during this procedure: Peterson's defect made from the antecolic DI anastomosis and the mesenteric defect from the ileoileostomy anastomosis. I do not routinely close Peterson's defect after a duodenal switch; however, I will close the mesenteric defect. I typically close this defect with a running 3–0 PDS or Stratafix suture. I bring this suture onto the bowel as well to help avoid any kinking of the ileoileostomy. The use of absorbable or permanent suture for closure of the mesenteric defect is dependent on surgeon preference.

23.2.7 Anastomotic/Staple Line Leak Test

I typically test my DI anastomosis and gastric sleeve staple line with a combination of methylene blue dye administered via the calibration tube followed by air insufflation. For those who are concerned about the potential for anaphylaxis to the blue dye, air insufflation with 1 L per minute via the calibration tube is also adequate after the gastric staple line and DI anastomosis have been submerged in saline irrigation. Another option is intraoperative endoscopy and air insufflation leak test, but I find this unnecessary and more time-consuming than the other previously mentioned techniques. Next, I typically place a 19 Fr drain through the right lateral trocar site and place it in the subhepatic space near the duodenal dissection bed in order to monitor for postoperative duodenal stump leak and pancreatic leak. Lipase is sent from the drain on POD2 and the drain removed prior to discharge if normal.

23.3 Single Anastomosis Duodeno-Ileal Bypass with Sleeve Gastrectomy

The single anastomosis duodenal switch is a simple modification of the traditional switch. It was created in order to limit the risks of macronutrient deficiencies and decrease the technical complexity of the duodenal switch, all while still achieving similar weight loss and resolution of comorbid conditions when compared to the traditional duodenal switch. The length of the common channel can vary between surgeons but typically is 250–300 cm, as opposed to the traditional duodenal switch which has a common channel length of 125–150 cm. The technical aspects of the two procedures are identical with two exceptions: the ileoileostomy is not performed and, therefore, no mesenteric defects need to be closed [9].

23.4 Conclusion

The biliopancreatic diversion with duodenal switch and single anastomosis duodeno-ileal bypass with sleeve gastrectomy are the two most effective bariatric procedures with regard to overall weight loss and resolution of comorbid conditions. However, these operations are very technically demanding laparoscopically which has contributed to their limited use. The ability to employ the robotic platform to assist in these procedures gives the bariatric surgeon more control over the operation through better visualization, more precise dissection, and more ease when performing hand-sewn anastomosis. By approaching these operations in a stepwise manner, these complex bariatric procedures become less daunting and give the surgeon the confidence to offer their patients the full scope of weight loss procedures.

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Chapter 24
Laparoscopic Biliopancreatic Diversion with Duodenal Switch: Surgical Technique

Laurent Biertho, Léonie Bouvet-Bouchard, and Phil Vourtzoumis

24.1 Introduction

Obesity is known as a multi-factorial, complex, chronic, and relapsing disease [1]. Although lifestyle changes remain a key factor in the treatment of obesity, bariatric surgery is considered as the only approach leading to significant, long-term, beneficial impact in patients with severe obesity. Several weight loss procedures are endorsed by medical and surgical societies, including "biliopancreatic diversion with duodenal switch" (BPD-DS), which is the subject of this chapter. The surgical principle of a biliary bypass goes back to 1923, as described by Mann and Williamson [2]. In 1973, Nicola Scopinaro adapted the technique to decrease caloric absorption by adding a distal gastrectomy and performed the first biliopancreatic diversion [3]. The distal gastrectomy was necessary to decrease the risks of ulcers, but protein malabsorption, gastrointestinal side effects, and dumping syndrome were common. The technique was then modified in the late 1980s, to remove as much parietal cell located in the fundus and to increase the common channel length from 50 cm to 100 cm [4, 5]. This led to the creation of the BPD-DS, as we still know it (Fig. 24.1). It was later adapted to the laparoscopic approach in 1999 [6] which led to dramatic reduction in peri-operative complication rates [7].

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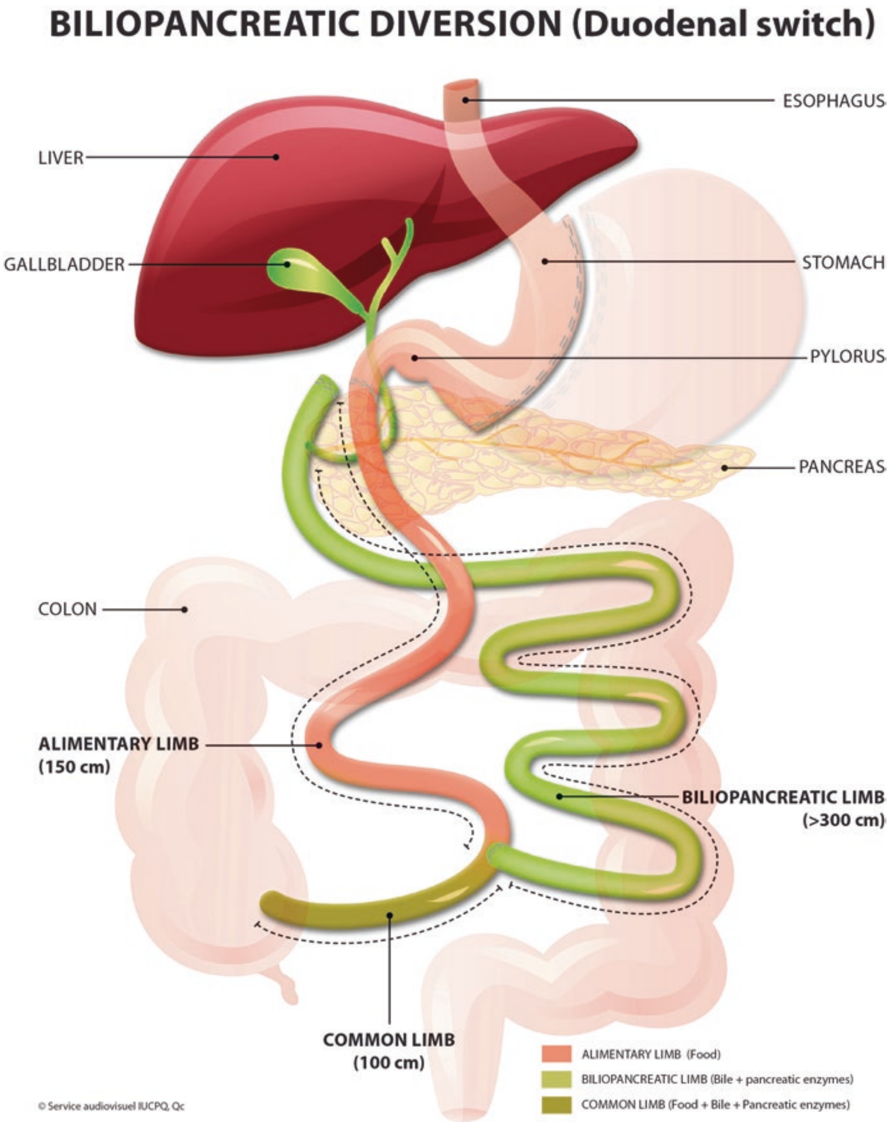

Fig. 24.1 Biliopancreatic diversion with duodenal switch

In short, the current BPD-DS technique we described in the present article includes three specific components. First, the sleeve gastrectomy provides some caloric restriction while decreasing acid production and accelerating gastric emptying. A 250-cm total alimentary limb is created to decrease caloric absorption. Finally, a 100-cm common channel is formed, where food bolus mixes with biliopancreatic juices, resulting in decreased protein and fat absorption and in a strong metabolic effect. Long-term outcomes, side effects, and complications have been described extensively in the literature [7–11], and we will focus this chapter on surgical technique and peri-operative management.

24.2 Surgical Technique (Video 24.1)

24.2.1 Preoperative Evaluation

All bariatric patients are evaluated by a multidisciplinary team, including a bariatric surgeon, bariatric nurse, and dietician. Consultation with a dietician qualified in BPD-DS is of utmost importance to correct eating disorders and to educate patients on the recommended diet after BPD-DS (high-protein, very low-fat diet). Before surgery, a low-calorie, high-protein diet can also be used to decrease the size of the liver and the amount of intraperitoneal fat. A psychiatric or psychological evaluation is requested for patients with a history of mental health or when clinically indicated. Screening for diabetes, dyslipidemia, and obstructive sleep apnea is performed. These comorbidities are controlled prior to surgery, especially when moderate to severe sleep apnea is detected, and noninvasive positive pressure ventilation should be initiated before surgery.

Preoperative blood work consists of a complete blood cell count, liver enzymes, albumin, calcium, parathyroid hormone, vitamin D, vitamin A, vitamin B12, and iron panel. Preoperative nutritional deficiencies should be detected and treatment initiated *before* surgery, to decrease the risks of poorly controlled deficiencies in the postoperative period. In our practice, all patients receive a multivitamin complex that contains vitamin B1 (Centrum Forte©) and vitamin D3 supplementation (10,000 U per day for 1 month followed by 1000 U per day until surgery) at least 3 months before surgery.

24.2.2 Preparation and Patient Positioning

The patient is placed under general anesthesia and placed in the supine, split-leg position with both arms open (Fig. 24.2). The surgeon stands between the patient's legs, and the assistant to the left side, except for the sub-mesocolic part of the procedure where they both are on the patient's left side. Before the beginning of the surgery, appropriate antibiotic (cefazolin 2 g IV for patients weighing ≤120 kg and 3 g for patients weighing >120 kg) and deep venous thrombosis prophylaxis (heparin 5000 U SC 2 hours before surgery) are given.

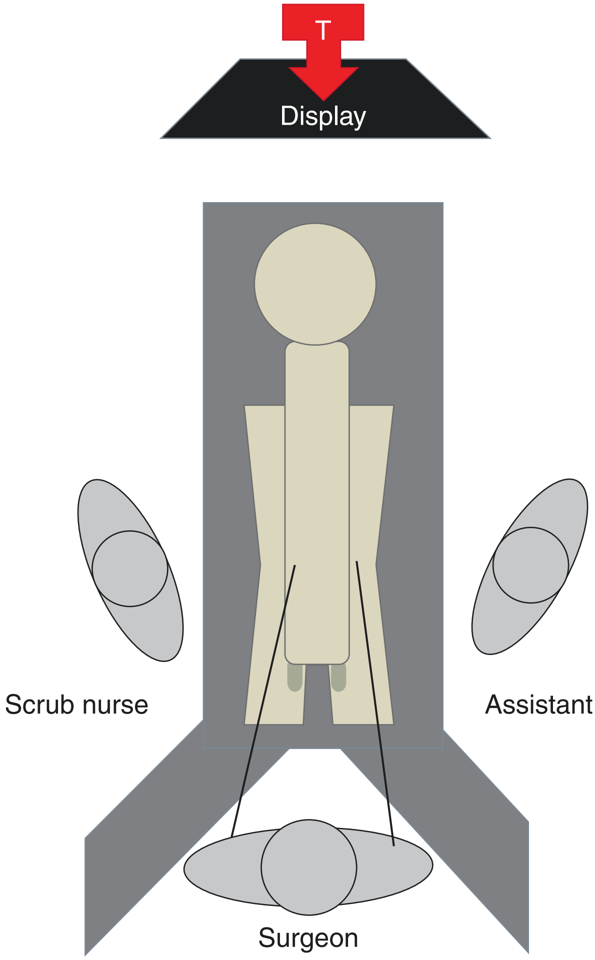

Fig. 24.2 Patient positioning

24.2.3 Peritoneal Access and Ports Positioning

A 15-cm Veress needle introduced in the left subcostal area is used to establish a 15-mm Hg pneumoperitoneum. The first 5- or 12-mm optical trocar is then placed, 2 handbreaths under the xiphoid, for a 30° endoscope. Two 12-mm ports are placed at the same level in the left and right upper flanks. Three more 5-mm ports are placed, one subxiphoid for the liver retractor, one in the left upper quadrant for the assistant, and one in the left lower quadrant for the sub-mesocolic part of the procedure (Fig. 24.3).

24.2.4 Gastric Mobilization

The patient is placed in a reverse Trendelenburg position. The gastrocolic ligament is divided off the greater curvature, using an ultrasonic scalpel (Fig. 24.4). This dissection is carried from 4 cm proximal to the pylorus up to the angle of His. The left

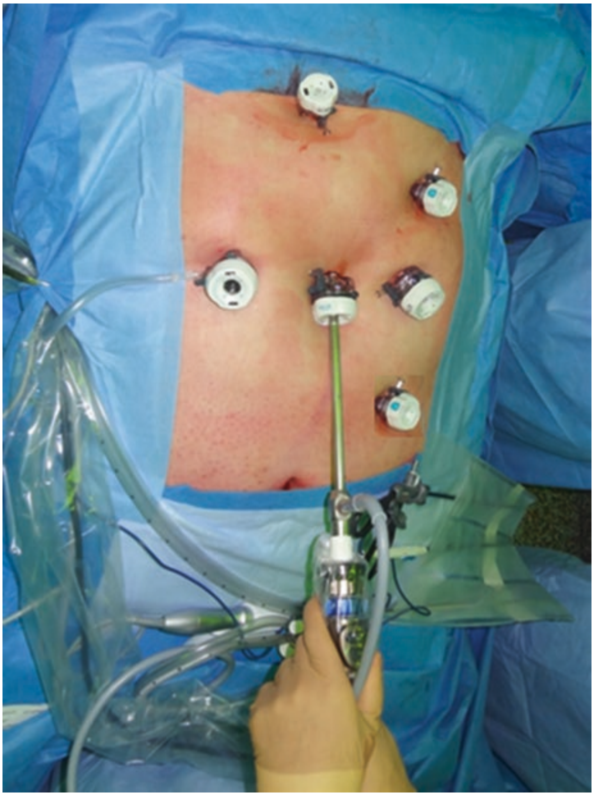

Fig. 24.3 Trocar placement for laparoscopic BPD-DS

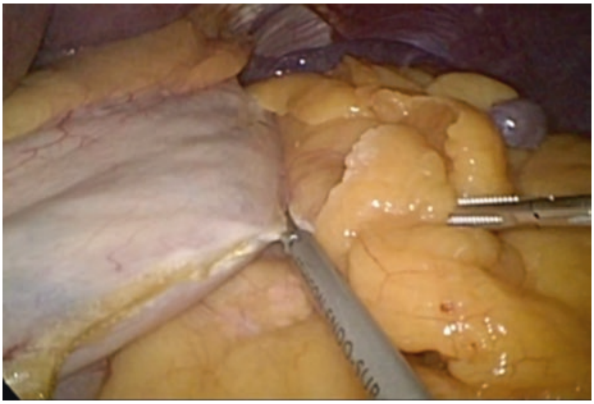

Fig. 24.4 Transection of the gastrocolic ligament

crux is exposed to assess that mobilization of the fundus is complete and to avoid leaving a gastric pouch at that level. At the same time, the presence of a hiatal hernia is ruled out. When a hiatal hernia is detected intraoperatively, it should ideally be repaired at the same time.

The feasibility of the duodenal switch is then assessed. If anatomic concerns are encountered (i.e., limited working space due to high intra-abdominal pressure, super obese man with a short mesentery, dense adhesions at the level of the duodenum or in the pelvis), a staged approach can be considered by doing a sleeve gastrectomy as a first-stage surgery.

24.2.5 Duodenal Dissection

The assistant grasper is placed on the antrum from the left subcostal port, applying a left horizontal traction, essential for a good duodenal exposition. The pylorus is identified, and the peritoneum at the inferior and superior edge of the duodenum is opened. The common bile duct is often visualized at the superior aspect of the duodenum and can be used as a landmark. A perfect knowledge of the position of major anatomical structures (pancreatic head, common bile duct, gastroduodenal artery) is essential for duodenal dissection. Two different approaches exist for the mobilization of the first duodenum.

The posterior approach consists in a complete mobilization of the inferior and posterior attachments of the duodenum. The gastrocolic ligament transection is carried down to the duodenum, and the pyloric artery is controlled using ultrasonic energy or clips. A posterior dissection is performed using the gastroduodenal artery as a landmark for distal mobilization of the duodenum. A window is then created on the upper aspect of the duodenum, and a 15-cm Penrose drain is used for retraction. The window is slightly enlarged to accommodate the anvil of a 60-mm linear stapler. An Echelon Flex™ (Johnson and Johnson, USA) with a blue cartridge is introduced through the 12-mm left upper quadrant trocar for a transverse duodenal transection. Stapler line reinforcement (Gore Seamguard™, WL Gore and Associates, USA) can be used on the anvil side, avoiding clip placement on the staple line for control of bleeds.

The inferior approach is a direct duodenal approach to create a retroduodenal tunnel. A window is created at the inferior part of the duodenum, 3–4 cm distal to the pylorus. Careful blunt dissection is used to identify the plane between the posterior duodenal wall and the pancreas, avoiding small venous branches, the gastroduodenal artery, and injury to the back wall of the duodenum. If difficulties are encountered, the dissection can be converted to a posterior approach. When the retroduodenal dissection reaches the upper part of the duodenum and the window is completed, the duodenum is transected 2–4 cm distal to the pylorus (Fig. 24.5).

24.2.6 *Sleeve Gastrectomy*

The goal of gastrectomy in BPD-DS is to reduce acid production and to be only mildly restrictive. It is of utmost importance not to create the sleeve too tight along the bougie (in opposition to a stand-alone sleeve gastrectomy) as this would increase the risk of protein malnutrition. A bougie is used to calibrate the sleeve, performed along the vessels on the lesser curvature, and the transection is started 5–7 cm from the pylorus using a 60-mm stapler (Fig. 24.6). Black or green cartridges are used for the first two to three firings. As the transection progresses toward the fundus, the length of the staples is decreased from green to blue cartridges. Either clips, oversewing sutures, or buttressing materials are used to control hemostasis on the staple line. The gastrectomy specimen is then placed in a bag and removed through the 12-mm trocar in the right flank after slight enlargement of the aponeurosis.

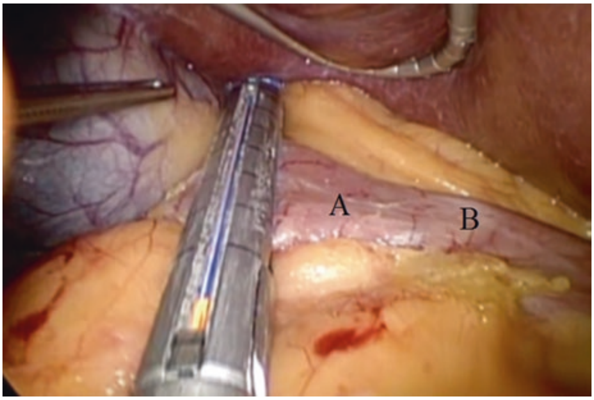

Fig. 24.5 Transection of the duodenum (**a**) using a 60-mm stapler with a blue load, 3 cm from the pylorus (**b**)

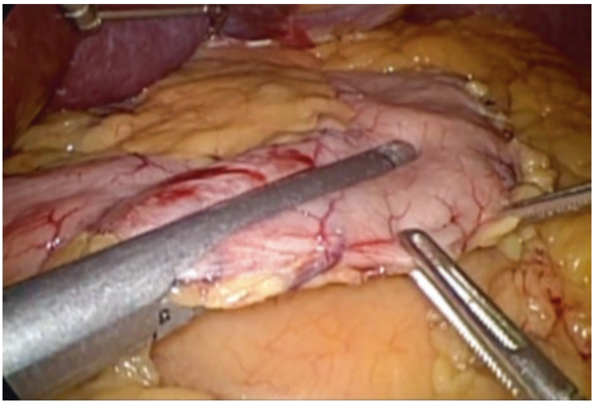

Fig. 24.6 The sleeve gastrectomy is started 5–7 cm from the pylorus

24.3 Small Bowel Measurement and Transection

The patient is placed in a Trendelenburg position with the left side down. The surgeon uses the two left flank trocars. Starting at the ileocecal junction, a common channel of 100 cm is measured, and the future site of the ileoileostomy is marked, using a large clip on each side of the mesentery. The length of the metallic part of our bowel graspers is 5 cm, and we use it to measure the small bowel. The small bowel is then run another 150 cm and transected at that level (250 cm from the ileocecal valve), using a 60-mm linear stapler with a white cartridge. The corresponding mesentery is opened a few centimeters to decrease tension on the duodenal anastomosis. The alimentary limb is immediately marked using a metallic clip and should be placed in the right upper quadrant. Our technique of choice, especially in patients with high BMIs, is to place a Penrose drain below the small bowel at 250 cm to help bring the small bowel to the duodenum and to reduce the tension on the duodenal anastomosis. The duodenal anastomosis is done before transecting the ileum (similar to a single-anastomosis BPD-DS).

24.3.1 Duodenoileostomy

This anastomosis is usually performed first, to reduce tension on the small bowel mesentery. The patient is placed in a slight head-up position. The proximal alimentary limb is brought to the transected first duodenum in an antecolic fashion. If there is tension on the anastomosis, the omentum can be mobilized from its attachments to the ascending colon. A hand-sewn end-to-side anastomosis is then created. The first anastomotic layer is made, joining the anti-mesenteric side of the small bowel to the duodenum (Fig. 24.7). A 2-cm enterotomy is made on each intestinal side, and another running suture is used to create the back wall of the anastomosis, starting from the top of the intestinal opening. The anastomosis is completed by creating

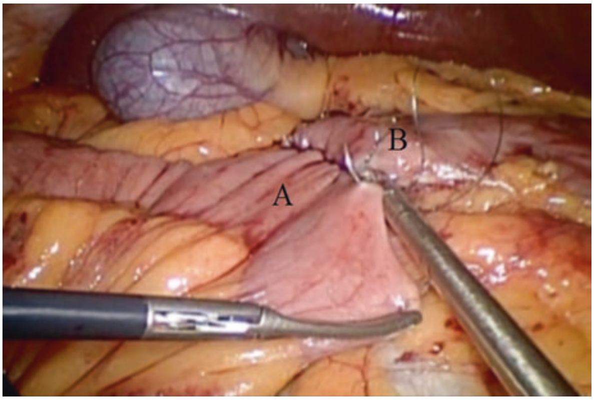

Fig. 24.7 The first posterior layer is created using 3.0 V-Loc™ suture, to approximate the alimentary limb (**a**) to the proximal duodenum (**b**)

the anterior part of the anastomosis, starting from the top and going down to the posterior wall suture located on the inferior aspect of the anastomosis (Fig. 24.8). A 23-cm, 3.0 absorbable V-Loc suture or 3.0 PDS suture is used for all anastomosis layers.

24.3.2 Ileoileostomy

The patient is placed in head-down position with the left side down for the creation of the ileoileostomy, 100 cm from the ileocecal valve. The stump of the biliary limb is first attached to the common channel in an anti-peristaltic configuration, using 2.0 Vicryl™ suture (Fig. 24.9). A side-to-side anastomosis is created using a white load of a 60-mm linear stapler-cutter. The bowel opening is closed using a single layer of 3.0 V-Loc™ suture, starting from the mesenteric side (Fig. 24.10).

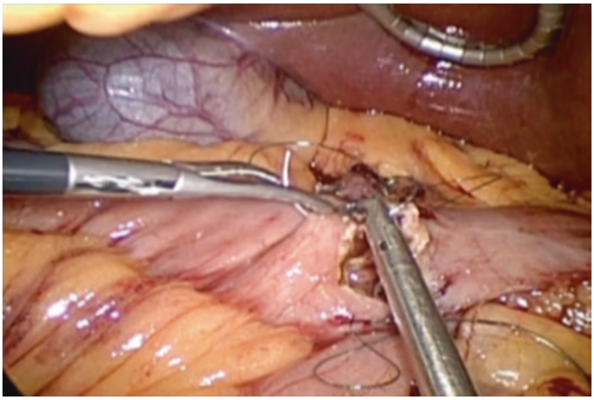

Fig. 24.8 The anterior wall of the anastomosis is created, using a 3.0 V-Loc™ running suture, starting from the top of the anastomosis

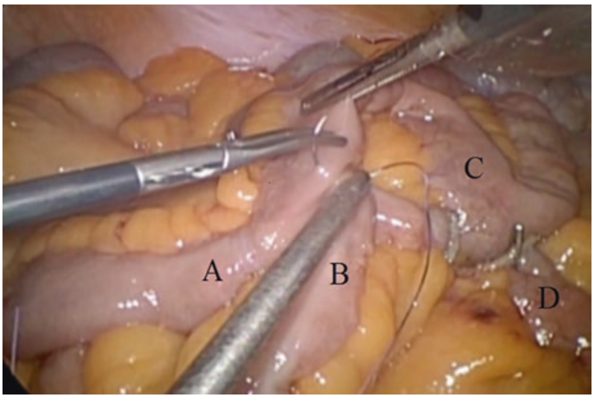

Fig. 24.9 A 2.0 Vicryl suture is placed to approximate the common channel (**a**) and the biliary limb (**b**). The alimentary limb (**c**) is located in the patient's right flank. The disconnected alimentary limb can be seen on the right side of the picture (**d**)

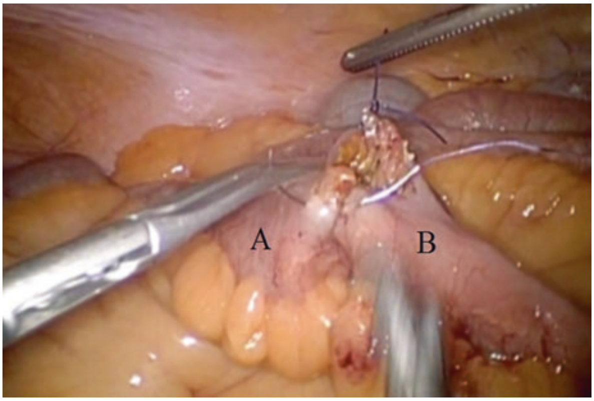

Fig. 24.10 The intestinal opening of the anastomosis is closed with a 3.0 absorbable suture. The common channel (**a**) is on the left and the biliary limb (**b**) on the right of the picture

24.4 Closure of Mesenteric Window and Petersen Window

The ileoileostomy is retracted to the right upper quadrant with the 2–0 Vicryl™ stay suture, allowing good exposure for the mesenteric window closure. The window is closed from the left using a 23-cm 2.0 Prolene suture.

The patient is then placed head up with the left side up, and the transverse colon is lifted up using the right upper quadrant trocar. Petersen's defect is then closed using the same type of suture. A routine cholecystectomy and liver biopsy are then performed.

The dilated 12-mm trocars in the right flank are closed with 2.0 Vicryl™ using a fascia closure device. Trocars are removed, and the pneumoperitoneum is exsufflated under direct vision.

24.5 Postoperative Care

Regular subcutaneous heparin is given the evening of surgery (heparin 5000 U SC). All patients are started on a low-molecular-weight heparin on postoperative day 1 for 3 weeks post-op. Pneumatic compression devices, incentive spirometry, and noninvasive airway support (C-PAP or Bi-PAP) are also used. Patients are allowed water the day of surgery, followed by clear liquids on the first postoperative day and a full liquid diet on postoperative day 2. Patients are usually discharged on the second postoperative day on a full liquid diet for 2 weeks. The diet progressed to pureed diet, minced diet, and then regular diet every 2 weeks. Patients who still have their gallbladder are placed on ursodiol (Actigall, Ciba-Geigy, Summit, New Jersey), 250 mg orally, twice a day, for 6 months. Daily vitamins and mineral supplementations are started within the first month after surgery (ferrous sulfate, 300 mg;

Table 24.1 Clinical outcomes in large series of BPD-DS (>100 cases) with a minimal follow-up of 5 years

Authors	Follow-up (yrs)	N	Weight loss (%)	T2DM (% remission)	HTN (%)	DLP (%)
Himpens [8]	11 ± 5	153	TBWL: 41 ± 10%	88%	81% improved	>90%
Marceau [9]	8 (5–20)	2615	EWL: 71% (55 kg)	93%	60% cured 91% improved	80%
Biertho [10]	9 ± 4	810	EWL: 76 ± 22%	92%	60% cured	–
Pata [11]	12 ± 3	874	21 points of BMI lost	67% to 97%[a]	>96%	>96%

Legend: *yrs.* years, *N* number of patients, *TBWL* total body weight loss, *EWL* excess weight loss, *T2DM* type 2 diabetes, *HTN* hypertension, *DLP* dyslipidemia
[a]Remission rate was 67% for patients initially on insulin and 97% when initially on oral medications

vitamin D2, 50,000 IU; vitamin A, 30,000 IU; calcium carbonate, 1000 mg; and a multivitamin complex). These supplements are adjusted over time, and education in consuming a high-protein diet is reinforced. The patient is followed with blood analysis (similar to preoperative blood work) at 4, 8, and 12 months and annually thereafter. Fasting glucose, hemoglobin A1C, and lipid panel are performed every year. Table 24.1 summarizes the medium- and long-term outcomes after BPD-DS in series with more than 100 subjects. As expected, the overall metabolic outcomes for BPD-DS are excellent, with remission rate for T2D above 90% for patients on non-insulin therapy and resolution of HTN above 60% and dyslipidemia above 80% on the long term.

24.6 Conclusion

BPD-DS offers one of the best long-term controls of obesity-related diseases and is associated with one of the lowest risks of weight gain. It should be part of surgeons' armamentarium, particularly for the management of weight regain following sleeve gastrectomy. Like any advanced surgical procedure, there is a learning curve associated with laparoscopic BPD-DS, but standardization of the different surgical steps allows keeping complication rates low. The use of a hand-sewn anastomosis, particularly, is associated with some of the lowest risk of anastomotic leak. In case of intraoperative difficulties, the procedure can be converted to a stand-alone sleeve gastrectomy, and a duodenal switch can be performed, typically 18 to 24 months after the initial surgery.

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Chapter 25
SADIS: Technical Details

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25.1 Introduction

Laparoscopic single-anastomosis duodenal switch or SADI-S (single-anastomosis duodeno-ileal bypass with sleeve gastrectomy) was first described in 2007 with the intention of simplifying a complex surgical technique, the biliopancreatic diversion with duodenal switch, while maintaining its metabolic principles [1]. Weight regain and comorbidity recurrence have lead bariatric surgeons to modify established bariatric procedures, such as sleeve gastrectomy and Roux-en-Y gastric bypass, or introduction of new ones; hence, SADI-S was originated. This was achieved by practicing a vertical gastrectomy as a restrictive procedure with pyloric preservation, followed by an end-to-side duodeno-ileal anastomosis in the first duodenal portion, beyond the pylorus (Fig. 25.1).

The idea of performing one anastomosis in the SADI-S technique was taken from the mini-gastric bypass or one-anastomosis gastric bypass (OAGB). Nevertheless, unlike OAGB, by preserving the pylorus, alkaline reflux is ruled out, resulting in a more physiologic disposition. The reduction to a single anastomosis decreases surgical time and postoperative risk of leakage. Furthermore, it avoids the opening of the mesentery, so no mesenteric defects are created, and therefore no internal hernias are expected, avoiding this type of complications seen in patients undergoing a Roux-en-Y gastric bypass.

Since its development, SADI-S procedure has offered satisfactory results for the treatment of morbid obesity and its metabolic complications, not only as a primary procedure but also as a revisional or second-step surgery after a failed sleeve

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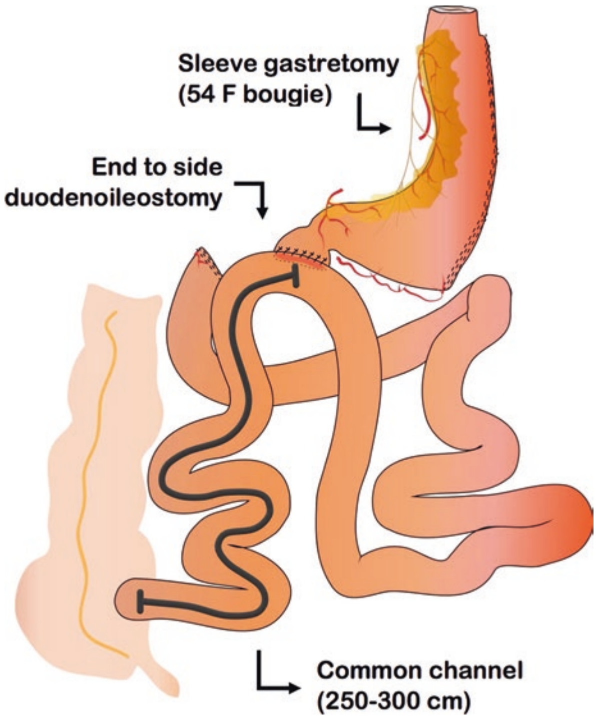


Fig. 25.1 SADI-S configuration

gastrectomy. Undoubtedly, as all surgical procedures, drawbacks have been encountered, although these side effects have been well tolerated and postoperative complications have appeared to be minimal [2–4].

25.2 Surgical Technique

25.2.1 Patient Preparation

Patients are thoroughly evaluated before the intervention by a team of specialized endocrinologists, surgeons, and anesthetists, and they undergo a number of tests including an upper gastrointestinal endoscopy, barium swallow, chest X-ray, electrocardiogram, and blood tests. Respiratory function tests and psychiatric evaluation are performed as well. Prior to surgery, patients are recommended to follow a healthy, low-calorie diet in order to lose as much weight as possible before surgery, as well as introducing them to a healthy lifestyle. This will not only reduce the possibility of postoperative complications, but it will also improve postoperative results.

The procedure can be divided into a two-step technique, starting with the sleeve gastrectomy and continuing with a one-loop duodeno-ileostomy.

25.2.2 Position of the Patient and the Surgical Team

The first part of the operation is performed with the operating table under forced reverse Trendelenburg position. The surgeon is positioned between the patient's legs, the first assistant on the patient's left side, holding the camera, and the second assistant on the patient's right side, holding the liver retractor (Fig. 25.2).

For the second part of the surgery, namely, the duodeno-ileal bypass, the position is changed. The patient is placed horizontally, and the surgeon moves from the initial position between the legs toward the left side of the patient, as well as the camera assistant, who will introduce the laparoscope through the left subcostal trocar, leaving the upper umbilical and right midline trocars as working trocars (Fig. 25.3).

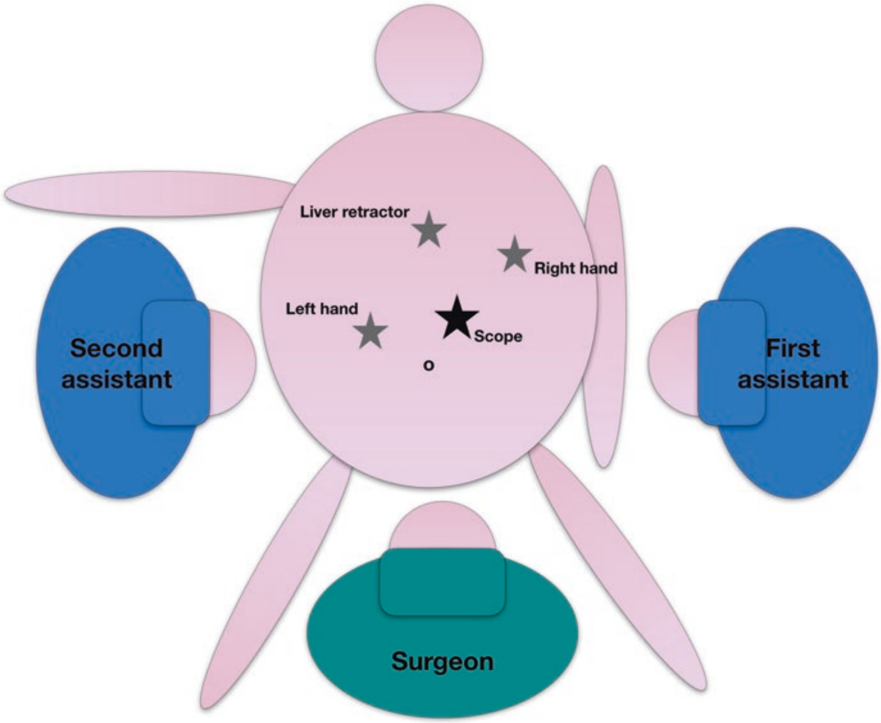


Fig. 25.2 Initial trocar and surgical team positioning

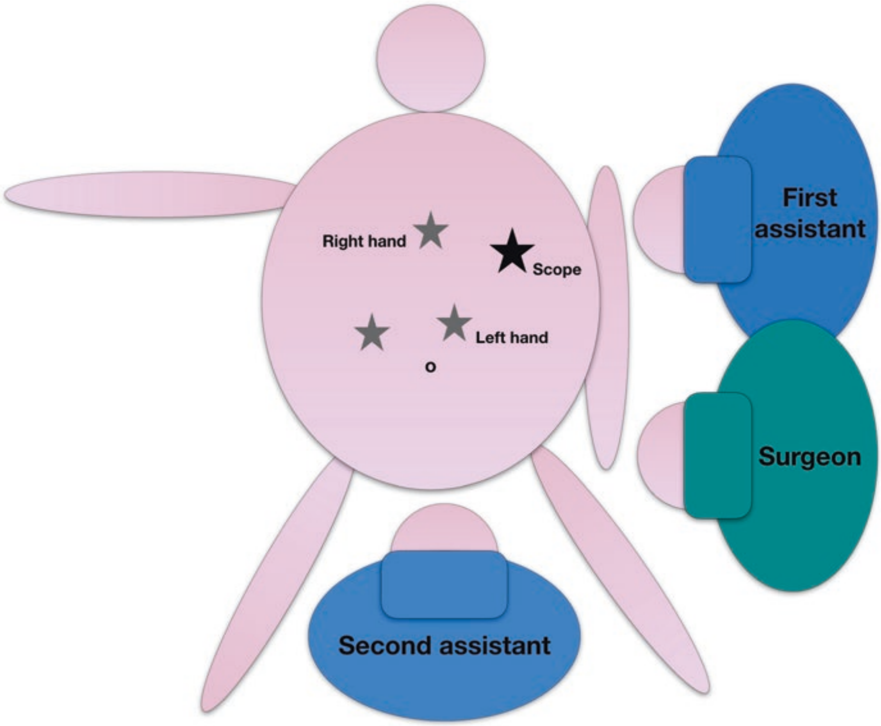


Fig. 25.3 Final trocar and surgical team positioning

25.2.3 Trocar Position

The standard laparoscopic approach is performed by placing four trocars. A 10–12 mm optical trocar (Optiview) is inserted above the umbilicus, slightly left from the midline, and pneumoperitoneum is applied. A 10–12 mm left subcostal trocar is placed to introduce the harmonic scalpel for the surgeon's right hand and for the introduction of the stapler for the duodenal section during the second step. A 5 mm trocar for the surgeon's left hand initially, and subsequently for the hepatic retractor, is placed in a subxiphoid position. Finally, a 10–12 mm trocar is placed right from the midline position for the surgeon's left hand and to introduce the stapler during the sleeve gastrectomy (Figs. 25.2 and 25.3).

25.2.4 Procedure

25.2.4.1 Sleeve Gastrectomy and Duodenal Dissection

The first step begins with the release of the fundus and dissection of the left crus (Fig. 25.4). This way, the need for an additional tensile clamp is avoided. Complete devascularization of the greater curvature of the stomach is performed, and any hiatal hernia is always searched. All vessels from the gastroepiploic arcade are divided, from the fundus to the first duodenal portion. Adhesions from the gastric posterior wall to the pancreas are also divided with a harmonic scalpel.

To begin duodenal dissection, the antrum is raised with gentle traction of the posterior gastric wall, leaving the duodenum in a vertical position. The duodenum is dissected proximally, taking care not to injure the right gastric artery. A precise circumferential dissection of the first duodenal portion is performed, up until 3–4 cm from the pylorus, to facilitate an adequate mobilization for an easy and safe anastomosis, always making sure we prevent any devascularization (Fig. 25.5). Dissection of the duodenum from the pancreatic surface is carried out until the pancreaticoduodenal groove is reached and the gastroduodenal artery is identified (Fig. 25.6). To complete the duodenal dissection, the peritoneum overlying the hepatoduodenal ligament is slightly opened, and a vessel loop or silk tape is passed (Fig. 25.7).

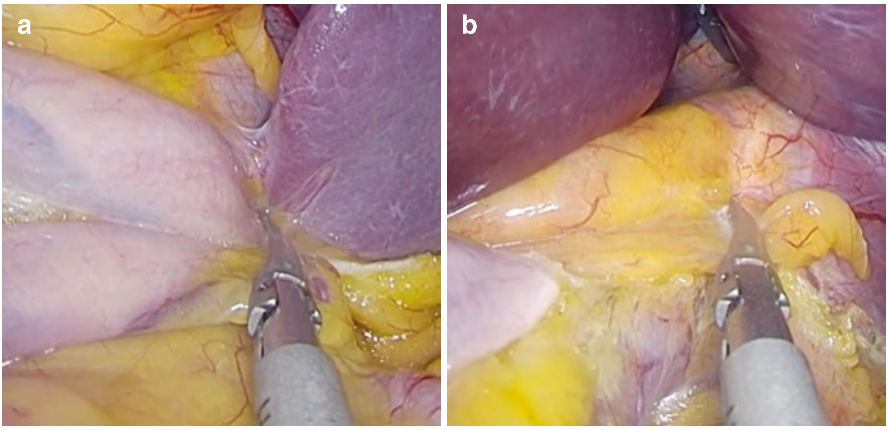


Fig. 25.4 Fundus mobilization (**a**) and dissection of the left crus (**b**)

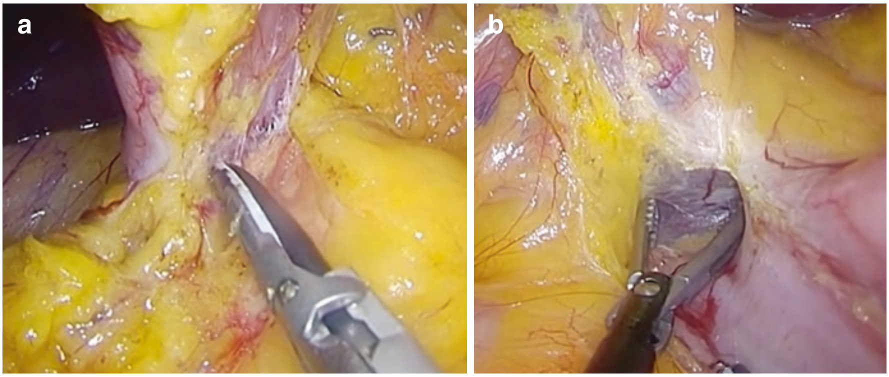


Fig. 25.5 Circumferential dissection of the first duodenal portion (**a**) with the opening of the hepatoduodenal ligament (**b**)

Fig. 25.6 Gastroduodenal and right gastric arteries

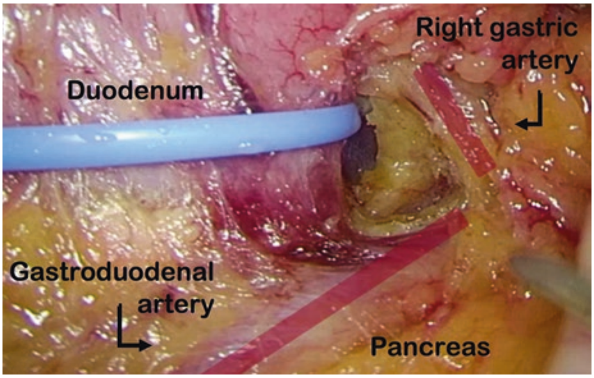
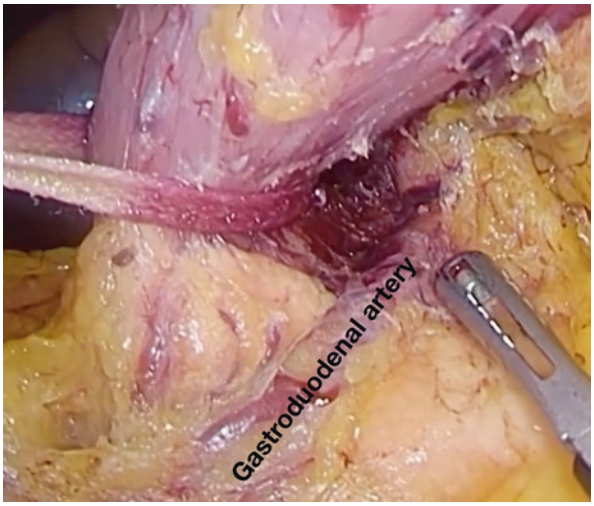


Fig. 25.7 A vessel loop or silk tape is passed surrounding the first duodenal portion



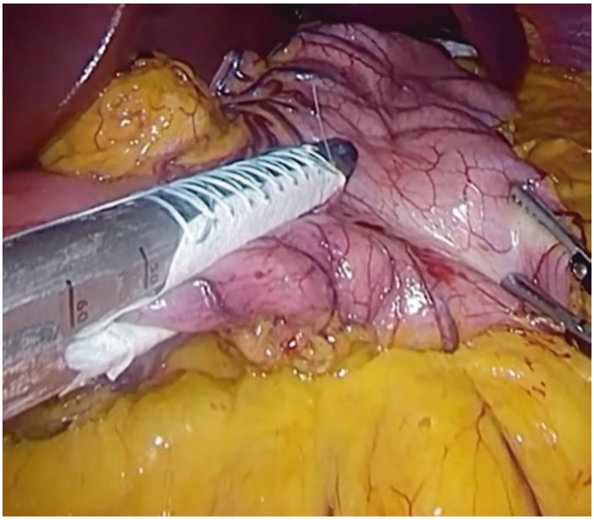


Fig. 25.8 Sleeve gastrectomy is performed over a 54 French bougie using a black plated linear stapler (Echelon Ethicon), coated with Seamguard (Gore) sheets for staple line reinforcement

At this point, a vertical sleeve gastrectomy is performed over a wide 54 French bougie starting 5 cm from the pylorus, with a black plated linear stapler (Echelon Ethicon), coated with Seamguard (Gore) sheets for staple line reinforcement (Fig. 25.8). The stapler is introduced through the right midline trocar. The suture line is revised for bleeding points, placing titanium clips if required.

Once the gastrectomy is done, the duodenum is sectioned with a 60 mm blue cartridge linear stapler (Echelon Ethicon) as distal as possible from the pylorus, introducing the stapler through the left subcostal trocar (Fig. 25.9). We finish this part of the surgery by placing the first stitch of the anastomosis. With this step, we avoid confusion with any possible duodenal rotation during bowel measurement.

25.2.4.2 Duodeno-Ileal Bypass

The patient is placed horizontally, and the surgical team moves to the second position (Fig. 25.3). The ileocecal junction is identified and 250–300 cm, depending on each case, is measured upward. Measurement of the bowel is performed, stretching the loops at the anti-mesenteric border in 10 cm intervals, having administered 20 mg of hyoscine butylbromide (Buscopan) intravenously to obtain a complete relaxation of the bowel wall and so gaining the maximum possible length. The selected loop is ascended in an antecolic fashion, and an end-to-side, two-layer, hand-sewn anastomosis to the proximal duodenal stump is carried out with running sutures of V-Loc 3/0 (Covidien) and interrupted PDS 3/0 (Johnson & Johnson) stitches for the second anterior layer (Fig. 25.10).

Having finished the anastomosis, both the sleeve gastrectomy staple line and duodeno-ileal anastomosis are checked for leaks by means of oral introduction of methylene blue. The surgery is completed with the removal of the resected stomach through the right midline trocar and the placement of a vacuum drain.

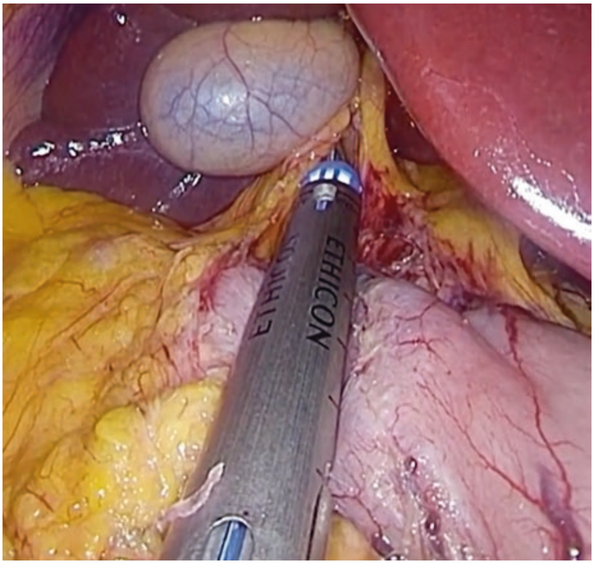


Fig. 25.9 The duodenum is sectioned with a 60 mm blue cartridge linear stapler (Echelon Ethicon) as distal as possible from the pylorus

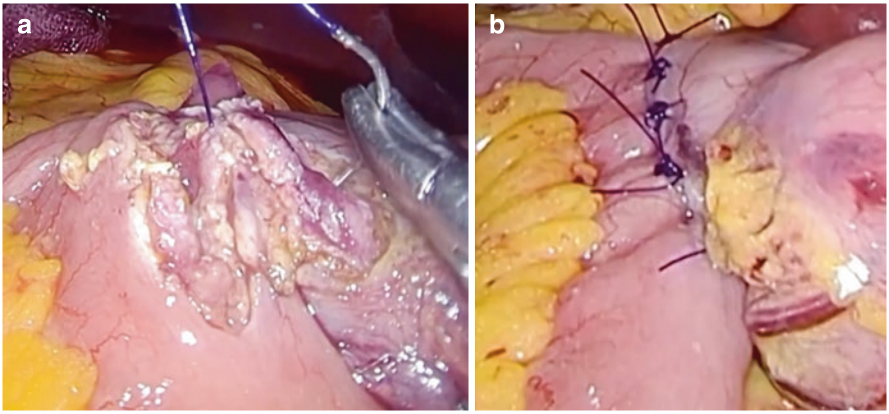


Fig. 25.10 An end-to-side, two-layer, hand-sewn duodeno-ileal anastomosis is carried out with running sutures of V-Loc 3/0 (Covidien) (**a**) and interrupted PDS 3/0 (Johnson & Johnson) stitches for the second anterior layer (**b**)

25.3 Postoperative Course

The patient is taken to a recovery unit for immediate postoperative care. Six to eight hours postoperatively, the patient begins oral intakes of water on the surgical ward, starting with a low-caloric liquid diet the following day. On the second day after surgery, the patient starts with a low-caloric shake diet (Optifast). The abdominal drain is removed on the third postoperative day, and patient is discharged the next day if postoperative course is uneventful.

During follow-up, for the first postoperative month, patients follow a low-caloric diet based on self-prepared shakes (800 kcal/day). Multivitamin supplements, calcium, and iron are initially prescribed and maintained depending on the results of subsequent blood tests. The patient will continue with periodical visits to the endocrinologist and the surgeon for life, with three to four visits per year during the first 2 years and then once a year.

25.4 Technical Pitfalls

This bariatric technique entails four fundamental technical challenges, which are an adequate sleeve gastrectomy configuration, careful duodenal dissection and division, a correct intestinal measurement, and duodeno-ileal anastomosis. Subsequent errors may therefore be the following:

- *Insufficient fundal dissection when performing the sleeve gastrectomy and/or undertreatment of a hiatal hernia.* A complete fundal mobilization has to be performed when constructing the sleeve gastrectomy to avoid ending up with a bicameral stomach. Hiatal hernias should be searched, especially when diagnosed preoperatively, to remove the fundus entirely in order to avoid problems such as gastroesophageal reflux disorders and/or weight regain.
- *Insufficient duodenal dissection.* Complete dissection of the first portion of the duodenum is crucial to facilitate its mobilization in order to perform an easy and safe anastomosis, making sure we end up with 3–4 cm from the pylorus. This dissection should always be carried out above the gastroduodenal artery to avoid damage both to the right gastric artery and to the bile duct. If this is not possible, division of the right gastric artery should be done at its origin.
- *Duodenal devascularization.* This may consequently affect the duodeno-ileal anastomosis.
- *Inaccurate measurement of the common limb from the ileocecal valve.* The measurement of the common limb must be precise, as a short limb would put the patients at risk of malnutrition. A less effective weight loss technique is preferable rather than a severe malnourishment, which could be fatal for the patient.
- *Technical difficulties concerning the duodeno-ileal anastomosis.* The anastomosis is usually undemanding to perform either mechanical or hand-sewn, as long as it is done with care. An intraoperative test, with oral methylene blue, for example, is recommended.

In particular situations, such as aged patients or those with liver or bowel diseases, 300 cm is the preferred length of the common limb to avoid important nutritional complications.

25.5 Technical Advantages of SADI-S

- Pyloric preservation is more physiologic and avoids biliary reflux.
- Dismantling SADI-S is feasible in case of complications.
- No mesenteric defects are created; therefore, no internal hernias are expected.
- No anastomotic concerns such as strictures or ulcers have been observed regarding the duodeno-ileal anastomosis.
- Easy, quick, and reproducible surgical technique.

25.6 Conclusions

SADI-S has become an easier, quicker, and more physiologic biliopancreatic diversion than the original duodenal switch, without jeopardizing weight loss or metabolic results after the reduction to one anastomosis.

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Chapter 26
Technical Aspects of Single Anastomosis Duodenal Switch: SIPS Version

Michael Marchese, Lauren Rincon, Donna Bahroloomi, and Mitchell Roslin

Bariatric surgery is different than most surgical specialties where pathology is addressed and corrected. Rather, bariatric surgery seeks to create a controlled abnormality in an effort to reduce hunger, achieve weight loss, and decrease a disproportionately high-fat percentage without excessive muscle loss. The latter objective is a challenge with bariatric procedures that bypass the intestine, thus placing the patient at risk for muscle wasting. How to best achieve these goals while minimizing complications is the unceasing objective of the bariatric surgeon.

The single anastomosis duodenal switch, specifically the stomach intestinal pylorus sparing (SIPS) modification, was first introduced in the USA by Roslin and Caban in 2009. Concurrently, a Spanish group led by Torres and Sánchez-Pernaute described a single anastomosis duodenal switch modification, the single anastomosis duodenal ileostomy (SADI) [1]. The SIPS modification makes use of a smaller sleeve gastrectomy (performed over a bougie size 40 F–44 F) while maintaining approximately 3 m of the intestine for digestion. Contrarily, the SADI modification makes use of a larger sleeve gastrectomy (performed over a bougie size 50 F–55 F) while maintaining a shorter common channel of 200–250 cm for digestion. Through the utilization of both a gastric and intestinal approach, the single anastomosis duodenal switch-type procedures seek to provide sustained weight loss.

A drawback of gastric-only procedures (i.e., vertical sleeve gastrectomy) is adaptive thermogenesis [2]. Following surgical intervention, caloric intake decreases. The resultant weight loss is associated with an increase in parasympathetic tone and a decrease in sympathetic tone. The net effect of these adaptations is decreased metabolism. At approximately 9 months postoperatively, the patient's intake

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increases matching their now decreased metabolic rate resulting in a weight loss nadir. Nonadherent patients are prone to recidivism at this time. With the addition of an intestinal conduit, maximal weight loss is increased, and some recidivism is thwarted. Unfortunately, intestinal bypass is not without consequence. These ramifications include decreased absorption of divalent cations, such as calcium and iron (normally absorbed in the duodenum), and less frequently trace minerals (i.e., copper, selenium, and zinc). Further, the absorption of fat-soluble vitamins is reduced, and the risk for protein malnutrition increased [3].

The technical aspects of the SIPS which seek to balance the beneficial and detrimental effects of a gastric and intestinal-based bariatric procedure will be discussed.

The operation begins by locating the terminal ileum and the ileocecal valve. Approximately 300 cm of the small intestine is measured by counting back from the ileocecal valve and fastened with a stay stitch. Although not exact, we employ graspers to measure the bowel. Literature published by Torres and Sánchez-Pernaute demonstrated that 250 cm of the small intestine is sufficient for the common channel. However, when the common channel approached 200 cm, numerous episodes of diarrhea were common. Since our technique employs an imperfect method of measurement, there is a significant chance of error (approximately 25%) and a tendency to underestimate rather than overestimate the length. As a result, we advocate for 300 cm to account for this potential miscalculation and limit the risk of diarrhea. Chronic diarrhea can be physiologically compensated for via the adaptive nature of the small and large intestine; however, side effects are significant and can be life-limiting. Additionally, excess weight loss can exceed 100% when the small intensive isn't adequate resulting in excess catabolism and muscle wasting [4].

After measuring the small intestine, we proceed with our sleeve gastrectomy by entering the lesser sac. The epiploic branches and posterior adhesions of the stomach to the retroperitoneum are taken down. The resulting blood supply of the stomach should be based solely along the lesser curvature. We begin our dissection along the greater curvature at the angularis and proceed proximally, ligating the epiploic and short gastric vessels until the base of the left crus of the diaphragm is visualized. If a hiatal hernia is encountered, we address it at this point. The area of the caudate lobe is taken down and the distal esophagus mobilized resulting in the restoration of an intra-abdominal segment of the esophagus. The crura are then re-approximated. We then proceed distally along the greater curvature and past the angularis, removing any posterior adhesions. The distal extent of the dissection of the greater curvature is past the pyloric valve and the prepyloric vein of Mayo.

The pylorus can now be elevated, and via a plane superior to the gastroduodenal artery, the duodenum is encircled. We use an articulating grasper to transverse this plane and encircle the duodenum. Once the duodenum is encircled, we staple a 3–4 cm duodenal cuff. This is facilitated via gentle traction to the stomach. We recommend using a blue or purple staple load with buttress material when transecting the duodenum. It is our opinion that buttress material helps to decrease bleeding along the duodenal stump staple line. Excessive difficulty or visualization of the pancreas may represent a distal dissection plane. In our practice, we have not encountered a duodenal stump leak without a concomitant pancreatic injury. To avoid injuring the pancreas, it is essential to elevate both the antrum and pyloric valve, thus ensuring the proper plane and facilitating encircling the duodenum.

We then perform our sleeve gastrectomy over a 40 F–44 F bougie [5]. The gastric transection should be initiated approximately 5 cm proximal to the pylorus. Key technical aspects of sleeve gastrectomy include the preservation of some antrum and avoidance of an excessively small sleeve which can exacerbate diarrhea.

Once the sleeve gastrectomy is performed, the stay stitch and previously measured small bowel are identified, and duodenal-jejunal anastomosis is performed. We prefer a hand-sewn technique, utilizing barbed suture. Complete mobilization of all posterior adhesions allows for a tension-free anastomosis. Although triple staple techniques have been described, it is our belief that these techniques are both difficult and associated with an increased risk of damage to the pyloric area. We advocate for a hand-sewn anastomosis performed either laparoscopically with a standard needle passer, via an endoscopic suturing device, or robotically.

With our hand-sewn technique, we first address the posterior layer after creating a 1.5–2 cm enterotomy on both the duodenum and small bowel. The posterior layer is sewn in a continuous fashion with barbed suture. We then pass an oral gastric tube on top of the posterior layer and into the efferent limb. We start the anterior layer at the inferior corner by tying the anterior stitch to the posterior stitch and running it halfway along the anterior wall. In the superior corner, we start another suture meeting at the halfway mark and tying both together. We test our anastomosis with the oral gastric tube that's in place. Figure 26.1 demonstrates the key technical aspects

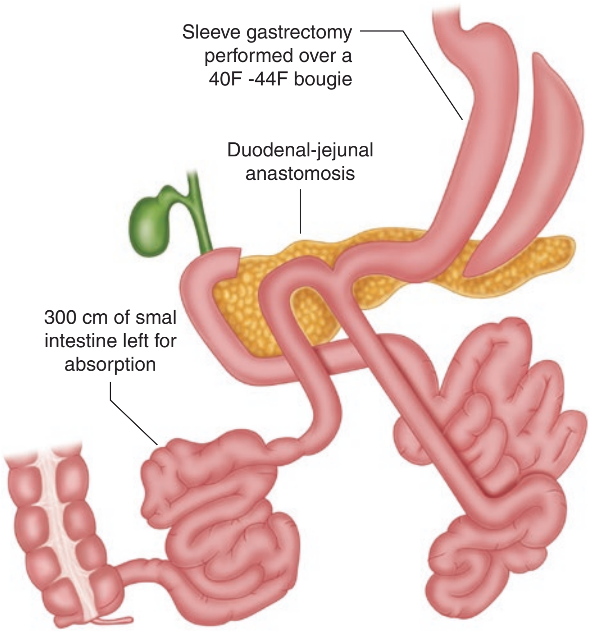

Fig. 26.1 Technical aspects of SIPS. Visual representation of SIPS including sleeve gastrectomy performed over a 40 F–44 F bougie and a duodenal-jejunal anastomosis performed 300 cm proximal to ileocecal valve

of SIPS including a sleeve gastrectomy performed over a larger bougie than a sleeve gastrectomy and a duodenal-jejunal anastomosis performed with a loop 300 cm proximal to the ileocecal valve.

Proper technique while performing the SIPS-type procedure maximizes the benefits of a combined gastric and intestinal procedure. Our goal of this operation is to promote fat loss while maintaining adequate lean muscle mass. Essential technical aspects to ensure this goal include performing an adequate sleeve gastrectomy and maintaining 300 cm of the small bowel for absorption.

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Chapter 27
Duodenal Bipartition or Side-to-Side Duodeno-Ileostomy: Rationale and Technical Details

Michel Gagner and Maxime Lapointe-Gagner

27.1 Rationale

Since the introduction of laparoscopic sleeve gastrectomy from 2000, there has been a tremendous increase in bariatric surgical procedures worldwide, and this technique is now most accomplished for severe obesity and type 2 diabetes [1]. According to a recent French national countrywide data, revisions of sleeve gastrectomy occur at more than 10% after 10 years, with >87% concern of weight regain, insufficient weight loss, or recurrence of type 2 diabetes [2]. Re-interventions have also increased in the last 10 years either due to weight regain or intractable gastroesophageal reflux disease following the latter operation. As a last resort, severe reflux may be contained by Roux-en-Y gastric bypass following disappointment of medical treatment, as other methods have not been fully approved in all countries (magnetic collar beads, i.e., LINX from Torax, radiofrequency sphincter augmentation, i.e., STRETTA, ligamentum teres-plasty, etc.) [3]. For weight regain after sleeve gastrectomy, especially in patients with a higher body mass index (BMI), laparoscopic duodenal switch (DS) and its variants are increasingly suitable for revisional surgery, since conversion to Roux-en-Y gastric bypass can produce relatively poor or fair results [4]. Single anastomosis duodenal switch, or single anastomosis duodeno-ileostomy (SADI), is a variant that has become more popular because it is less technically complicated (avoidance of ileo-ileostomy) and results

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in comparable weight loss at 5 years and resolution of comorbidities with fewer side effects [5]. Interestingly, this procedure was first proposed by Del Genio when he was at the experimental surgery laboratory of Mount Sinai, several years before the seminal paper of Sanchez-Pernaute and Torres [6]. For type 2 diabetes, similar results may certainly be obtained with hypoabsorptive surgery, after sleeve gastrectomy [7, 8].

A recent variation of this procedure is the side-to-side duodeno-ileostomy or “duodenal bipartition,” similar to gastric bipartition of Santoro [9]. Although a Roux-en-Y limb is used in his original description, duodenal bipartition categorically avoids the risk of gastro-ileostomy marginal ulcers, and the connection is small bowel-to-small bowel, with bile thwarting acid [9]. Mahdy personalized this concept to create the SASI bypass (for single anastomosis sleeve ileal), where a loop of the ileum at approximately 250 cm from the ileocecal valve is anastomosed to the antrum, but with lesser results than an end-to-side duodeno-ileostomy, contributing an extra 40% of EWL after sleeve gastrectomy [10].

Before human implementation, the duodenal bipartition has previously been tested in a porcine model and has proven to be an effective weight loss procedure by both creating an early stimulation of the distal ileum (with GLP-1 and PYY 3–36 release), the so-called ileal brake, and by continually providing absorption of nutrients, such as by progressing the normal pathway of the third duodenum and continuing distally to the jejunum and proximal ileum due to dual lumen pathways (Fig. 27.1) [11]. Hence, this assembly generates a lower risk of malnutrition and hypoproteinemia compared to a full duodenal switch or even a single anastomosis duodeno-ileostomy, where liver failure is still a possibility.

This procedure (duodenal bipartition) can be accomplished either with the first/second parts of the duodenum after the pylorus with an antecolic anastomosis or with the third portion of the duodenum in a transmesocolic/infracolic approach (described here). It is possibly easily reversed with one cartridge and a linear stapler

Fig. 27.1 Schematic representation of a side-to-side duodeno-ileostomy with a transmesocolic approach. The inferior third portion of the duodenum and the anti-mesenteric distal ileum are approximated

by laparoscopic approach if clinical situations require it in the future. One mesenteric defect is involved both ways and is closed laparoscopically with a running nonabsorbable suture, most straightforwardly on the left side, between the transverse mesocolon and the mesentery of the ileum up to the transverse colon itself. Postoperative care and follow-up are similar to a duodenal switch SADI, but you can anticipate a lower risk of malnutrition and hypovitaminosis, lesser bleeding and leakages, and a faster recovery [12]. Interestingly, a more radical concept has been evaluated in the porcine model: a duodeno-colic bypass, side-to-side, reminiscent of weight loss after colic fistulas. This may never reach the stage of common clinical applications [13].

27.2 Technique

Duodenal bipartition can be performed with sleeve gastrectomy (at the same time) or as a second-stage procedure. In this chapter, I describe a technique for the second stage as it is likely to be the most common condition. The technique is described, and images are taken from a didactic video from the session "Emerging Techniques in Bariatric Surgery – Laparoscopic Duodeno-Ileostomy," from the Annual Congress of the American College of Surgeons in 2009; hence, this technique of side-to-side duodeno-ileostomy has been around for more than a decade and is available in the Online video Library of the American College of Surgeons, as ACS-2771 [14, 15].

The side-to side anastomosis is most easily performed while the main operator is on the left side of the patient. The left arm can lie on the side of the body, while a camera or other assistant can be on the upper left side. Interchangeably, a between-the-leg position, the so-called French position, can also be used. The port positions will be similar to a duodenal switch or SADI procedure, with a camera position in the umbilicus or somewhat to the left paramedian area, superior to the umbilicus. Since a linear stapler is required (if not doing a full hand-sewn anastomosis which is a possibility), the stapler port is slightly higher and to the left of the camera port. A retraction grasper is best in the upper subcostal left to lift the transverse colon and greater omentum cephalad. Another 5 mm port, either on the right of the umbilicus, slightly inferior for the left hand, is required for suturing.

The first maneuver is a diagnostic laparoscopy to assess the feasibility of the approach, as previous surgeries may create significant adhesions to the ileum (like appendectomy, prior colectomy, or pelvic surgery in women) or adhesions near the transverse colon and greater omentum from upper quadrant surgeries. If the ileum is free (or needs to be freed from adhesions) and the transverse colon can be pushed cephalad to expose its transverse mesentery, then the duodenum really becomes apparent and visible, given that it is in the left retroperitoneum.

Figure 27.1 schematically represents this concept. In Fig. 27.2, we attempt an opening of the peritoneum lying over the third portion of the duodenum (which is retroperitoneal) after lifting the transverse colon. An ultrasonic or bipolar dissector creates a linear, transverse opening from left to right, enough to reach the

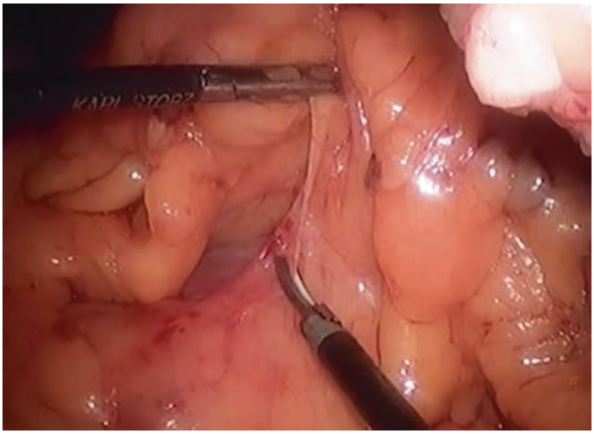

Fig. 27.2 Opening the peritoneum over the third portion of the duodenum (which is retroperitoneal after lifting the transverse colon). An ultrasonic dissector is making a linear opening from left to right enough to get the anti-mesenteric border for the anastomosis

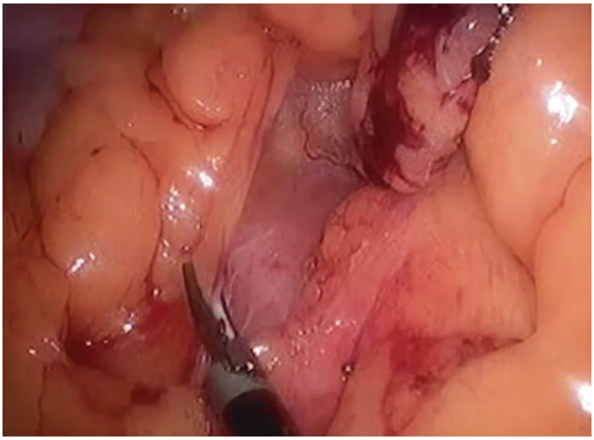

Fig. 27.3 Exposed third portion of the duodenum

anti-mesenteric border for the anastomosis (5–6 cm). After exposing the third portion of the duodenum, we assess the mobility for a side-to-side anastomosis and ensure that we have enough length, since the stapler itself is 60 mm which is adequate for such anastomoses to remain patent long term (Figs. 27.3 and 27.4).

Measurement of an adequate length of the ileum is necessary and has to be done accurately, since the ileum that is too short will result in malnutrition. In a classical DS and SADI, the distances are 250 cm from the ileocecal valve (in SIPS, it will be 300 cm), and in cases where the stomach has not been resected, a shorter distance is possible. The length measurements are performed using a 50 cm umbilical measuring tape and run with flat traumatic forceps (laparoscopic Dorsey bowel forceps, Storz, Tuttlingen, Germany). Enterotomies are made on both sides of the bowel on the left side of the duodenum, as the stapler will be inserted from left to right. The openings are not too large but are just wide enough to insert a linear stapler of 60 mm in length (Figs. 27.5 and 27.6). These openings can be made using either a hook with monopolar energy or with the harmonic scalpel. The stapler is introduced

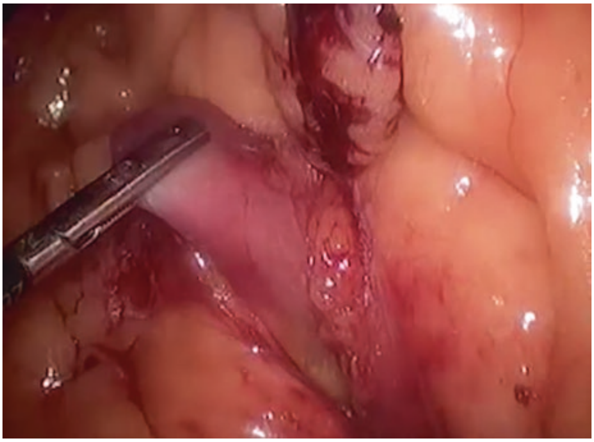

Fig. 27.4 Pulling and assessing mobility for an anastomosis

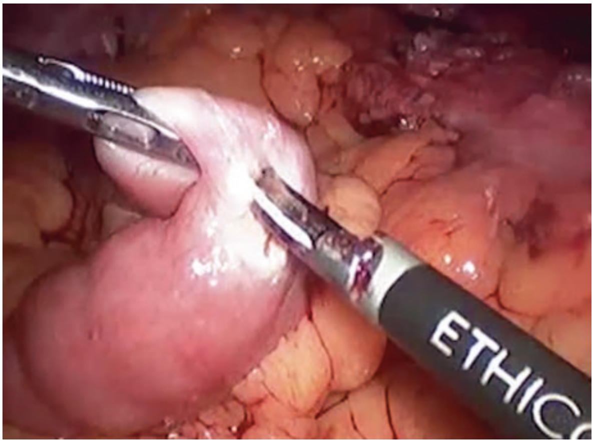

Fig. 27.5 Making an enterotomy on the ileal side

from left to right, with the anvil in the thinnest bowel (duodenum), using a white cartridge in order to get good apposition and minimize bleeding (Fig. 27.7). The enterotomies are closed with running suture; I prefer a 3–0 absorbable monofilament or equivalent (Fig. 27.8).

A methylene blue test can be performed with a nasogastric tube in the stomach using 200 ml with the duodenum and ileum clamped with bowel forceps. This test not only helps ensure that the anastomosis is not leaking but also importantly that lumens are patent and no kinks have occurred. Running 2–0 nonabsorbable sutures, on the left side, from top to bottom, uniting the mesocolon and the mesentery of the ileum are used to close the mesenteric defect (Fig. 27.9). This is closed on the left side of the anastomosis, as closing on the right is more difficult and unnecessary. Doing so will prevent an internal hernia and possible bowel obstruction in the future.

The ultrasonic blade should point upward when opening the peritoneum over the duodenum to avoid burning the duodenal wall itself. The markings on the mesentery

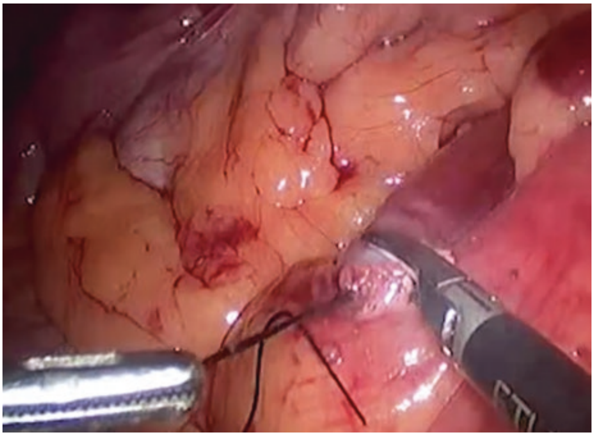

Fig. 27.6 Making an enterotomy on the left side of the duodenum (with a traction silk suture under)

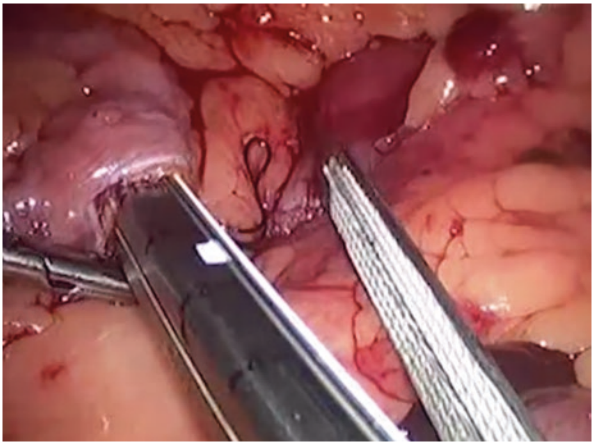

Fig. 27.7 A linear stapler is inserted in both enterotomies, with the largest end into the ileum

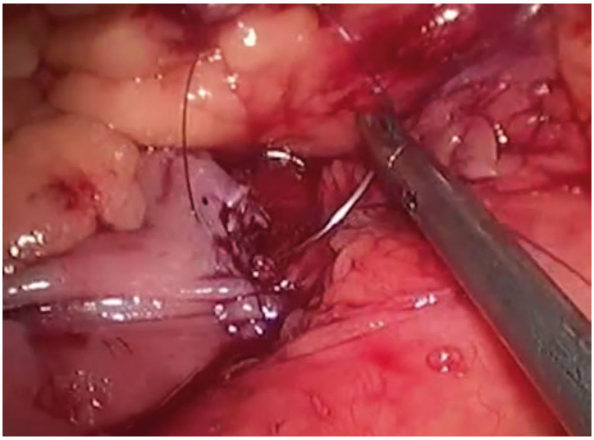

Fig. 27.8 Closing the last centimeter on the entero-enterostomy with running suture

of the ileum are done with metal clips or alternately with a suture on the anti-mesenteric side, which can also be used for traction during the entero-enterostomy (Fig. 27.10). When the stapler is inserted, it helps to place traction sutures underneath to pull the bowel toward the stapler. If the mesentery is not suitable for an infracolic approach, then a supracolic route can be used, and a side-to-side anastomosis is performed the same way on the first/second portion of the duodenum. The mesenteric space is trickier to close and starts typically on the taenia of the transverse colon. Uniting the mesentery of the colon to the ileum, splitting the greater omentum (in between the right third and left two-thirds), facilitates this maneuver at the beginning of the case. Postoperative care is similar to a DS or SADI with nutritional rapid progression, protein supplements, mineral, and multiple vitamins, including fat-soluble vitamins which should be provided. Blood levels of micronutrients are critical as well as regular follow-up visits to ensure excellent nutritional health.

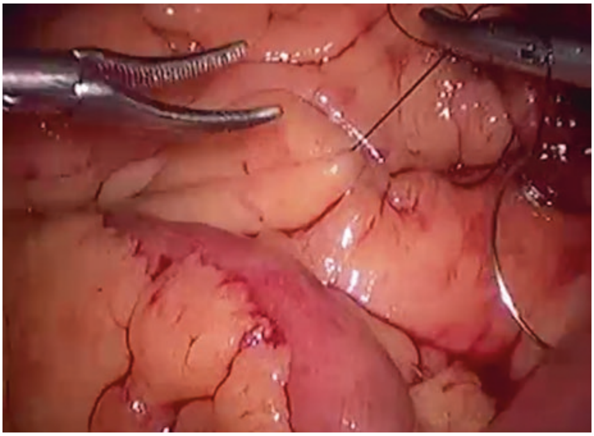

Fig. 27.9 Closing the mesenteric defect with a running nonabsorbable suture, on the left side, from top to bottom

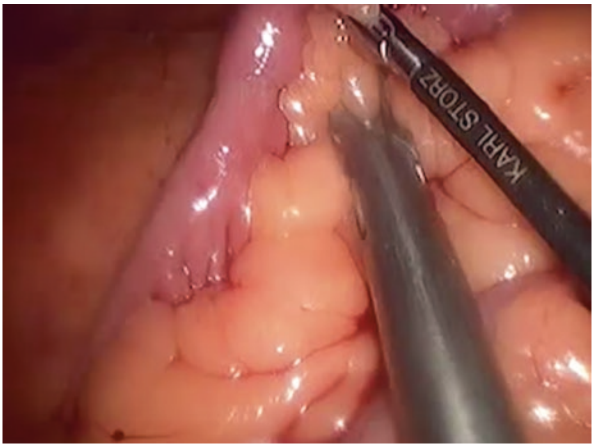

Fig. 27.10 Marking with a clip, the ileal measurements from the ileocecal valve

The results of patients operated on more than 10 years ago show 18 months of linear weight loss and no weight regain. The weight loss from duodenal bipartition is similar to SASI patients; however, they do not experience the bile reflux that these patients have with the biliopancreatic limb coming to the antrum. This is a major advantage of the duodenal bipartition, as the bile getting to either the second duodenum (in an antecolic approach) will be dependent on the pylorus as a barrier, or the third/fourth duodenum in an infra-colic approach, and adding more distance to reflux back into the stomach. The advantage of an antecolic approach leaves the possibility of a revision to a full SADI or DS if needed, as a third-stage procedure, in case of inadequate weight loss or type 2 diabetes recurrence.

Finally, these approaches will be the basis for lesser invasive procedures performed by magnetic surgery [16].

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Chapter 28
Duodeno-Ileal Anastomosis with Hand-Sewn Technique

Amador Garcia Ruiz de Gordejuela, Marc Beisani Pellise, and Oscar González López

28.1 Introduction

Duodeno-ileal anastomosis is one of the trickiest steps during a duodenal switch procedure. Although it may seem a simple end-to-side or end-to-end small bowel anastomosis, the anatomical issues of both ends and the anthropometric characteristics of the patients may complicate the procedure itself. Hand-sewn anastomosis also requires a skilled surgeon with good experience in laparoscopic suturing [1]. On the other hand, it may provide a safe and reliable anastomosis.

28.2 Surgical Technique

Patients are placed in a supine position with opened legs, in a modified Lloyd-Davies position, and five to six trocars are placed as shown in Fig. 28.1. For the duodeno-ileal anastomosis, the surgeon will work between the legs of the patient, with the assistants at both sides.

We usually perform it in a simplified fashion [2], first constructing the duodeno-ileal anastomosis and, after that, the Roux anastomosis next to it, as in the simplified Roux-en-Y gastric bypass described by Lonroth [3]. During the counting of the alimentary limb, it is important to move the small bowel to the right side of the

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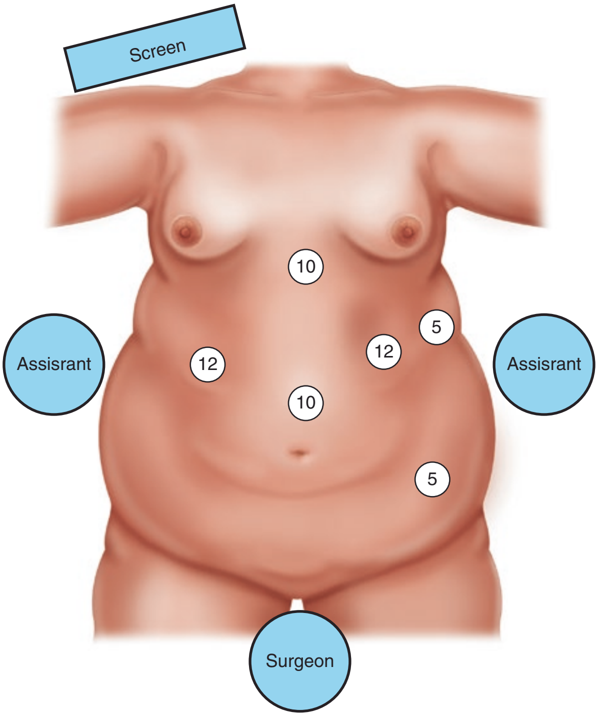

Fig. 28.1 Trocar positioning for duodenal switch

patient. This way, once the anastomosis is being constructed, the alimentary limb will be kept on the right side of the patient and the biliopancreatic limb on the left side. This practice avoids torsion of the mesenterium and enables an easy ascending of the intestinal loop to the duodenum.

Our group usually ligates and sections the right gastric artery on its root, as it was presented by Marchesini et al. [4, 5]. This technical gesture offers a greater mobilization of the duodenal ending, reducing tension to the anastomosis, without compromising the blood supply.

For the hand-sewn anastomosis, we usually prefer monofilament absorbable sutures. Our general practice consists in performing a double layer with 2–0 and 3–0 running sutures.

The first layer is a sero-serosal end-to-side 2–0 running suture of the posterior wall. This first layer will approach and fix the ileum to the duodenal ending. In this layer, it is important to take big bites of the duodenal ending (even including the staple line) and going almost through the mesenteric side of the small bowel (Fig. 28.2).

We usually keep both endings of that first running suture quite long, in order to allow the assistant to grab them from the epigastric and left side trocars. This gesture, combined with the previous ligation of the right gastric artery, enables the assistant to take control of the whole anastomosis. It then can be easily mobilized and oriented as desired, in a maneuver that resembles the flying of a kite (Fig. 28.3).

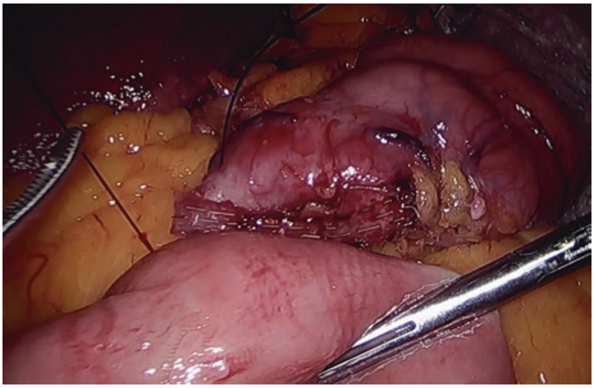

Fig. 28.2 First layer of the duodeno-ileal anastomosis

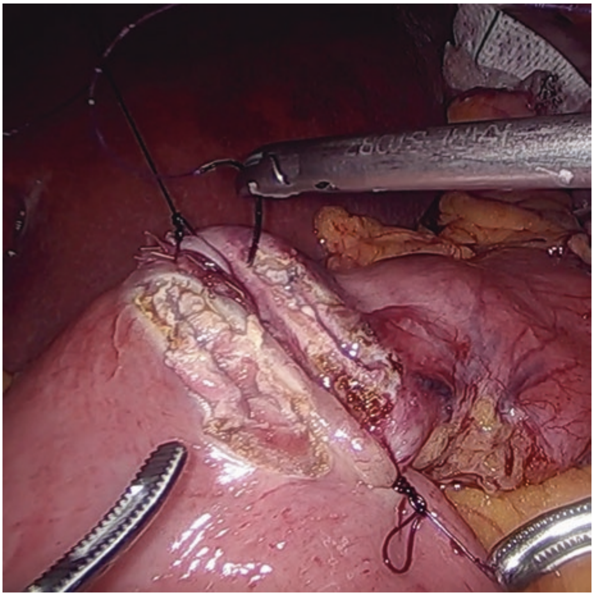

Fig. 28.3 Kitesurfing of the anastomosis from the assistant

The assistant's kite piloting of the anastomosis is of much help when performing a hand-sewn duodeno-ileal anastomosis, for it facilitates enormously the surgeons' suturing effort by rotating and tilting the anastomosis as suited for each stitch.

After finishing the first posterior layer, the surgeon will open both sides of the anastomosis. The length of the opening will be determined by the width of the duodenal ending. It is important to be careful not to harm the posterior wall during the opening. It should be also taken into consideration that the ileal ending may dilate during the suturing due to tractions, so it may be recommended to open it a little less than the duodenum.

Next layer is the inner layer of the posterior wall. We usually use a 3–0 monofilament running suture. This layer should include the whole posterior wall. For the angles, the creation of "V"-shaped stitches (Connell stitches) facilitates a good closure of these weak points.

The first layer of the anterior wall will also be a 3–0 monofilament running suture. This suture will close the anastomosis. Unlike the previous layer, here it is recommended to be careful and keep the mucosa out of the stitch. It may be argued to be only an aesthetic preference, but we firmly believe it favors a better consolidation of the anastomosis.

Finally, a second anterior layer of 2–0 running monofilament suture is performed. This will be a sero-serosal suture to reduce tension and keep the anastomosis secured and closed.

All the layers are constructed from the right side to the left side of the patient (from the lesser to the greater curvature). As said before, the kite piloting of the anastomosis is the key to obtain the right orientation needed for each stitch.

28.3 Potential Points of Discussion

Here we summarize potential variations of the technique we have described:

- Suturing. We highly recommend running sutures to single stitches. Single stitching is time-consuming, and in cases where the duodenum is still attached down to the liver, they can be really tricky to complete.
- Sutures. For running sutures, the absorbable monofilament is our choice. We do not consider non-absorbable sutures due to the risk of ulcer formation.
- Single vs. double layer. A single layer is feasible and may be easier to perform. It may also reduce the risk of stenosis. But in patients operated for duodenal switch, their anthropometrics are usually associated with heavy and short mesenteries that may create tension in the anastomosis. Some surgeons usually do not perform the anterior sero-serosal layer.
- Barbed sutures. They may be helpful when creating the anastomosis, but they are usually more expensive, and, importantly, they do not have a way back, which can be a major drawback in some situations.

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Chapter 29
Circular Anastomosis in Duodenal Switch

Ainitze Ibarzabal Olano, Javier Osorio Aguilar, and Amador Garcia Ruiz de Gordejuela

29.1 Introduction

The duodenal switch is a bariatric surgical procedure that was conceived as a modification of the Scopinaro technique. This technique, which can be considered one of the most complex procedures in obesity surgery, was described by Hess and Marceau in 1988, and unlike the Scopinaro technique, it preserved the pylorus and avoided biliary reflux. In September 1999, Rabkin performed the first laparoscopically assisted duodenal switch, and in the same year, Michel Gagner performed it totally laparoscopically. From then until the implementation of single anastomosis malabsorptive techniques, it has been the malabsorptive technique of choice.

Technically, it involves two main steps: restriction and malabsorption. There are several technical variations described in literature from both steps.

One of the most challenging steps of the procedure is duodeno-ileal anastomosis. It can be performed in three different ways: linear mechanic, hand-sewn, and circular mechanic. A multicenter study with 457 patients showed that both sutures (linear and circular) are safe with a low rate of postoperative complications, although the circular sutures showed a greater tendency to hemorrhage and surgical wound

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infection but required less surgical time [1, 2]. There is no evidence on the suitability of one type of anastomosis or another in duodenal switch.

Our group usually performs the circular mechanic anastomosis.

29.2 Circular Mechanic Duodeno-Ileal Anastomosis

Once the vertical gastrectomy has been performed, the duodenum is dissected 3–6 cm from the pylorus and sectioned. The preservation or not of the right gastric artery varies according to the surgical groups. The section may offer an advantage of an enhanced mobility of the duodenal ending, favoring a less tension anastomosis.

After performing the duodenal dissection, and without sectioning the right gastric artery, we introduce the circular suture device from the mouth guided by a nasogastric tube. The tip of the device can be taken out in the middle zone of the staples in the duodenum.

In cases of a high duodenum, or even very stacked below the liver, the tip of the nasogastric tube can be taken out also from the inferior margin if the duodenum is not very mobile. This technical trick will allow more margin of mobility and a few centimeters to perform the anastomosis easier.

Occasionally, it may be difficult to introduce the OrVil from the mouth. In those cases, the trocar orifice where we will place the circular suture device can be enlarged, and after having made a running suture with a monofilament suture in the duodenum, we introduce the OrVil through the patient's abdominal wall.

After this step, we identify the alimentary loop 250 cm from the ileocecal valve and section it. We then perform an enterotomy at the sectioned distal ending and introduce the circular suture device through this hole. Usually and if the duodenal stump is mobile, this device can be introduced from the left side of the patient (enlarging the hole of the 12 mm trocar in our right hand), but if this is not the case, the device can be introduced from the right side.

From the right, it is more difficult to introduce the device into the ileal loop, but it is easier to perform the anastomosis if the duodenal stump is not very mobile, and from the left, it is easy to introduce the device into the loop, but it is difficult to perform the anastomosis if the duodenal stump is fixed.

The diameter of the circular device is always 25 mm. Even though the 21 mm suture may be much easier to introduce and handle, it is related to stenosis.

Next, we section the ileal loop with a linear suture device and reinforce the anastomosis at the corner end with a loose stitch of an absorbable suture. We removed the intestinal fragment through the trocar orifice that we enlarged to introduce the suture device protected in an Endo bag.

Once the duodeno-ileal anastomosis has been performed, we proceed to perform the common channel at 100 cm from the ileocecal valve and close the mesenteric defects with non-absorbable sutures.

29.3 Technical Issues

This circular mechanical anastomosis allows to perform a standardized anastomosis from patient to patient with less risk of stricture, as some studies have shown, but with potential higher risk for bleeding.

The main technical difficulties we may face from this anastomosis are:

Introduction of the OrVil from the mouth. Duodenal switch is mainly reserved for higher BMI patients, so sometimes it can be challenging to direct the orogastric tube until the distal stomach and pass the pylorus with the tip.

Introducing the circular suturing device. As it has been previously described, introducing it from the right side of the patients allows a better approach to the duodenal ending but a more difficult introduction of the ileum. From the left side of the patient, the ileum is easily approached, but the anastomosis can be challenging, especially in those cases with higher or stacked duodenal endings.

When the OrVil cannot be introduced from the mouth, it is necessary to open the duodenal ending and perform a purse-string suture. This technical gesture may reduce the length of the duodenal ending and may compromise the pylorus in some patients.

29.4 Technical Variations of the Circular Anastomosis

Even though the circular mechanic anastomosis seems to be the most stable and with less technical variations, we may find several:

- The diameter of the stapler is not discussed, as the 21 mm is highly related to stenosis.
- Introduction of the OrVil: from the mouth or from the abdominal wall with a purse-string suture at the duodenal ending.
- Introduction of the stapler. It can be done from the right or the left side of the patient. Both have pros and cons that have been previously discussed.
- Opening of the duodenal ending. When the OrVil is introduced from the mouth, the tip of the tube is usually extracted from the middle of the posterior wall, trying to use the whole ending and allowing to create some kind of alienation from the duodenum to the ileum. Some difficult cases will require performing the opening at the inferior corner of the duodenal section, allowing the anastomosis to move down the anastomosis a few centimeters and reducing tension.
- The single stitches of reinforcement of the staple line are not performed by all groups. This technical gesture reduces the tension and may assure some kind of better hemostasis.

29.5 Points of Discussion

Restriction is performed by performing a vertical gastrectomy, and at this point, there are several variables depending on the surgical groups. The main variables are the distance at which the first shot is made in the antrum and the caliber of the probe with which the stomach is calibrated. In a recent study of 390 patients [3], it was shown that starting the gastric sect. 3 cm or less from the pylorus was significantly associated with greater weight loss, even though these patients presented more oral intolerance in the immediate postoperative period. These data are confirmed by a recent randomized study [4] comparing an antral resection 2 cm from the pylorus with a resection 6 cm beyond, showing more weight loss in the group of patients with a larger resection and without associated complications.

Another controversy is the size of the sleeve and whether the size of the tube used to calibrate the gastrectomy has an impact on weight loss. In a recent meta-analysis [5] comparing the results of weight loss and complications in patients operated with thicker tubes compared to thinner ones, it is concluded that thinner tubes are related to greater weight loss, but thicker tubes have fewer associated complications.

When these laparoscopic surgical procedures were described, serious postoperative complications were initially observed, which made it necessary to perform this procedure in two stages, a first restrictive stage and a second malabsorptive stage, when the patient had already lost some weight and the surgical intervention was safe. The decision to perform this surgery in one or two stages also varies according to the patient's BMI and the surgical team, but in a study carried out comparing the results of surgery in one or two stages, no differences in total weight loss were observed, but there were differences in the complications [6].

29.6 Summary

The circular stapler anastomosis is an easily reproducible anastomosis. There are few points of discussion and variations. It is a safe and usually quite straightforward anastomosis. When the OrVil can be introduced from the mouth, it is also a quick anastomosis.

Even though there are just a few trials comparing the three different ways, they all conclude that this kind of anastomosis is safe, with low risk of stenosis and slightly higher risk of bleeding.

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Chapter 30
Duodenoileal Anastomosis with Linear Stapler Technique

Oscar Gonzalez Lopez, Amador Garcia Ruiz de Gordejuela, and Marc Beisani Pellise

30.1 Introduction

The duodenoileal anastomosis is considered to be the Achilles' heel of the duodenal switch and its variants. It is technically the most demanding stage of the operation and the place where most postoperative complications arise. Different techniques have been proposed, both stapled and hand-sewn. Initially, the use of circular stapled devices was the most common laparoscopic approach. However, this requires to pass the anvil through the mouth, which is a time-consuming maneuver, and increases the risk of surgical wound complications at the site where the stapler is introduced into the abdomen. Later, a "right-angled" side-to-side linear stapled anastomosis was described for the duodenal switch [1], which seemed to avoid the problems related to the circular anastomosis without adding much technical complexity.

One of the most common variations of the duodenal switch is the single anastomosis duodenoileal bypass with sleeve gastrectomy (SADI-S), described by Sanchez-Pernaute et al. in 2007 [2]. It is based on the principle that preserving the pylorus would stop biliary reflux to the stomach, thus making a Roux-en-Y configuration unnecessary. Although still a recent incorporation to the surgical arsenal against obesity, it has progressively gained popularity due to its greater technical simplicity and has already been endorsed by the International Federation

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for the Surgery of Obesity and Metabolic Disorders (IFSO) [3] and the American Society for Metabolic and Bariatric Surgery (ASMBS) [4] as an accepted alternative to the classic duodenal switch. In its original description of the laparoscopic SADI-S, Sanchez-Pernaute et al. recommend the same "right angled" side-to-side linear stapler technique previously introduced for the duodenal switch [5]. In this chapter, we will elaborate on how to perform this anastomosis and highlight some important technical aspects.

30.2 Procedural Approach

30.2.1 Common Limb Measurement

Although some groups prefer to perform this step after taking down the duodenum, we believe that it is a good practice to begin by measuring the future common limb, in order to discard any anomaly that could pose a contraindication to the technique.

With the surgeon and the assistant in the left side of the patient, the ileocecal valve is identified and the ileum counted back between 2 and 3 m. There is controversy on the ideal length of the common limb, as the initial 200 cm limb has been associated with a hardly acceptable high rate of postoperative malnutrition. However, limbs of more than 300 cm may not obtain good weight loss outcomes. In our practice, we perform the anastomosis at 270 cm from the ileocecal valve if the patient has previously undergone a conventional sleeve gastrectomy and may shorten it to 250 cm if the sleeve is performed by us in the same act and made intentionally "floppy."

Once the selected ileal loop is identified, it is ascended antecolically and fixed to the gastrocolic omentum. Marking the efferent limb with a stitch may be convenient, in order to avoid twisting the loop later on.

30.2.2 Duodenal Dissection

The duodenal dissection is the most delicate part of the procedure. A thorough anatomical knowledge is mandatory, as important structures (i.e., the pancreaticoduodenal vessels and the hepatic hilum) lie around the working area. Moreover, the vessels of the lesser curvature should be preserved at all costs to avoid compromising the gastric and pyloric blood supplies.

First, the gastroepiploic vessels should be taken down and the gastric antrum lifted to the anterior abdominal wall and pulled to the left, in order to comfortably

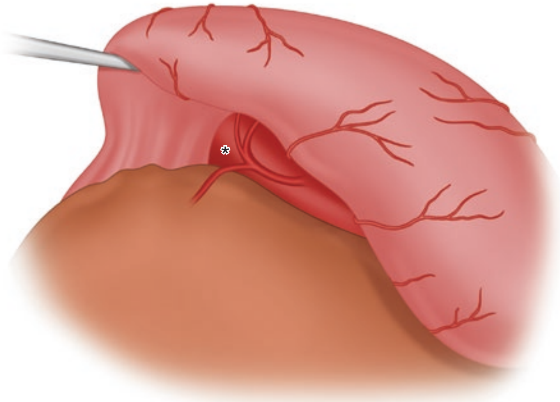

Fig. 30.1 Dissection of the posterior aspect of the duodenum. The asterisk marks the window where the stapler will go through, in the space limited by the gastroduodenal artery, the right gastric artery, and the duodenum

access the lesser sac and carefully dissect the subtle plane between the pancreas and 3–4 cm of the posterior aspect of the duodenum. The gastroduodenal artery, which will cross under the dissection plane, perpendicular to the duodenum, usually marks the limit of that dissection. However, visualizing the gastroduodenal artery is not mandatory. During this dissection, the pancreaticoduodenal vessels can be found running parallel to the duodenal axis from the pancreas to the pylorus. The right gastric vessels can be seen going upward, perpendicular from the gastroduodenal artery and leaning to the duodenum (Fig. 30.1). Gently retracting the liver cranially may help to move away the hepatic hilum during this stage. When the posterior aspect of the duodenum has been freed and the space limited by the gastroduodenal artery, the right gastric artery, and the duodenum has been identified, the dissection is completed. It may be useful to leave a gauze pad in the dissection bed, in order to help with hemostasis and protect the hepatic hilum before moving to the anterior aspect of the duodenum to finally open the window in the thin peritoneal layer of the hepatoduodenal ligament.

After completing the duodenal dissection, it is then sectioned with a laparoscopic linear stapler device passed through the window previously created. We recommend the use of the white or blue cartridges of the Echelon (Johnson & Johnson, New Jersey, USA) or the beige cartridge of the Endo-GIA (Medtronic, Minnesota, USA). Attention must be paid only to include the duodenum when closing the device. In normal conditions, neither the distal nor proximal duodenal stumps need additional reinforcing.

When performing this linear stapled anastomosis, preserving the right gastric artery is recommended for two main reasons:

- It fixes the duodenal stump and facilitates later on the introduction of the linear stapler through a small duodenal entrance.

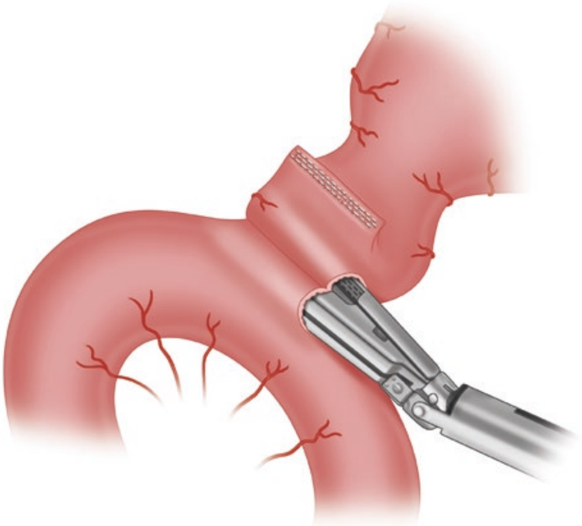

Fig. 30.2 "Right-angled" side-to-side linear stapled anastomosis

- After the duodenal section and the linear anastomosis are completed, there will be a hypovascularized region between the two (Fig. 30.2) that can critically depend on the blood supply arriving from the right gastric artery. That should be specially kept in mind when performing a staged approach, if the integrity of the left gastric artery from the previous sleeve surgery cannot be reassured.

30.2.3 Duodenoileal Anastomosis

After the selection of the suitable ileal segment and the section of the duodenum are completed, a 2–3-cm-long side-to side duodenoileal anastomosis is performed. The linear stapler is introduced parallel to the longitudinal axis of the small bowel and parallel to the duodenal section line, through small incisions on the antimesenteric aspect of the ileum and the lateroposterior aspect of the duodenum, approximately 1 cm from the section line (Fig. 30.2). A white or beige cartridge is usually used for that stage, entering the thick stem through the ileum. When retrieving the stapler, it should remain semi-closed to avoid stretching the orifices, and any bleeder from the stapled line should be carefully identified and controlled.

Finally, the orifices are closed with a running suture. Also, the anterior aspect of the anastomosis is reinforced with a running suture, including the section line of the duodenal stump. We prefer using a 3-0 braided resorbable suture for the former and resorbable auto-locking 3-0 suture for the latter, although other options could be suitable as well (Fig. 30.3). The anastomosis can then be tested for leaks with methylene blue introduced through an orogastric tube. Indocyanine green can also be used to confirm an adequate blood supply.

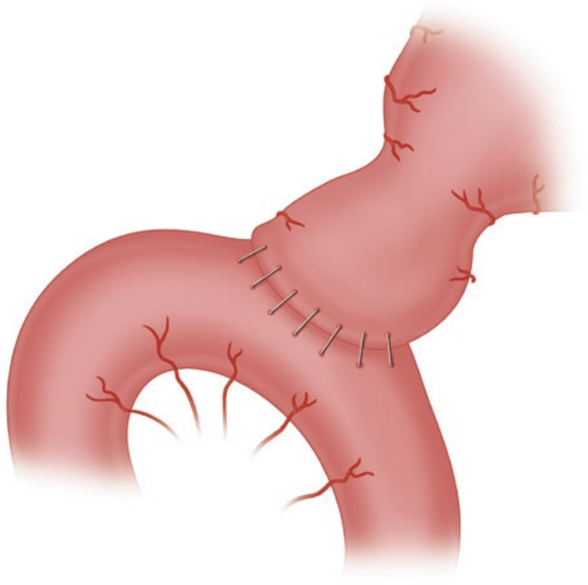

Fig. 30.3 Final appearance of the anastomosis, after closing the orifices and reinforcing the anterior aspect

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Chapter 31
Staged Duodenal Switch for High-Risk Patients

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31.1 Introduction

In the USA, since the year 2000, the adult obesity rate has increased from 30.5% to 42.4% in 2018, with the subset of severely obese patients increasing rapidly. Hispanic and non-Hispanic Black adults had the highest age-adjusted prevalence of obesity [1]. This presents as a public health crisis, as the prevalence of obesity mirrors the prevalence and burden of many comorbid diseases, affecting several organ systems. Despite several pharmaceutical, lifestyle, and public health measures aimed to address the disease, the obesity epidemic in the USA continues to grow [2]. In patients suffering from morbid obesity refractory to lifestyle change, bariatric surgery has demonstrated effective long-term treatment. Given the procedural efficacy, safety, and utilization of laparoscopic methods, procedures such as laparoscopic adjustable gastric band (LAGB), sleeve gastrectomy, Roux-en-Y gastric bypass (RYGB), and biliopancreatic diversion with duodenal switch (BPD/DS) have been increasingly utilized in the USA.

LAGB and RYGB are the most common bariatric procedures aimed for weight reduction; however, the BPD/DS is the most effective procedure, resulting in the greatest excess weight loss (EWL) among the various surgical options. Patients undergoing BPD/DS often experience decreased hunger due to the reduction in gastric volume and further EWL through diminished nutrient absorption within the alimentary limb. The procedure is technically intensive, requiring a skilled surgeon with clinical expertise for choosing appropriate patients. As a result, BPD/DS

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accounts for <1% of bariatric surgery, despite the powerful impact on weight and improved resolution of obesity-related comorbidities, such as type II diabetes. Increased perioperative morbidity and long-term nutritional adverse effects related to the nature of the technique add to the disinclination of its use. However, BPD/DS still maintains a critical role in the treatment of super-obese patients (BMI > 50 kg/m^2), due to the effective management of their disease. In high-risk or super-super-obese patient groups (BMI > 60 kg/m^2), a two-stage procedure may be utilized to limit procedure time, leading to a reduction in the perioperative morbidity and mortality. The first stage consists of a sleeve gastrectomy, followed by duodenoileostomy and ileoileostomy approximately 6–18 months after [3, 4]. The objectives of this chapter will be to (1) provide an overview of the procedure, (2) describe indications and contraindications, (3) briefly describe the surgical technique, and (4) outline surgical outcomes and complications related to staged BPD/DS.

31.2 Procedure

By staging the BPD/DS into two stages, (1) sleeve gastrectomy and (2) duodenoileostomy and ileoileostomy, operation duration is decreased, and complications related to increased time under anesthesia are reduced [4, 5]. Staging of procedures may be planned preoperatively, or the decision can be made during the sleeve gastrectomy portion. Indications for intraoperative decision for procedure staging include physiologic compromise of the patient or questionable technical feasibility of the remaining maneuvers. The SG and BPD portions of the procedure have also been reported using a robotic-assisted technique, with similar outcome to purely laparoscopic procedures [6]. In other bariatric procedures, such as the RYGB, a comparison of robotic-assisted surgery to laparoscopy demonstrated a potentially increased leak rate at the gastric pouch or remnant stomach level [7].

31.3 Stage 1: Sleeve Gastrectomy

Commonly a stand-alone procedure, the sleeve gastrectomy is conducted laparoscopically and is the first portion of the staged BPD/DS for high-risk or super-super-obese patients. In this procedure, approximately 75–80% of the stomach is removed in a vertical fashion to limit food volume intake. The stomach volume will be reduced from 2 L to 100–150 mL, and due to the removal of the fundus, the new stomach is largely resistant to stretch and accommodation of large ingested volumes. With the patient in supine position and surgeon standing on the patient's right and working ports in the right subcostal and mid-abdomen, the camera is in the left mid-abdomen. If the liver is enlarged and interfering with the procedure, a liver retractor can be added through the extreme right-sided port to provide leeway. Using an ultrasonic or bipolar energy device, the greater curvature of the stomach is devascularized and mobilized approximately 4–6 cm from the pylorus superiorly to the left crus of the diaphragm. After mobilization, a 60 Fr bougie is passed to guide gastric division. If a hiatal hernia is noted during the procedure, repair is indicated to reduce postoperative gastroesophageal reflux and retained elements of the stomach leading to impaired weight loss. Creation of the gastric sleeve utilizes a thick tissue cartridge with a linear stapler. Stapling must be conducted in the same horizontal plane to avoid functional obstruction caused by a spiral-sleeve contour. Stapling along the bougie should not be overly tight, as improper staple firing may occur. The stapling will begin 4–6 cm above the pylorus to spare much of the antrum. In a two-staged procedure, the gastric specimen can now be removed, and the procedure is terminated. The weight loss goal for this first stage in high-risk patients is a 100–150 pound weight loss (or until weight plateau), often reached within 6–18 months after the sleeve gastrectomy.

31.4 Stage 2: Duodenoileostomy and Ileoileostomy

31.4.1 Duodenal Transection

Excessive visceral fat may complicate the dissection, and bleeding can blur the tissue planes. Due to this, the duodenal transection can be technically demanding; however, it is critical to minimize excessive duodenal devascularization and injury to the duodenum and pancreas. With lateral retraction of the antrum to linearize the first portion of the duodenum, free the peritoneum on the inferior and superior portions of the duodenum, until the duodenum fuses posteriorly with the pancreas. Either a curved or right-angle dissector can be used to create this retroduodenal tunnel. Posteriorly through this window, a stapler cartridge can be applied to the gastroduodenal artery. A suture is then placed at the inferior corner of the duodenal cuff staple line, with its tail incised approximately 4 cm to allow later proximal anastomosis to the ileum. Another suture is placed to create the posterior anastomosis and is to remain while the alimentary limb is created.

31.4.2 Alimentary Limb Creation

The greater omentum is opened toward the patient's right, allowing the ileum to be connected with the duodenum. Moving to the patient's left side, working through the LUQ subcostal and lateral mid-abdominal ports, identify the terminal ileum at the ileocecal junction. If the patient has a past abdominal surgery history, examine the region for intra-abdominal adhesions before duodenal transection. Measuring 100 cm from the cecum, mark the ileum at the site of later ileoileostomy. Another 150 cm past this point, transect the ileum using a stapler. Mark this distal end of the biliopancreatic limb to distinguish from the alimentary limb. The alimentary limb is carried through the omental window toward the duodenal cuff. If excessive tension is present, a second sagittal vascular stapling can be applied. If significant tension still remains on the alimentary limb, it can be brought through a mesocolic window opposed to the omental window.

31.4.3 Duodenoileostomy

The duodenoileostomy anastomosis may be implemented with many techniques. Understanding each technique allows for surgical flexibility depending on differing anatomy. The techniques include (1) hand-sewn technique, (2) circular stapler technique, and (3) linear stapler technique.

The hand-sewn technique avoids enlarging port sites for stapler accommodation and anvil manipulation. The method constructs more consistent sizing of anastomosis than either technique involving stapler use. The previously placed duodenal suture is tied to the previously placed ileal suture placed 100 cm from the cecum, to create the posterior outer row of the anastomosis. Enterotomies are made along the entire length of the ileum and duodenum, and the inner layer of the anastomosis is made with two sutures with anterior closure. A permanent running suture is placed as the outer layer conjoining the anastomosis.

The circular stapler technique creates the duodenoileostomy using an EEA stapler. The EEA anvil can be inserted directly to the duodenal cuff staple line or passed transgastrically, transabdominally, or transorally. Opening the proximal end of the alimentary limb and aligning it with the duodenal cuff bring the stapler through the antimesenteric border of the proximal alimentary limb and staple the join the segments at the anvil.

In the linear stapler technique, the alimentary limb is brought to the duodenal cuff, and an enterotomy is made in the ileum and duodenum. A stapler is inserted, but due to difficult alignment of the stapler to form the anastomosis, two firings are often necessary. Due to these angulation challenges, there is inconsistency in the size and shape of anastomosis with this method. Lastly, the common enterotomy is hand-sewn closed.

31.4.4 Ileoileostomy

Following the alimentary limb distal from the duodenoileostomy to the marking 100 cm proximal to the ileocecal valve, identify the distal biliopancreatic limb. Approximate the alimentary limb and the distal biliopancreatic limb using a suture. With small enterotomies in either limb, create an anastomosis using a 2.5 mm stapler, and then hand suture to join the remaining enterotomies using a single layer stitch to avoid narrowing of the anastomosis.

31.4.5 Robotic-Assisted Laparoscopic BPD/DS

With the patient in Trendelenburg position, running the small intestine approximately 250 cm from the ileocecal valve, the surgeon will mark with a silk stitch proximally and a Vicryl stitch distally. Prior to docking the robot, the patient is placed in reverse Trendelenburg position. Once docked, the duodenal switch is conducted by creating a window behind the duodenum, 2.5 cm distal to the pylorus. The sleeve gastrectomy is begun by exposing the left crus by creating a window in the greater omentum from 6 cm proximal to the pylorus, up to the angle of His. A 34 French bougie is passed into the antrum. Using a linear stapler, the stomach is transected. Upon completing the gastric sleeve, the linear stapler is used to transect the duodenum through the same omentun window. The duodenoileostomy is created by anastomosing the proximal portion of the duodenum to the ileal stitches 250 cm from the cecum, made earlier. Ileoileostomy is begun through a window around the ileum, proximal to the duodeno-ileostomy. Using a linear stapler, transect the biliary limb, and 125 cm distally on the small intestine from the cecum, anastomose the biliary limb and ileum. The duodeno-ileostomy and staple are both tested with saline and methylene blue submersion. The gastric remnant can be removed through the right lower quadrant port. Drains may be placed next to the sleeve gastrectomy staple line and anastomoses [8].

31.5 High-Risk Classification Leading to Staging

Preoperative

- Super-super-obese patients (BMI > 60 kg/m^2) [4].
- Patients unlikely to tolerate prolonged general anesthesia [9].
- High-risk classification according to the Obesity Surgery Mortality Risk Score (OS-MRS).
  - Risk factors: BMI > 50 kg/m^2, male gender, hypertension, pulmonary embolism risk, age > 44 [10].

Intraoperative decision

- Physiological compromise in the patient.
- Presence of adhesions.
- Hepatomegaly.
- Torque on instruments [9].

31.6 Postoperative Care

Telemetry and the use of continuous pulse oximetry can aid in the detection of early postoperative complications. Patients are NPO with IV fluid administration until the following morning. Variable methods for pain management may be utilized;

common protocols include Dilaudid PCA with ketorolac [11]. Patients should be placed on chemoprophylaxis for venous thromboembolism and should ambulate within 6 h of the surgery. Patients with obstructive sleep apnea should utilize their at-home airway device to maintain patency. Spirometry and other respiratory therapy may be utilized to decrease incidence of pneumonia and atelectasis following surgery [12]. Many patients may be discharged on the second postoperative day, while others, especially those classified as super-super-obese, may require an extended stay and have less predictable comorbidities. For 2 weeks following the operation, patients will stay on a puree diet and transition to solid foods over the course of 1 month.

For 1 month after surgery, patients are instructed to take:

- Proton pump inhibitor.
- Multivitamin with iron.
- Vitamin D.
- Calcium citrate.
- B complex vitamin.
- 80–90 g of protein daily (as a liquid)
- Vitamin A (indefinitely).

31.7 Indications

- For BPD/DS, it is recommended that patient BMI exceeds 50 kg/m^2, while other weight loss surgeries may be indicated for less severe obesity [13].
- Staged BPD/DS is often indicated with super-super obesity (BMI > 60 kg/m^2).
- Obesity with severe type II diabetes [5].
- Suboptimal outcomes of previous bariatric surgery (e.g., sleeve gastrectomy) [14].

31.8 Contraindications

- Uncorrectable coagulopathy.
- Large abdominal wall hernia.
- Preexisting malabsorptive disorder (celiac disease, inflammatory bowel disease, malignancy).
- Severe gastroesophageal reflux disease (sleeve gastrectomy may worsen reflux).
- Others: inability to maintain follow-up, inadequate support, active substance or alcohol abuse, smoking, patient financial standing to afford postoperative supplements and medications [15].

31.9 Complications

31.9.1 Surgical

The laparoscopic BPD/DS is the most technically demanding bariatric surgery and, not surprisingly, has high surgical complication rates up to 15–38% in the proceeding weeks to months. However, it is important to note that this procedure is conducted in the most severely obese patients with comorbid diseases, increasing morbidity and mortality. More recently, the use of a staged BPD/DS has led to a reduction of related morbidity and mortality [16, 17].

Major surgical complications of BPD/DS:

- Anastomosis leaks (at any staple or suture line, commonly duodenal or gastric leaks).
  - Features: tachycardia, elevated white blood cell count, fever.
- Intra-abdominal abscess.
- Pulmonary embolism (manage with aggressive perioperative prophylaxis).
- Congestive heart failure or pulmonary hypertension exacerbation (use perioperative fluids conservatively).
- Myocardial infarction.
- Obstruction and stricturing.
- Digestive bleeding.
- Intraperitoneal hemorrhage.
- Internal hernia.

Minor surgical complications of BPD/DS:

- Pneumonia and atelectasis.
- Stenosis.
- Food intolerance.
- *C. difficile* colitis.
- Pancreatitis.
- Wound infection.

31.9.2 Nutritional

There is a reasonable likelihood for nutritional deficiencies to develop from vitamin and mineral and protein malabsorption. The long-term nutritional risks can be minimized with careful patient selection, nutritional supplementation, education, and follow-up [18, 19]. Protein deficiencies can result from reduced intake (due to decreased gastric volume), obligate loss, and malabsorption. However, the amount of protein loss to malabsorption is uncertain, as studies have demonstrated that 50 cm duodenal segments are sufficient in absorbing protein loads [20]. This study highlights the importance of the surgeon's choice of limb length measurements during the DS as it impacts both protein and fat absorption. Mild-moderate protein deficiencies can be managed with dietary supplementation and patient education. In the instance of severe protein deficiencies, treatment with hyperalimentation and diuresis is indicated, and refractory surgery to lengthen the common channel may be required. Despite prophylactic vitamin and mineral supplementation, there is a high prevalence of micronutrient deficiencies or insufficiencies in DS patients [21]. The subsequent malabsorption of micronutrients in these patients may cause their deficiency status to be refractory to supplementation.

Compared to RYGB, DS switch patients categorized as super-obese were more likely to experience lower levels of vitamins A and D and had a larger decrease in thiamine levels after surgery. These super-obese patients may require more intense supplementation or frequent alimentation and regular nutritional status monitoring [22].

Long-term (15–20 years) metabolic outcomes resulting from nutritional deficiencies [19]:

- Albumin and hemoglobin deficiency.
- Vitamin A, B9, B12, and D deficiency.
- Iron deficiency.
- Calcium deficiency.
- Hyperparathyroidism.

31.10 Outcomes

BPD/DS has demonstrated superior weight loss to all other bariatric procedures, resulting in over 70% EWL, compared to 61.2% for gastric bypass and 68.2% for gastroplasty [23]. The efficacy of the procedure is highest among super-obese patients, resulting in the highest percent EWL and percent BMI reduction compared to other bariatric surgeries [24]. As a secondary or staged procedure, BPD/DS is gaining popularity. From 2015 to 2017, the total bariatric caseload increased 19.2%, BPD/DS increased 63.7%, and revision procedures increased 114.1% [25]. Expert consensus points to the use of BPD/DS in the case of revisional bariatric surgery or for planned staged surgery in super-obese and high-risk patients [18]. BPD/DS has also shown a more powerful effect in treating obesity-related diseases, such as type II diabetes, hypertension, and hyperlipidemia, when compared to RYGP [26].

31.11 Conclusions

While bariatric surgery is the only proven lasting method for weight loss in morbidly obese patients, BPD/DS is the most effective method to maximize EWL. However, this procedure comes with potential surgical risks and long-term metabolic deficits due to nutrient malabsorption. In super-obese or other high-risk patients, the procedure can be implemented in a staged fashion, with the duodenoileostomy and ileoileostomy following 6–18 months after gastric sleeve placement. Revision duodenal switch surgery may also be indicated in the setting of revisional bariatric surgery and is gaining popularity for this use.

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Chapter 32
Duodenal Switch, SADI, and SIPS in Adolescent

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The use of metabolic and bariatric surgery in adolescents has demonstrated very positive outcomes for the treatment of severe obesity [1]. The two most common procedures performed are the laparoscopic sleeve gastrectomy (LSG) and the laparoscopic Roux-en-Y gastric bypass (LRYGB) [2]. In this chapter, we will focus on the possible role of the duodenal switch and its derivatives (SADI and SIPS) in adolescents with severe obesity. Firstly, we will provide a brief overview of relevant current practices with regard to adolescents and metabolic and bariatric surgery.

According to the World Health Organization (WHO), the worldwide obesity prevalence has nearly tripled since 1975. A troublesome statistic in 2019 depicted a very bleak reality, when nearly 38.2 million children worldwide under the age of 5 years old were overweight or obese [3]. Also, it was believed that over 340 million children and adolescents between the ages of 5 and 19 years old were also overweight or obese [3]. The American Academy of Pediatrics (AAP) said it best, when they described this as an “epidemic within an epidemic” [4]. In our society, children are the future of tomorrow, and those suffering with severe obesity are at an unfair disadvantage, as their life expectancy will be shortened.

Obesity is a multifaceted problem that stems from one or more intricate imbalances in genetics, metabolism, environment, and lifestyle behaviors [5, 6]. However, for a very long time, it was perceived that individuals who suffered from obesity were solely responsible, as a result of their own actions. It wasn’t until 2013, when the American Medical Association recognized obesity as a disease, that we began to slowly break down this stigma [7]. Over the years, there has been a dramatic rise in published reports with respect to obesity, especially within the adolescent population.

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It is very clear that metabolic and bariatric surgery in adults has a significant role in curbing weight loss and improving comorbidity-related complications. Adolescents are faced with very similar and unique obesity-related comorbidities causing chronic and progressive diseases: hypertension, dyslipidemia, cardiovascular disease, obstructive sleep apnea, polycystic ovarian syndrome, diabetes mellitus type 2, nonalcoholic fatty liver disease, idiopathic intracranial hypertension, gastroesophageal reflux disease, bone and joint dysfunction, depression, social isolation, and overall poor quality of life [8, 9]. The implications of these comorbidities during adolescence have a definite negative impact on their overall well-being and will continue to be an issue in adulthood if not addressed. For example, nearly half of adolescents diagnosed with a new onset of diabetes type 2 will progress to insulin dependence after a median of 11 months [8].

Various treatment modalities for the management of adolescents with severe and morbid obesity have been widely examined [10]. Many suggest non-surgical measures, such as focusing on obesity prevention and implementing lifestyle (diet and exercise) and behavior modifications [2]. Unfortunately, no studies to date have been able to demonstrate any long-term success, with rather disappointing outcomes. Surprisingly, most of the evidence to date seems to point toward the effective role of metabolic and bariatric surgery [11]. Implying its importance does not suggest that this is the only option; however, adolescents with severe obesity require a dedicated multidisciplinary approach in order to ensure appropriate and timely advanced treatment options.

In 2018, the American Society of Metabolic and Bariatric Surgery (ASMBS) published a review article with guidelines for pediatric metabolic and bariatric surgery [8]. Their recommendations were clear; metabolic and bariatric surgery in adolescents is safe and effective. More importantly, surgery should not be withheld from adolescents with severe comorbidities, and early intervention is necessary to reduce the risk of persistent comorbid complications. Following this, in 2019, the American Academy of Pediatrics produced a policy statement thereby re-iterating the current evidence and importance of adolescent bariatric surgery [4].

Despite these recommendations, there seems to be a rather slow acceptance from healthcare professionals. Provider bias has been a limiting factor that has likely attributed to diminished access [12]. Some prefer the "watchful waiting" approach and to focus on lifestyle modifications for simple lack of knowledge of metabolic and bariatric surgery and safety concerns in adolescents [4]. Many fear for potential nutritional deficiencies during an important period in adolescent physical growth, maturation, and cognitive development [13, 14]. It is imperative to find ways to educate our colleagues and stress the importance that metabolic and bariatric surgery is part of the treatment algorithm and should not be a last resort measure.

Patient selection criteria definitions for adolescent metabolic and bariatric surgery may vary depending on specific site experiences and classifications. For example, the ASMBS defines an adolescent as per the WHO guidelines, which is a person who is between 10 and 19 years of age [8]. On the other hand, the American Academy of Pediatrics defines an adolescent as anyone from 13 to 18 years of age [4]. Others may use Tanner staging or maturity levels to decide. Indications for surgery are more or less similar to adult recommendations. Weight criteria ranges for candidacy are based on the body mass index (BMI), and targets may have varied over the years. The current accepted guidelines suggest a BMI ≥40 or ≥140% of the 95th percentile or a BMI ≥35 or ≥120% of the 95th percentile with one or more obesity-related comorbidities.

Interestingly enough, there are no real age cutoffs noted in any practice guidelines. However, if a person is below the age of an adolescent and meets specific criteria, surgery may be considered if the benefits outweigh the risks. There is also no data thus far that necessitates the assessment of an adolescents' puberty status, which is usually measured by Tanner staging or linear growth curves. No study has ever been able to demonstrate any negative impacts on development. Alqahtani et al. have been leaders in metabolic and bariatric surgery in adolescents. Their experience in this particular field is not like any other in the world, and they have exemplified this by showcasing a program that is an evidence-based multidisciplinary care of the pediatric/adolescent bariatric surgery patient [15]. They have shown that a group of children, between the ages of 5 and 9 years old and who underwent LSG, showed a 20 cm gain in height after 5 years compared to a matched non-surgical control group. These findings therefore suggest an improvement in linear growth curves, which is contrary to many beliefs with regard to adolescent bariatric surgery. However, it is important to take all of this with a grain of salt and understand that a great deal of this information we have is still premature, as obesity surgery in adolescents with extremely long-term follow-up is lacking.

There have been many reviews over the years looking at the effectiveness of several metabolic and bariatric surgeries in adolescents. The following discusses some of these experiences but is not exhaustive given the marked interest over the years.

The laparoscopic adjustable gastric band (LAGB) is a reversible procedure and therefore seemed like a good approach in adolescents. Unfortunately, the long-term outcomes for this procedure in adults were limited, and the complication rates far outweighed the benefits. The experience in adolescents was purely trial based and limited as well. Pena et al. studied a group of 21 adolescents undergoing LAGB, and surprisingly, the reintervention rate was 42% [16]. Eventually, the use in people under the age of 18 was restricted, and the ASMBS does not recommend this weight loss procedure [8].

The two most common procedures performed today in adolescents are the LSG and the LRYGB. Originally, the LRYGB had been one of the first procedures performed in adolescents, given the experience gained from this procedure in adults having been around since the 1960s. Over the years, the LSG has also gained popularity, likely because it's technically simpler with minimal malabsorptive risks and offers great outcomes. It has now become the most widely performed procedure worldwide, in the adult and adolescent population. We know that both these procedures provide effective weight loss and improvement in obesity-related comorbidities in adults. When introducing these procedures into the adolescent population, it was crucial to ensure that they are safe and have minimal complications. In order to ensure this, there have been many studies published describing outcomes and experiences of metabolic and bariatric surgery in adolescents, but there are three frequently cited studies providing important long-term follow-up assessments.

The Teen-Longitudinal Assessment of Bariatric Surgery (Teen-LABS) study by Inge et al. in 2014 provided a 3-year report on outcomes of 228 adolescents undergoing LSG (67) and LRYGB (161) in a prospective, multicenter, observational study [17]. The mean age of participants was 17 years and the mean BMI was 53. At 3 years, both procedures showed similar total weight loss: 26% in the LSG group and 28% in the LRYGB. More importantly, there was a 95% remission rate of type 2 diabetes, 74% remission of hypertension, and significant improvement in weight-related quality of life. Adolescent development is one of the main concerns with malabsorptive procedures. Although they did not report any adverse growth-related events, they did observe several micronutrient deficiencies. There were 57% of participants with abnormally low ferritin levels at 3 years, vitamin B12 levels declined by 35% with 8% of participants being deficient, 16% were deficient in vitamin A, and lastly 37% were deficient in vitamin D. These deficiencies were well described secondary to LSG and LRYGB and simply stress the importance of very close long-term follow-up and ensuring that appropriate supplementation is provided postoperatively.

The Adolescent Morbid Obesity Surgery (AMOS) study is a 5-year prospective nationwide Swedish study that followed 81 adolescents (13–18 years of age) who underwent LRYGB [18]. The LRYGB group was also matched with 80 adolescents non-surgical control group and 80 adults who underwent LRYGB as a surgical control group for comparison. The mean total weight loss at 5 years was 28% which was comparable to the Teen-LABS study. They also observed a substantial improvement of reported metabolic risk factors and comorbidities within 2–3 years after LRYGB. The micronutrient deficiencies observed were similar to the Teen-LABS study and inherent with a LRYGB. Iron deficiency with low hemoglobin levels and vitamin D deficiency were observed after 5 years. They suspect that poor compliance with supplementation may have been a factor in this population, which has also been previously described as limitations in the adolescent population. Adult controls had almost identical outcomes to the adolescent surgical patients.

Another interesting study by Inge et al. aimed to study the long-term outcomes of bariatric surgery in adolescents, the FABS-5+ study (Follow-up of Adolescent Bariatric Surgery at 5 Plus Years) [19]. This was a prospective follow-up analysis extension study. There were 58 participants who had a mean 8-year follow-up after undergoing a LRYGB. The focus of this study was to highlight any potential later adverse effects after undergoing metabolic and bariatric surgery in adolescence. Although the usual weight-related benefits and metabolic effects were observed in this study as to others, there were roughly 63% of participants that still remained obese (BMI > 35). This higher residual BMI was indeed associated with a higher risk of future health-related complications. This leads the authors to believe that the time point as to when surgery is offered in adolescents with severe obesity is crucial. Being able to intervene early on in the obesity timeline can have a more effective long-term weight loss benefit as it may be difficult to reverse. Another observation, which seems to be a common theme with these procedures, is the long-term nutritional deficiencies. Abnormalities in iron studies, vitamin D levels, and elevated PTH and vitamin B12 levels were noted. Given the abnormalities in vitamin D-PTH levels, there are concerns for a negative effect on bone health in these patients. This area needs further research as the long-term effects in adolescence still remain unclear, especially if a younger cohort of patients undergoes these procedures prior to completing their linear growth. Again, adherence to supplementation is crucial, and this seems to be a difficult factor in this population.

Now, we will focus our attention on the duodenal switch and its derivatives in adolescents. Today's duodenal switch has no doubt provided very effective weight loss in super obese adults with, for example, excellent remission rates in diabetes [20]. The key to success to this operation is to find the right nutritional and supplementation balance with lifelong follow-up to avoid unwanted protein calorie malnutrition and vitamin deficiencies. The literature with respect to these procedures in adolescents is very sparse. This may be reflective of the malabsorptive power this operation has and the fear for potential side effects in adolescents.

One of the first studies published in 2007 by Papadia and Scopinaro highlighted a group of 76 adolescents (mean age 16.8 years) that underwent the original biliopancreatic diversion described by Scopinaro [21]. This procedure involved a distal gastrectomy with a common channel of 50 cm from the ileocecal valve. In this cohort of patients between 1975 and 2005, there was a near 100% follow-up rate with a mean of 11 years. There was a mean excess weight loss of 78%; however, there was a very high rate of late nutritional complications. Protein malnutrition was found in 11 patients between 1 and 10 years postoperatively. Some required elongation revisional surgery and others complete restoration due to proteinuria and liver cirrhosis. Overall there was a close to 5% late mortality rate. The authors described these worrisome complications to early procedural technicalities that seemed to have evolved over the years. The authors also believe that should these patients have been operated on in the later 10 years of the evolution of their procedure, outcomes would have been improved.

This biliopancreatic diversion has certainly evolved over the years, and the current variations have brought upon the biliopancreatic diversion with duodenal switch as described by Hess and Marceau [20, 22]. As we know it, this procedure involves a sleeve gastrectomy followed by a Roux-en-Y configuration involving a common channel of 100 cm from the ileocecal valve and a total Roux limb of 250 cm. Variations on the theme involve a single anastomosis loop configuration with varying common channel limbs between 250 and 300 cm. In 2010, Marceau et al. reported their long-term experience with duodenal switch in adolescents [23]. This group involved ten adolescents between the ages of 16 and 17 years who underwent a duodenal switch and had a mean follow-up of 10.6 years. There were no deaths or perioperative complications noted. A decrease of mean BMI from 56 to 29 was observed, with an excess weight loss of 82.1%. All comorbidities were cured postoperatively. They did not observe any important side effects or deficiencies. Marginally mild abnormalities were noted in iron, hemoglobin, and calcium/PTH/vitamin D that were corrected by increasing supplementation. However, there was one unresolved problem with calcium and elevated PTH levels. This seems to highlight the possibility of bone health in this population. The concern of undergoing a procedure that may affect bone health in adolescents can be a side effect that will not be obvious until later in adulthood. However, Marceau et al. published a series in 2002 concluding that providing close surveillance for metabolic disturbances, the use of appropriate supplements, and avoidance of malnutrition allowed for the beneficial effects of surgery to outweigh the risks of postoperative bone disease [24]. Also, this study was able to demonstrate that weight loss prior to pregnancy minimized the risk of obesity in children as a result compared to their mothers at the same age. There was also no evidence of malnutrition in any of the adolescents postoperatively as compared to the study by Papadia. Benefits of the duodenal switch in adolescents were clear in this long-term follow-up study, and they outweighed the risks of rare and marginal deficiencies. However, this study did involve a small sample number, and it is difficult to extrapolate safety risks. Secondly, longer-term studies would still be necessary to evaluate any potential side effects later on in adulthood.

It is very difficult to extrapolate findings from adult metabolic and bariatric surgeries and translate them to the adolescent population. With regard to the duodenal switch, there is very limited long-term data available in order to predict any important potential side effects in adolescents once they reach adulthood. There is definitely more risk associated with this malabsorptive procedure; however, we know from the adult population that very close follow-up and strict adherence to supplementation diminish the risk of severe protein calorie malnutrition and macro−/micronutrient deficiencies [25]. Studies have shown that adolescents may have difficulty in adhering to strict postoperative supplementation [4, 8]. This would definitely place them at risk for potential major complications down the line. Also, the importance of long-term follow-up in these procedures is crucial. The potential implications in adolescents of missed follow-up visits and blood work assessment can also put them at risk for further complications. It is also very difficult to assess the safety in growth development and neurodevelopment in this population after undergoing malabsorptive surgery. There is also the question of when would it be an appropriate timing to undergo a duodenal switch in an adolescent with severe obesity. Concerns of bone health in the future are important, and there are no real major long-term studies to date to help make any of these conclusions in this group of patients. Most societies and experts will extrapolate knowledge and fear of causing harm in this group by restricting these procedures early on.

A prospective study from the Board of the Spanish Society of Obesity Surgery and Metabolic Diseases, represented by a group of 60 experts from 9 national societies, agreed on the need to abandon the biliopancreatic diversion in adolescents due to excessive operative morbidity and severe nutritional deficiencies [26]. These claims likely arose from the initial study published by Papadia et al. However, the ASMBS states that this surgery, biliopancreatic diversion with duodenal switch or single anastomosis duodenal switch, should be reserved for adults in most cases [8]. They recommend staged procedures for inadequate weight loss or weight regain once the adolescent reaches adulthood. This definitely seems to be a viable treatment plan.

Clearly, we understand the importance in not delaying surgery for adolescents with obesity, especially with severe obesity. With that being said, sleeve gastrectomy has become the most popular procedure to date in adults and adolescents. It would be fair to offer an adolescent with severe obesity a sleeve early on, in order to begin the weight loss process. Following this, allowing for an adequate delay postoperatively, in order to eliminate any potential growth development risks and waiting for adulthood, a second-stage duodenal switch can be proposed. Biertho et al. in 2018 demonstrated that a second-stage duodenal switch was effective for the management of suboptimal outcomes of sleeve gastrectomy [27]. At 3 years, they observed an additional 41% excess weight loss and 35% remission of type 2 diabetes. These results suggest that outcomes between first-stage and second-stage duodenal switch are similar. Therefore, this approach in adolescents can be possible and may be a safer path toward adequate weight loss and comorbidity resolution in those with severe obesity.

In summary, adolescent obesity is rising at alarming rates, and it has been demonstrated that lifestyle modifications alone are not successful methods for sustained weight loss. A mountain of evidence has established the role of metabolic and bariatric surgery in adolescents over the years, and most have proven to be effective and safe. Currently, the sleeve gastrectomy is the most common procedure performed, along with the Roux-en-Y gastric bypass. Both of these procedures provide similar weight loss outcomes with near-complete reversal of obesity-related comorbidities. The biliopancreatic diversion with duodenal switch and its derivatives are very efficient malabsorptive procedures, especially in the super obese population. Although some studies have used this procedure in adolescents with promising outcomes, there is still very limited data to support its clear benefit and safety profile in this age population. The potential risks for severe protein malnutrition, vitamin deficiencies, and bone health seem to influence most healthcare professionals to not consider this as a safe option despite the lack of any convincing evidence. The ASMBS and the AAP have made clear recommendations to avoid the use of this procedure in adolescents.

A multidisciplinary approach is recommended when considering an adolescent with severe obesity for metabolic and bariatric surgery. We believe that early intervention is crucial and if required the biliopancreatic diversion with duodenal switch or its derivatives should be part of the treatment armamentarium as a staged approach once adulthood is reached.

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Chapter 33
Duodenal Switch (DS), Single Anastomosis Duodeno-Ileal Bypass (SADI) and Stomach Intestinal Pylorus-Sparing Surgery (SIPS) in the Elderly

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33.1 Introduction

The median age of the population has steadily increased since 1970, whilst the incidence of obesity has nearly tripled during the same period, affecting more than 650 million adults [1]. This has led to a sharp rise in the prevalence of obesity amongst the elderly population reaching over 40% of individuals between the age group of 60 and 69 years in the United States [2]. With life expectancy continuing to increase, there has been a growing demand to treat elderly patients with obesity and severe obesity. Bariatric surgery is the most effective treatment of obesity; however, there are no clear guidelines or procedural recommendations for this selected group of patients. Consideration of risks and benefits and shared decision-making has significant importance in the treatment of individuals of advanced age.

Duodenal switch (DS), single anastomosis duodeno-ileal bypass (SADI) and stomach intestinal pylorus-sparing surgery (SIPS) are appropriate surgical options for elderly patients with similar clinical outcomes when compared to the younger population [3]. In the following chapter, we will be discussing age-related aspects of obesity and bariatric surgery with a particular focus on DS, SADI and SIPS procedures.

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33.2 Obesity and Age

With advanced age, there is a decrease in metabolic activity which is compounded by a decrease in physical activity [4, 5]. This results in a higher proportion of elderly obese patients developing significant co-morbidities, such as type 2 diabetes mellitus, hypertension, dyslipidaemia, cardiovascular diseases and cancer, that can be difficult to manage [6, 7]. The severity of these obesity-related conditions significantly impacts perioperative mortality and morbidity and increases the risk of surgical complications [8, 9].

33.3 Bariatric Surgery in the Elderly

With the advancement of anaesthesia, surgery and perioperative care, operative interventions can even be considered in significantly advanced age meaning there are no maximum age criteria for bariatric surgery [10]. Historically, bariatric surgery in the elderly population was associated with a higher risk compared to younger individuals. The risk associated with bariatric surgery was extremely high in some cases with a reported perioperative mortality of 4% and perioperative morbidity of 20% [11, 12]. Hence, advanced age was considered a relative contraindication for bariatric surgery, and some guidelines were not recommending surgical treatment of obesity in this group of patients [13]. However, more recent studies have highlighted that there are no significant differences between surgical outcomes in the geriatric population compared to younger adults [14, 15]. There is still a debate around weight loss and remission rates of co-morbidities in both these populations. Initially, improved weight loss and higher remission rates of co-morbidities were reported following bariatric surgery in the younger population [16]; however, other studies have suggested that there is no significant difference in co-morbidity remission related to age, but weight loss does appear lower in the elderly [17, 18].

33.4 Choice of Bariatric Procedure in the Elderly

There is no preferred bariatric operation identified for the geriatric patient group [17]. It is unclear from the literature as authors report conflicting findings suggesting different procedures being more appropriate for this age group [19, 20]. The most common bariatric procedures worldwide are laparoscopic sleeve gastrectomy (LSG) and laparoscopic Roux-en-Y gastric bypass (LRYGB). This is mirrored in the elderly population by DS being the fourth most commonly performed procedure following LSG, LRYGB and laparoscopic gastric banding [21]. As a result, there are not many studies specifically investigating the outcome of DS, SADI and SIPS in the geriatric population. There are indications for LSG which can provide some benefits particularly in reducing perioperative risks and avoiding malabsorption in this patient group [20, 22]. However, other studies suggest that DS and LRYGB are just as safe and effective for the elderly and younger age groups. Both of these operations are combined restrictive and malabsorptive procedures with improved weight loss outcomes and remission of co-morbidities compared to LSG which is a primarily restrictive procedure with additional effects on ghrelin reduction to decrease hunger.

SADI and SIPS are modifications of DS surgery and were established with the aim to reduce the complications that occur with DS and LRYGB which involve two anastomoses and have risks such as dumping syndrome, internal herniation, ulceration and vitamin deficiency [23, 24]. SADI involves a loop duodeno-ileostomy and is technically more straightforward than the DS. In SIPs, a 300 cm common channel is used in order to reduce chronic diarrhoea and flatulence [25, 26]. The preservation of the pylorus provides control of solid emptying and decreases the risk of dumping syndrome and helps to maintain a physiologically based rate of gastric emptying [27, 28]. It has been reported that weight loss outcomes of SADI and SIPS are better than LSG but comparable to DS and LRYGB [29, 30].

When deciding on the best procedure for elderly patients, it is important to individualise the approach. LSG may offer the benefit of decreased perioperative risks and less malabsorptive complications secondary to impaired absorption of nutrition. However, resolution of long-standing co-morbidities is less likely. DS, SADI and SIPS are all appropriate choices for elderly patients and may offer enhanced weight loss and improvement of co-morbidities compared to LRYGB [31–33]. However, they should only be used in patients with appropriate fitness for surgery. In individuals with a poor cardiovascular status, a two-stage approach can be a potential solution. Initial LSG is a safe procedure which can be further complemented with a single or double anastomosis duodeno-ileal bypass should the patient performance status improve significantly following the initial procedure.

33.5 Preoperative Assessment, Anaesthesia and Perioperative Care in Elderly Patients

Preoperative assessment and optimisation in elderly patients are extremely important and should begin during the first consultation with the bariatric surgeon. Initial steps should include frailty and geriatric assessment to ensure that operative treatment of obesity is the most effective method of managing the patient's weight and co-morbidities. Successful geriatric assessment is strongly linked to improved postoperative outcomes [34]. There are readily available tools such as the one published by Chan et al. [35]. A careful consideration and extensive discussion about risk and benefits of bariatric surgery are the recommended next step. If a decision has been made for consideration of surgery, organ-specific pre-assessment and bariatric multidisciplinary team meeting should follow the initial consultation. Clear evidence suggests that obesity is often related to poor-quality food leading to inappropriate nutrition, whilst old age is also linked to malnourishment. Therefore, careful nutritional assessment and optimisation should always be carried out in these individuals prior to bariatric surgery [36, 37]. Intraoperative anaesthesia in geriatric patients with obesity is often challenging and should be carried out by experienced bariatric anaesthetists. In general, depending on the choice of procedure, routine postoperative observation on a high-dependency unit (HDU) is almost uniformly recommended for geriatric patients. Adherence to enhanced recovery pathways is beneficial for this patient population and will be covered in a separate section. One further factor to consider is postoperative cognitive disorder that can affect elderly patients frequently. This could manifest as delirium postoperatively, or it can subsequently develop into a long-term condition. Early recognition of sepsis and anaemia and enhanced intraoperative monitoring are all important adjuncts that can help to reduce the incidence of this type of cognitive dysfunction [35].

33.6 Surgical Technique

The majority of bariatric operations are performed laparoscopically which is the gold standard method since the late 1990s. However, there is evidence in elderly patients that DS can be performed effectively with an open approach too. There is clear consensus that laparoscopic surgery is safer and has better outcomes in the geriatric population, and it is the recommended approach regardless of surgical subspecialty [38].

When performing laparoscopic DS in the elderly, there are a few technical points that must be given careful consideration. Meticulous surgical technique is of paramount importance as any operative errors can lead to significant consequences in the elderly. Intra- or postoperative complications are more likely to have a devastating effect in this age group; hence, careful surgical technique and meticulous haemostasis are increasingly important in geriatric patients. For the same reasons, these patients should be operated on in centres with expertise in DS, SADI and SIPS only.

During laparoscopy, intra-abdominal pressures must be set individually based on surgical exposure and feedback from the anaesthetist. From a surgical perspective, obese patients require high pressures during induction of pneumoperitoneum; however, bariatric patients are commonly difficult to ventilate due to advanced central airway narrowing, asthma, obstructive sleep apnoea or other advanced lung diseases. Geriatric patients with several co-morbidities often have more friable tissue, and hence port placement, suturing and stapling must be carried out with precision.

33.7 Postoperative Management: Enhanced Recovery

Postoperative management can often be challenging in this age group due to the indolent and less pronounced clinical response that results in difficulty establishing the diagnosis and a delay in treating complications. A prompt improvement in glucose homeostasis should be anticipated following DS, SADI and SIPS in diabetic patients, and their medication should be modified accordingly. Geriatric patients are more prone to dehydration and hypotension which must be taken into account when adjusting antihypertensive medication postoperatively [39]. Dumping syndrome is frequent following bariatric surgery and is determined by the size of gastric pouch and the speed of gastric emptying. Elderly patients are more vulnerable to reactive hypoglycaemia following these operations in the short and long term, and therefore they must be monitored carefully [40]. Long-term nutritional deficiencies are common in the elderly following DS; hence, vitamin and micronutrient replacement are mandatory for all patients. Finally, rapid weight loss can lead to symptomatic cholelithiasis with difficult endoscopic approaches related to these surgeries, and therefore ursodeoxycholic acid should be considered to mitigate gallstone-related complications [39].

As discussed above, there has been a rapid change in the last 10 years in the reports of the outcome of bariatric surgeries in the elderly. Surgical technique, however, has not changed significantly over the last 10 years in this field. Laparoscopic bariatric procedures have been performed for more than 30 years, and there have been no major advancements in the steps of these operations either. So why has there been a sudden change in age-related outcome? The reason for this improvement is most likely related to the development of perioperative enhanced recovery programmes for bariatric patients [41, 42]. These pathways seem to improve not just the perioperative surgical outcomes but the weight loss, co-morbidity status and quality of life [42]. Elderly patients are more likely to develop severe postoperative complications due to their reduced reserve capacity. Enhanced recovery pathways are standardising the perioperative care leading to a decrease in morbidity and early recognition of complications. For bariatric surgery in the elderly, an established local enhanced recovery programme is recommended.

33.8 Long-Term Results

Bariatric surgery in the elderly has been associated with good long-term weight loss and reduction of co-morbidities [18]. At the same time, DS has been associated with favourable long-term results in the geriatric population. Although weight loss outcomes appear to be inferior to younger population, remission of co-morbidities is equivalent between these groups [3]. This simultaneously corresponds with previous findings of slow metabolism and impaired weight loss and gives reassurance to bariatric surgeons that DS, SADI and SIPS have equivalent long-term outcomes in both the young and elderly patients.

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Chapter 34
Right Gastric Artery Ligation: The Brazilian Results

João Caetano Marchesini and João Batista Marchesini

Bariatric surgery is considered the most effective management for weight loss in patients with morbid obesity. It is also the most effective approach for improvement or remission of related comorbidities. Among the several factors that influence the surgeon's choice of technique are gender, BMI, meal preferences, age, presence of GERD, comorbidities, the local anatomy, and surgeon's skills [1].

Since 1994 when Wittgrove and Clark started the laparoscopic RYGB, it has been the most performed bariatric procedure until 2013 and was considered as the gold standard in this field. For the last years, sleeve gastrectomy has emerged and gained surgeon's preference exponentially up to reach the position of the most performed surgery in some countries, including the USA [2, 3].

Despite their success, both procedures achieve moderate results in terms of weight loss and have a relative high rate (20–25%) of insufficient weight loss or weight regain [3, 4].

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The second pathway for development of bariatric surgery was based on the improvement attempts of the original jejunoileal bypass with different lengths of the excluded biliopancreatic limb in association with a moderate gastric restriction resulting in a second generation of malabsorptive operations. At the end of the 1980s, Marceau and Hess added some technical changes in the biliopancreatic diversion proposed by Nicola Scopinaro in 1979 [5], resulting in another type of biliopancreatic diversion: the sleeve gastrectomy with duodenal switch (DS) [6, 7] . It was based after DeMeester's proposal of a duodenal switch for the treatment of reflux alkaline gastritis [8]. It is considered a modern version of the original biliopancreatic diversion and has been published with better results in terms of weight loss and control of related diseases. Unfortunately, this technique shows the worse side effects regarding nutritional problems.

This procedure has more than 35 years of history and has demonstrated the best results ever in terms of durable weight loss and comorbidity resolution. Despite this, in the last International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) bariatric surgery survey, it only represented less than 0.5% of the worldwide series [2].

The main reason for such conservative numbers is that biliopancreatic diversion with duodenal switch is usually associated with high morbidity and mortality rates, high technical complexity, and elevated long-term nutritional sequelae [1]. Recent literature about BPDDS with large follow-up points out good results and few complications but even though this literature is unanimous. Undoubtedly, this is the most technically demanding and complex bariatric procedure, and the skills and training of the surgeon certainly will influence in the decision in doing it [9, 10].

The hardest part of the procedure is related to the duodenal approach and the duodeno-ileal anastomosis.

On the standard BPDDS technique, gastric blood supply is provided by the left and right gastric arteries after the vertical sleeve gastrectomy. The divided duodenal bulb remains in place, over the head of the pancreas and under the liver, leading to a generally difficult duodeno-ileal anastomosis. The three major causes of anastomotic leakage are tension, poor technique, and poor blood supply. In order to have good blood supply, many duodeno-ileal anastomoses remain tense and technically imperfect [11]. Previous studies performed by us to evaluate gastric blood supply found that the left gastric artery alone was sufficient to perfuse the entire organ due to the rich submucosal arterial network (Figs. 34.1a and b) [12, 13]. On our proposal, the right gastric and the right and left gastroepiploic arteries are divided, and the sleeve gastrectomy portion, pylorus, and duodenal bulb are maintained through the left gastric artery blood supply. Technically, the surgeon lifts and supports the duodenum on his left hand grasper, and the assistant lifts the gastric antrum creating space for the artery dissection with the ultrasonic scissors (Fig. 34.1c). The duodeno-ileal anastomosis is always performed manually (Figs. 34.1d and e).

The pylorus-preserving Longmire technique for reconstruction of the GI tract after duodeno-pancreatectomy [14], modified by Sugiyama et al. [15], involves an anastomosis of the remnant proximal duodenal bulb to the small bowel, transecting the right gastric and right gastroepiploic arteries. The ligation at its root guarantees

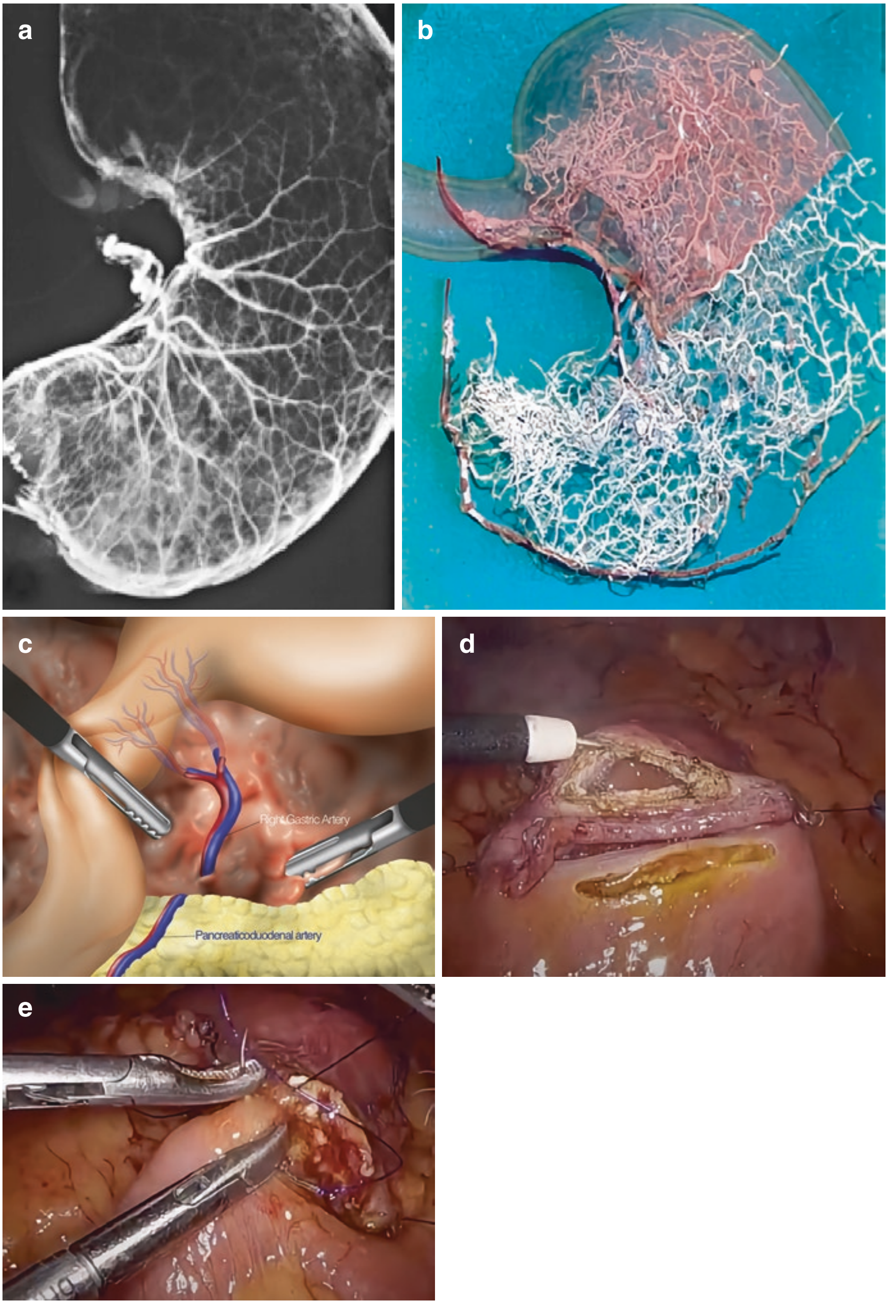

Fig. 34.1 (**a**) Contrast material injected into a single artery (left gastric artery) shows the rich gastric submucosal network (cadaver study). (**b**) Vinyl skeleton of the gastric blood supply showing the rich submucosal vascular structure (cadaver specimen). (**c**) Anatomical position of the right gastric artery. (**d**) Opening the duodenum for the duodeno-ileal anastomosis showing normal vascular aspect of the mucosa after the ligation of the right gastric artery. (**e**) Finishing the duodeno-ileal anastomosis

that the blood supply from the lesser curvature of the stomach keeps unaltered supplying good vascularization for the new anastomosis.

From September 1995 to January 2019, we performed a total of 1356 BBPDS in morbidly obese patients, freeing the duodenal bulb and pyloric portion of the stomach by ligating the right gastric artery. The main indication was for patients with BMI over 45 kg/m^2 with severe comorbidities or any patient with BMI over 50 kg/m^2 that had a clear understanding of the procedure and the necessity of a closer follow-up.

Important to notice is that the remnant stomach and the duodenal bulb are easily mobilized inside the abdomen in laparoscopic procedures and out of the abdomen in open procedures, leading to a simpler and easier anastomosis [11].

Leakages occurred in 16 patients (1.17%) at the uppermost part of the sleeve gastrectomy, in 2 cases at the duodeno-ileal anastomosis (0.14%), and in one case at the enteroanastomosis (0.07%). Overall morbidity rate was 5.8% (78 patients) and mortality rate was 0.22% (3 patients). Reoperation occurred in 4.2% (58 patients).

The rich submucosal blood supply ensures that the divided duodenal bulb during a duodenal switch procedure remains viable, and the anastomosis performed in this manner is not compromised by ischemic phenomena. In our two cases of leakages, both were identified as technical failure and treated with drainage and had a good outcome with no sequelae.

Based on our long-term clinical experience from this large number of patients, the low risk offered, and the facilitation promoted by this technical variation, the authors highly recommend its current use.

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Chapter 35
Surgery Failure: What Are the Options?

Julie L. Holihan and Erik Wilson

35.1 Introduction

Bariatric surgery is currently the best-known strategy for long-term weight loss. However, even patients who undergo bariatric surgery can fail to lose adequate weight or have weight regain (weight recidivism). Successful weight loss following bariatric surgery is commonly defined as at least 50% of excess weight loss [1]. Other definitions include weight loss of at least 25% of preoperative weight or achieving BMI <40 [2]. Definitions for weight recidivism can be variable, but it is often defined as 25% weight regain from lowest weight [1]. Weight recidivism occurs in 20–50% of patients who have had bariatric surgery [1, 3, 4]. However, failure following duodenal switch is uncommon. In fact, duodenal switch is often used as a revisional procedure following a failed Roux-en-Y gastric bypass or sleeve gastrectomy. Despite this, there are still a number of options for weight loss after failure of a duodenal switch.

35.2 Prevalence of Failure

Failure to achieve weight loss and weight recidivism varies by type of bariatric surgery, with duodenal switch-biliopancreatic diversion being one of the least likely to fail. A review of prospective and randomized trials of duodenal switch demonstrated a 0–14% rate of failure following surgery (Table 35.1). Variations in this rate are likely due to differences in surgical technique and follow-up duration.

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Table 35.1 Summary of evidence of failure following duodenal switch

Author (year)	N	Study type	Follow-up	Failure definition	Failure rate
Strain (2017) [5]	275	Prospective	1–9 years	Underwent additional surgery for insufficient weight loss	30 (11%)
Risstad (2015) [6]	29	RCT	61 months (54–73)	BMI > 40	4 (14%)
Cloutier (2017) [7]	20	RCT	12 months	EWL < 50%	0 (0%)
Skroubis (2014) [8]	130	Prospective	96 months	EWL < 50%	5%
Hedberg (2012) [9]	47	RCT	4 ± 1 year	EWL < 50%	4.8%
Sovik (2011) [10]	61	RCT	2 years	BMI > 40	0/27 (0%)

35.3 Reasons for Failure

To understand failure options, we need to understand reasons for failure. There are several reasons why a patient may be unsuccessful.

35.3.1 Patient Comorbidities

Unrecognized patient comorbidities have the potential to lead to surgical failure. Conditions such as alcoholism or other addictions can be missed preoperatively. Consumption of excessive alcoholic beverages can lead to excess weight gain through increased caloric intake from the beverages themselves and by leading to poor judgment when making dietary decisions. Furthermore, calories from alcohol are completely absorbed even after a duodenal switch, making the malabsorptive component of the surgery ineffective. Careful preoperative screening can help to avoid this problem.

35.3.2 Psychological Conditions

Psychological conditions can contribute to failure to achieve adequate weight loss. Though most patients undergo psychological screening prior to surgery, certain psychological conditions can be missed. A study of long-term outcomes following duodenal switch demonstrated that of nine patients with weight loss "failure," six of them had an undiagnosed psychological condition [2]. Examples of these conditions include bulimia, neuroses, and phobias. Thorough preoperative psychological evaluation is necessary to prevent missing these.

35.3.3 Physiologic/Anatomic Reasons

There are anatomic reasons that can lead to poor weight loss following duodenal switch. First, a gastric sleeve that is too large can negatively affect weight loss. Most surgeons aim for a gastric volume of less than 200 mL following surgery. Next, inadequate limb length can be responsible for poor weight loss following duodenal switch due to a lack of malabsorption. Malabsorption is a key component of weight loss following a duodenal switch [11]. Most surgeons aim for a common channel between 50 and 150 cm and a biliopancreatic limb of 100–550 cm to achieve this.

35.3.4 Lack of Support

In patients who have regained weight following bariatric surgery, many report feeling a lack of support from friends, family, and healthcare providers [12]. One study showed that patients who are unmarried or unemployed were more likely to experience weight loss failure compared to others, suggesting that a lack of social support may contribute to weight loss failure [2]. In addition, patients who skip follow-up appointments have been shown in some studies to have more weight regain than those who attend them [1]. Ensuring that a patient has access to adequate support via healthcare providers and/or peer support groups may help to mitigate this.

35.3.5 Noncompliance with Lifestyle Changes

Bariatric surgery is most effective when combined with lifestyle changes, including improved nutrition and exercise habits. However, many patients are unable to maintain this and adopt poor habits following surgery. This can lead to weight gain or failure to lose weight. Such habits may include frequent snacking/grazing, high carbohydrate or sweet intake, and high intake of liquid calories among other things. In addition, inactivity and a sedentary lifestyle can contribute to surgical failure. Preoperative education and setting long-term expectations are imperative to ensuring postoperative success.

Oftentimes, there is no one simple cause for surgical failure. Rather, the etiology is multifactorial. Physicians should consider all of these options when evaluating a post-duodenal switch patient for failure.

35.4 Patient Assessment

When a patient presents after duodenal switch with inadequate weight loss or weight recidivism, a thorough history should be obtained. The history should focus on behaviors such as alcohol intake and eating habits, which may help to uncover any previously undiagnosed comorbidities and psychological conditions. A careful dietary history should be taken including:

- Calorie consumption.
- Quality of diet, sweets.
- Portion size.
- Binge eating.
- Protein/carbohydrate intake.
- Snacking/grazing.

This will help uncover any unhealthy habits a patient may have. Food diaries can be a useful adjunct in determining dietary behaviors. Patients should also be questioned about physical activity and dedicated exercise time. Pedometers or other activity trackers may be utilized.

Next, the patient should be assessed for possible anatomic causes for the failure. Patients with higher gastric volumes have been shown to have more weight gain than those with lower gastric volume [1]. Sleeve size can be evaluated via upper GI or EGD, with ideal size of less than 200 mL.

Next, limb length should be assessed. In general, the common channel should be 100 cm. The alimentary limb is 150 cm. The biliopancreatic limb is 100–550 cm [13]. There is no easy way to determine limb length. Reviewing old operative reports may provide this information; however, even operative reports can be inaccurate if measuring was not meticulously performed. The most definitive method for measuring limb length is laparoscopy, but this is often unnecessary.

Since limb length is important to ensuring that the patient has adequate malabsorption, it can also be determined indirectly. Malabsorption can be measured by measuring fecal fat, fat-soluble vitamin levels, and frequency of bowel movements. Increased fecal fat levels are expected after duodenal switch, and normal levels may indicate inadequate limb length [13]. In addition, bowel movements are generally more frequent following duodenal switch, with patients experiencing around 20 per week [14]. If a patient has no change in frequency of bowel movements following surgery, this may also indicate a lack of malabsorption.

Finally, once it has been determined that there is no medical or psychological history or anatomic reason for surgery failure, a patient's resources and social support can be evaluated. Many patients will benefit from closer follow-up and accountability, which may have been lacking. Evaluation of partner and household habits may be prudent.

35.5 Options Following Failure

Treatment strategy will depend on findings from the patient assessment; however, treatments can be classified as medical or surgical.

35.5.1 Medical Options

Some patients have no correctable anatomic abnormality with their duodenal switch. These patients may benefit from an intensive medical weight loss program. Such a program is aimed at improving their dietary habits, improving food choices, and increasing physical activity/exercise. Measuring basal metabolic rate can be a useful adjunct to give patients a better idea of their individual caloric needs. In addition, such a program can provide support and accountability for patients that may help them to adhere to a healthier new lifestyle.

In some cases, anti-obesity medications can be used in conjunction with nutrition and exercise to improve weight loss. There are many weight loss medications available (Table 35.2) [15]. There is a lack of high-quality evidence supporting these, particularly after duodenal switch. However, small case series and observational studies suggest possible benefits following bariatric surgery. Referral to an obesity medicine specialist who can prescribe and monitor an appropriate anti-obesity medication should be considered.

Another option for additional weight loss following duodenal switch is the use of an oral superabsorbent hydrogel. Unlike anti-obesity medications, which can have frequent adverse effects, oral superabsorbent hydrogels are pharmacologically inert and are actually marked as a medical device rather than as a medication. These superabsorbent hydrogels are comprised of a polymer matrix that can absorb approximately 100 times their weight in water [16]. The particles function by occupying space in the stomach and small intestine, with the goal of promoting fullness [16]. This has not been studied in post-bariatric surgery patients. However, in non-bariatric surgery patients, patients treated with oral superabsorbent hydrogels had a higher percentage of weight loss compared to those treated with placebo [17]. The most frequent side effects were mild gastrointestinal effects. While further studies are needed, particularly in patients following bariatric surgery, oral superabsorbent hydrogels are a promising option for additional weight loss.

Table 35.2 Anti-obesity medications approved for long-term use by the FDA

Anti-obesity medication	Class
Phentermine-topiramate	Sympathomimetic/ anti-epileptic
Orlistat	Lipase inhibitor
Naltrexone-bupropion	Amine reuptake inhibitor
Liraglutide	GLP-1 receptor agonist

35.5.2 Surgical Options

Surgical options exist for patients found to have an anatomic abnormality on assessment. For those found to have a dilated sleeve, it is sometimes possible to perform a re-sleeve gastrectomy. The technique for this is as follows: laparoscopic lysis of adhesions is carefully performed to reveal the full sleeve. A 36–40 Fr bougie is inserted. An area approximately 5 cm proximal to the pylorus up to the esophageal hiatus is completely cleared. A linear stapler is used to divide any redundancy in the gastric sleeve along the bougie.

Another option for a dilated sleeve is an endoscopic sleeve gastroplasty. This is an endoscopic technique that reduces stomach volume through plication. Plication is not permanent and generally lasts 1–2 years. This is often long enough to allow patients to achieve additional weight loss. In this technique, 6–12 sutures are placed in a running fashion starting at the antrum and moving proximally [18]. Patients are put on a post-bariatric surgery liquid diet, just as if they had had a primary bariatric surgery, following this procedure.

If a lack of malabsorption is thought to be the problem, the common channel can be shortened. The channel should measure 100 cm. The distal end of the biliopancreatic limb can be divided, and a new, distal anastomosis can be performed. An alternative to this is increasing the length of the biliopancreatic limb, the bypassed portion of the small bowel. The normal length of the biliopancreatic limb is variable, ranging from 100 to 550 cm. The length of the patient's current biliopancreatic limb will determine how much it can be shortened.

35.6 Conclusions

Failure following duodenal switch is uncommon, with 0–14% of patients experiencing inadequate weight loss or weight recidivism. A careful and thorough patient assessment can reveal the underlying etiology for failure, allowing for successful treatment and improvement in weight loss.

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Chapter 36
Causes of Weight Regain After Duodenal Switch and Its Derivatives

Amin Andalib

36.1 Introduction

Classic duodenal switch (DS) and its derivative procedures are shown to be more effective than other common malabsorptive procedures such as Roux-en-Y gastric bypass (RYGB) both in achieving durable weight loss and resolving comorbidities [1–3]. However, certain reservations against classic DS like technical complexities and potential side effects such as frequent bowel movements and fat, micronutrient, and protein-calorie malnutrition render it unpopular and its practice to be scattered into only a handful of high-volume centers worldwide. As a result, classic DS comprises less than 5% of the annual bariatric procedures performed globally [4, 5].

Over the past decade, certain modifications have been introduced to the classic DS procedure via the single anastomosis DS (SADS) derivatives, which have shown promising results while addressing some of the apprehensions toward classic DS procedure. The most established of these derivatives are the single anastomosis duodeno-ileal bypass (SADI) and stomach intestinal pylorus-preserving surgery (SIPS) [6, 7]. The modifications implemented in SADS operations have the potential to change the procedure trends in the coming years especially in the current era of predominance of sleeve gastrectomy (SG) and the potential need for effective second-stage procedures for those with severe obesity with body mass index (BMI) ≥ 50 kg/m^2 and salvage surgeries for others with weight recidivism or refractory obesity-related comorbidities [8, 9].

Since its introduction in the late 1990s and despite the unpopularity and reluctance toward classic DS procedure [10, 11], there are several studies that report on

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its long-term outcomes [12–14]. However, the literature on long-term outcomes of the SADS derivatives is still lacking [15]. Moreover, information on weight loss failure and regain after classic DS and its derivative procedures are even more scarce. Nevertheless, this chapter aims to report on the incidence and the various causes of weight regain after these hypo-absorptive bariatric procedures based on the available body of literature.

36.2 Long-Term Outcomes of Duodenal Switch and Derivatives

36.2.1 Classic DS

Among established bariatric procedures, classic DS has been shown to offer patients the most profound and sustained weight loss [16]. When compared to RYGB as the most common malabsorptive procedure performed worldwide, classic DS is shown to lead to a superior and sustained weight loss with a difference of an extra 7–9 BMI points up to 5 years after surgery especially in patients suffering from severe obesity (BMI ≥ 50 kg/m^2) [17, 18]. According to reports from high-volume centers with large cohorts and long follow-up time >10 years after surgery with excellent retention rates (72–92%), classic DS procedure leads to a sustained weight loss equivalent to 71–75% excess weight loss (EWL), 55 kg in absolute weight loss, and a 20-point drop in the BMI [12–14, 19]. These drastic and decade-long weight loss estimates are virtually identical among all these long-term case series from four high-volume centers that include two of the original pioneering institutions where classic DS was first proposed and performed in.

As one of the pioneering centers, Hess et al. have provide a comprehensive account of 1404 consecutive DS procedures performed at their institution over a 16-year period [19]. They obtained a complete follow-up on 92% of the 182 eligible patients who had their surgery more than 10 years prior and reported a mean of 75% EWL after classic DS. Moreover, 94% of these patients had achieved and maintained a satisfactory weight loss of ≥50% EWL up to 12 years after surgery [19]. Similarly, in their 20-year comprehensive account of consecutive DS procedures in 2615 patients, Marceau et al. also report a mean weight loss of 55.3 kg equivalent to a 71% EWL or a 20-unit drop in BMI that was maintained for 5 to 20 years after surgery with a mean follow-up time of 9.8 years [12]. They had an overall 92% complete follow-up for the entire cohort and 82% retention rate among the 383 patients that were at least 15 years out from their DS procedures [12].

In another long-term study, Blockmans et al. report on the 10+ year outcomes of 153 patients that had undergone laparoscopic classic DS at their center (79% 10-year follow-up rate) [13]. At a mean follow-up time of 10.8 years, they observed a mean absolute weight loss of 54 kg and again a 20-point decrease in BMI [13]. Moreover, when they grouped patients in those with morbid obesity vs. severe obesity (≥50 kg/

m^2), they observed that the amount of weight loss was even more profound in the heavier subgroup by a mean of 4 units in their respective BMI drop [13]. These findings demonstrate the long-term efficacy of the classic DS procedure in achieving a profound and durable weight loss especially in patients suffering from severe obesity.

In terms of long-term improvements in associated comorbidities, hypo-absorptive procedures like the biliopancreatic diversion along with classic DS are also shown to lead to profound and sustained improvements especially in metabolic syndrome [1, 2, 12, 13]. In their 20-year comprehensive report with a mean follow-up of 9.8 years after DS (92% follow-up rate; $N = 2615$), Marceau et al. observed a 93.4% sustained remission rate of diabetes (blood glucose < 6 mmol/L; glycated hemoglobin A_{1C} < 6.5%), where nearly 40% of the patients were diabetic at baseline; only 4% of those diabetics who obtained remission suffered a relapse but only after a mean of 9.6 years after surgery, and they observed no new incident cases of diabetes in the patients that were not diabetic at baseline [12]. At a mean follow-up time of nearly 11 years after classic DS, Blockmans et al. also observed significant rates of long-term resolution of metabolic syndrome with 86% complete remission of diabetes and 81% and 95% resolution of hypertension and dyslipidemia, respectively [13]. However, they observed an alarming 43% rate of de novo gastroesophageal reflux disease (GERD) in their cohort of 115 patients with at least 10 years of follow-up after classic DS (gastroscopy was not performed systematically) [13]. This statistic could be alarming given that SG as the restrictive component of classic DS is a reflux-generating procedure and GERD can potentially lead to Barrett's esophagus, which in turn can progress from metaplasia to dysplastic disease and adenocarcinoma. Nevertheless, a recent population-level data comparing the reflux-protective procedure (RYGB) to the reflux-prone procedures including SG and classic DS (1860 classic DS procedures) did not show a significant difference in the incidence of esophageal cancer at a mean follow-up time of 7.6 years and up to 12 years after bariatric surgery [20].

36.2.2 Single Anastomosis DS Derivatives

As mentioned earlier, the DS derivatives all aim to address some of the technical and long-term nutritional concerns with the classic DS procedure. The two most established and studied of these derivative operations are SADI (introduced in 2007) and SIPS (introduced in 2016), which are essentially the same procedure with a small difference in the length of their proposed common channel and are essentially grouped together as SADS [6, 7].

As per the updated statement by the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) on SADS, as of March 2020, there were only 42 case series and 8 case reports on SADS most of which were reported after 2018 [15]. Furthermore, studies with long-term data (≥5 years) are even more scarce with only three studies from two centers all of which with small cohorts and low reported follow-up rates (<60%) [15]. There has only been one prospective study comparing SADS with the classic DS but with only short-term outcomes reported so far at 1 year [21]. Hence, contrary to classic DS, there is a lack of data on long-term outcomes of SADS, and the majority of reported information is medium-term at best.

Two recent systematic reviews have demonstrated a sustained EWL of 85% equivalent to a 19-point decrease in BMI units up to 2 years after SADS [22, 23]. Between both systematic reviews, 13–42% of the included studies comprised of SADS surgeries as salvage or second-stage procedures after a previous SG. As for improvements in comorbidities, SADS derivatives are also shown to be associated with 74% resolution of diabetes, 60–95% for hypertension, and 68–77% for dyslipidemia [22, 23]. Given the promising short- to mid-term outcomes especially in the era of SG predominance and the need for salvage procedures especially for patients suffering from severe obesity, SADS procedures have been endorsed by prominent international bariatric societies including IFSO and the American Society for Metabolic and Bariatric Surgery (ASMBS), who evidently call for more prospective studies to assess outcomes [15, 24, 25].

36.3 Weight Regain After Duodenal Switch and Derivatives

36.3.1 Classic DS

The convincing long-term (≥10 years) efficacy of the classic DS procedure in achieving profound and durable weight loss especially in patients suffering from severe obesity has turned it into a superior procedure especially as a second-stage surgery for super-super obese patients with BMI ≥ 60 kg/m^2 [12, 13, 19, 26]. Conversions to classic DS have also been shown to have superior results or used as ultimate revisional attempts to address significant weight recidivism after other common procedures including SG and RYGB [9, 27–29].

Various dichotomous definitions exist to describe success of weight loss after bariatric surgery such as percent EWL, percent total weight loss, percent excess BMI loss, or change in BMI [30]. Perhaps the most commonly used cutoff to define success after bariatric surgery is achieving ≥50% EWL, which is also not ideal given the lack of correlation with specific factors such as improvements in comorbidities and other patient reported outcomes like quality of life and satisfaction [31]. Another limitation of using 50% EWL cutoff is that percent EWL may significantly overestimate primary weight loss failure in patients with severe obesity at baseline (BMI > 50 kg/m^2) compared to their lower weight counterparts due to distortion from the initial BMI [32]. Furthermore, weight regain/recidivism is not defined in a standard fashion and very poorly reported in various studies [32, 33]. Moreover, given that weight regain always increases with time since both surgery and the nadir weight, the timing of assessment should always be reported and considered when interpreting the data, and weight regain should be reported a minimum of 3 years and ideally long-term (≥5 years) after bariatric surgery [34]. Return to BMIs > 35 or 40 kg/m^2 has also been used as a definition for weight recidivism and is shown to be associated with patient satisfaction after classic DS [35]. Given the low numbers of DS procedures performed worldwide, there is paucity of quality data on the incidence of long-term weight loss failure and regain after classic DS procedure.

In the 16-year case series by Hess et al., among 167 patients with ≥10 years of follow-up after surgery (92% follow-up rate of eligible patients), only 6% had unsatisfactory weight loss with <50% EWL long-term after classic DS [19]. The patients with unsatisfactory weight loss underwent revisional surgeries that included either common channel limb shortening or re-sleeve especially early in their experience when the gastric sleeves were made very large. Surprisingly, the weight loss after shortening of the common channel was unsatisfactory, as none of the patients lost >9 kg extra but did not regain any further weight. On the contrary, in the early group of primary operations when the sleeve was constructed larger, all patients that underwent a re-sleeve procedure had a subsequent effective weight loss [19]. Furthermore, in a 20-year comprehensive account of consecutive DS procedures in 2615 patients (847 with 10+ years of follow-up; 94% of the eligible patients), Marceau et al. describe that after a mean follow-up time of 7.3 years and up to 15 years, 8% of patients with an initial BMI ≤ 50 kg/m^2 did not achieve a BMI < 35 kg/m^2 vs. 17% of those with severe obesity at baseline (BMI > 50 kg/m^2) who did not obtain a BMI < 40 kg/m^2 [12]. However, repeat/revisional surgery for insufficient weight loss or weight regain was only necessary in 41 patients (1.6%) and consisted of further shortening the common channel length in 23 patients and re-sleeve in 18 individuals [12]. Finally, in another case series, Sethi et al. report on long-term outcomes of 100 patients who underwent biliopancreatic diversion and classic DS (64%) at their center [14]. At a mean follow-up time of 8.2 years with 72% retention at 10+ years (56 of 78 eligible), they observed an overall 8% weight loss failure rate observed 6.2 after surgery. This estimate was 13% among the group of patients with at least 10+ years of follow-up, but the authors do not offer any definition for what constituted weight loss failure, report no statistics for weight regain, and do not specify the distribution of the two procedures among the patients with 10+ years of follow-up [14].

Based on the available literature with 10+ year reported outcomes after classic DS procedure, the long-term incidence of weight regain is quite low (1.6–8%). This estimate is considerably lower than the respective long-term incidences of weight recidivism after SG and RYGB as the two most commonly performed bariatric procedures worldwide. Long-term (7+ years) incidence of weight regain after SG is shown to be 14–37% (13% requiring revisional surgery) and 8–20% after RYGB (3–6 years after surgery) [8, 36].

36.3.2 Single Anastomosis DS Derivatives

As mentioned above, long-term outcomes after SADS derivatives are scant. Overwhelming majority of the case series and cohorts are reported after 2018 and mainly include short- to medium-term outcomes after surgery which makes assessment of weight regain, an entity that is highly dependent on time since surgery, even more difficult [15, 25, 36].

In a recent study from Spain, Finno et al. retrospectively described their institutional outcomes of 181 patients that underwent SADI over a 4-year period compared to 259 that had classic DS but over a 12-year period [37]. In the SADI arm, over a mean follow-up time of 27 months after surgery, 5/181 patients needed conversions to a classic DS configuration. But only two of these patients (1.1%) underwent the revision to DS for inadequate weight loss, and there were no patients with reported weight regain [37]. However, the authors neither defined what constituted inadequate weight loss nor reported the efficacy of the conversion to DS in terms of weight loss [37]. Also, in their report of the first 100 patients who had SADI at their pioneering institution, Sanchez-Pernaute et al. describe a 1% rate of weight regain up to 5 years after surgery in a patient who originally achieved a 63% EWL 10 months after SADI but regained the weight up to an EWL > 50% by the end of the follow-up period [38]. Finally, in another recent prospective cohort study comparing SADI (N = 42) to classic DS ($N = 20$), at a median follow-up time less than 2 years, only 1/42 (2.4%) SADI patients had inadequate weight loss (51% EWL and BMI still > 40 kg/m^2) after a previous failed SG and underwent a conversion to classic DS [21]. Prior to SG, the patient suffered from extreme obesity with a BMI of 63 kg/m^2, and over the 8 months subsequent to the conversion of SADI to DS, the patient went on to lose an additional 15 kg in absolute weight and achieved a 63% EWL as of the last available follow-up [21].

Given the promising short- to medium-term outcomes that also seem to be comparable to classic DS and superior to RYGB coupled with continued calls for further quality studies by major international bariatric societies [2, 15, 21, 25], we can expect to have a better understanding of such statistics like weight regain/recidivism after SADS in the coming years. At medium-term follow-up, insufficient weight loss and weight regain after SADS derivatives are rare occurrences similar to classic DS and <10%. Moreover, in the current era of bariatric surgery, the need for safe and effective revisional surgeries is on the rise, especially after failed SGs and mainly in patients with severe obesity, so SADS procedures have a role. Single anastomosis DS derivatives also allow for a "three-step" approach (SG → SADI → DS) if needed, in the surgical treatment of obesity and related comorbidities especially in patients who suffer from extreme obesity (BMI ≥ 60 kg/m^2).

36.4 Causes of Weight Regain

36.4.1 Lifestyle and Patient-Related Factors

The cause of weight regain/recidivism after DS-type procedures is multifactorial, as is the case after all other types of bariatric surgery. Poor lifestyle habits and other patient-related factors are among the primary reasons for weight regain especially long-term after any bariatric surgery and require a multidisciplinary approach

[39–41]. Sedentary lifestyle and poor level of activity/exercise along with binge eating disorders, grazing, lack of impulse control, emotional eating, anxiety, and depression are among the most commonly cited lifestyle and patient-related factors associated with weight regain after bariatric surgery [42–44]. The significant negative association of such behavioral and psychological patient-related factors with weight regain after bariatric surgery has been more recently emphasized in light of the unfavorable impact from the coronavirus disease 2019 pandemic especially with the ensuing self-isolation and lower level of activity [45, 46].

In a recent systematic review by Athanasiadis et al. that included 32 studies involving 7391 RYGB and 5872 SG patients, regain of at least 10% of weight lost was observed to be 18%, and the authors reported that risk factors for weight regain fall in five main categories [47]. These categories included anatomical (surgical), genetic, dietary, psychiatric, and temporal factors. Among lifestyle and patient-related factors, anxiety, sweet consumption, emotional eating, portion size, food urges, binge eating, loss of control/disinhibition when eating, and genetics along with some surgical factors including gastrojejunal stoma diameter, gastric volume after SG, and time after surgery were found to be positively associated with weight regain after surgery [47]. This systematic review again highlights that the underlying factors that lead to weight regain after any bariatric surgery are multifactorial and require a systematic and multidisciplinary approach to address them.

36.4.2 Surgery-Related Factors

Given the multifactorial nature of weight recidivism after surgery, anatomical factors that could contribute to weight regain after DS-type procedures should also be considered and ruled out. Potential surgical targets in DS-type procedures either involve its restrictive SG component or the duodeno-ileal bypass component, i.e., the length of the common channel. To assess the SG component of DS-type procedures, investigations should include an upper gastrointestinal study or a sleeve volumetric study along with an upper endoscopy to rule out a grossly dilated sleeve or a poorly constructed SG with retained fundus. If present, these factors may contribute to inadequate weight loss or weight regain after surgery and can be a target for revisional re-sleeve surgery [19, 48–50].

Another potential surgical target to address weight regain after DS-type procedures would be to shorten the common channel. In classic DS, the common channel is already very short (100 cm), and given the hypo-absorptive nature of this procedure, patients are at a higher risk of developing long-term nutritional deficiencies especially fat-soluble vitamins, micronutrients, and protein-calorie malnutrition [13, 14]. Therefore, shortening the common channel further may risk exposing these patients to significant undesired malnutrition and at a very limited added benefit in terms of weight loss [19]. However, in case of SADS derivatives, common channel length is longer (250–300 cm) and theoretically amenable to further safe shortening. Thus, as previously mentioned, SADS derivatives allow for a step-up approach (SG → SADI → DS) especially for patients who suffer from extreme obesity [21, 37].

36.5 Summary

Despite having long-term data (≥10 years) after classic DS procedures, the information on long-term outcomes after its single anastomosis derivatives is still lacking, and these procedures remain less prevalent compared to SG and RYGB. Moreover, both primary weight loss failure and weight regain are not uniformly defined in the literature. The lack of consensus around the definition of weight regain coupled with limited prospective literature on long-term outcomes after DS-type procedures negatively impacts the conclusions drawn on this topic. However, based on the available data, the incidence of weight regain requiring a surgical intervention long-term after classic DS procedure is quite low (≤10%). Based on the current literature and up to medium-term follow-up, this statistic is also similar for the single anastomosis derivatives. The low incidence of reported weight regain after DS-type surgeries is not surprising given that these hypo-absorptive procedures are often considered the ultimate bariatric/metabolic salvage operations after other previous surgeries have resulted in weight recidivism and refractory metabolic comorbidities. As for causes of weight regain after DS-type procedures, similar to other types of bariatric surgery, the occurrence is considered multifactorial and associated with various patient-related, lifestyle, and surgical factors that require a multidisciplinary approach. Single anastomosis DS derivatives allow for a "three-step" approach (SG → SADS → DS), especially in those patients who suffer from extreme obesity. This step-up approach may be an option when the previous surgical step is faced with either inadequate weight loss or weight recidivism along with refractory comorbidities. Finally, there is a real need for more prospective studies including randomized controlled trials with long-term outcomes to further establish the support for the single anastomosis DS-type procedures.

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Chapter 37
Revisional Surgery for Weight Regain

Sara Ardila, Nathan Zundel, and Muhammad Ghanem

37.1 Introduction

Morbid obesity is a global chronic disease affecting 13% of people worldwide [1]. Weight loss surgery has been proven to be effective in addressing this chronic disease and its associated comorbidities. In 2016, over 200,000 procedures were performed in the United States, and the volume continues to grow [2]. Cases analyzed between 2015 and 2018 indicate an overall growth rate of 21.9% [3]. The most common surgeries performed in the United States are Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG), and biliopancreatic diversion with duodenal switch (BPD/DS). Estimated mean weight loss is 33% of the initial body weight [4]. Unfortunately, it is estimated that up to 25% of patients will have weight regain after primary surgery [5]. Weight regain or recidivism has emerged as a clinical entity and important public health issue given its association with re-emergence of obesity-related comorbidities, worsening quality of life, and increased healthcare costs. With the increased number of primary bariatric surgery performed worldwide, revisional surgery has also increased, and it has been shown to be the fastest-growing category of bariatric procedures, currently representing 7 to 15% of all bariatric operations [6]. Long-term rates of revisional surgery have been estimated to be as high as 56% [7]. In this chapter, we will focus on the incidence of weight regain, its definition, and revisional surgery to address it.

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37.2 Incidence and Causes of Weight Regain

Weight regain is estimated in up to 25% of patients following primary bariatric surgery [5]. The incidence of weight regain varies per index procedure (Table 37.1). In a single-center retrospective review of 534 patients, 64% sought revisional surgery for weight regain [3]. In addition, it is estimated that more than 80% of the weight regain happens within the first 6 years following primary surgery. A major factor contributing to weight regain is lack of adherence to recommended follow-up visits, observed in approximately 60% of patients 4 years after primary surgery [4].

The etiology of weight regain has been attributed to: [4, 11]

- Noncompliance with dietary recommendations.
- Hormonal/metabolic imbalance.
- Mental health.
- Physical inactivity.
- Anatomic/surgical factors.
- Medications.

Table 37.1 Estimated incidence of weight regain per primary bariatric surgery

Procedure	Incidence (%)
Adjustable gastric band	33.3–40
Vertical banded gastroplasty	26–74
Sleeve gastrectomy	5–25
Roux-en-Y gastric bypass	10–34
Duodenal switch	10

Data from Refs. [8–10]

37.3 Definition of Weight Regain

Defining weight regain has been a challenge. There is no clear definition or guideline established. Multiple groups have attempted to define weight regain. A systematic review and meta-analysis found that the most common definition is excess weight loss (EWL) less than 50% within 18–24 months after the primary operation.

Weight regain/recidivism has been defined as [12]:

- EWL less than 50% from the original preoperative weight (most common).
- BMI > 35 kg/m^2 or EWL < 50%.
- BMI > 30 kg/m^2 or 35 accompanied by EWL < 50%.
- Increase in BMI > 5 kg/m^2 compared with preoperative weight.
- Total body weight loss (TBWL) < 25%.
- Weight regain > 30% of lowest post-surgery weight.

One of the current challenges in the management of weight regain is its early recognition and subsequent intervention. Istfan et al. aimed to establish a guideline for the early recognition of weight gain. Based on their 11-year follow-up data from a multiethnic bariatric patient population, they defined weight regain according to the rate of increase in weight relative to nadir weight per 30-day interval [4]. They classified weight regain as mild, moderate, and rapid as weight regain/nadir of 0.2% to <0.5%, 0.5% to 1%, and >1% per 30-day interval, respectively.

37.4 Preoperative Evaluation

A multidisciplinary evaluation is essential prior to recommending revisional surgery to patients presenting with weight gain. As with primary surgery, a nutritional evaluation, behavioral/psychological assessment, and endoscopic and contrast series studies should be obtained. The latter will not only aid in establishing an anatomic etiology for weight regain if present, but it will also aid in choosing the type of revisional surgery [6].

37.5 Selecting the Type of Revisional Surgery

There are several revisional procedures following primary bariatric surgery. The choice of revisional surgery is tailored according to initial surgery (Table 37.2), cause of failure, and surgeon's experience. Multiple revisional surgeries have been described for all primary bariatric surgeries, but no standardized guidelines have been established.

In June 2019, 70 experts from 27 countries formed a committee and created the first consensus on revisional bariatric surgery. An agreement of 70% or more was

Table 37.2 Recommended revisional surgery based on index procedure

Index procedure	Recommended revisional surgery
Adjustable gastric band	RYGB, BPD/DS
Roux-en-Y gastric bypass	DRGB and BPD/DS or SADI-S
Nonadjustable band/vertical banded gastroplasty	RYGB
Sleeve gastrectomy	Re-sleeve, RYGB, BPD/DS, SADI-S

RYGB Roux-en-Y gastric bypass, *DS* duodenal switch, *DRBG* distal Roux-en-Y gastric bypass, *BPD/DS* biliopancreatic diversion with duodenal switch, *SADI-S* single anastomosis duodeno-ileal bypass and sleeve gastrectomy

considered consensus. Consensus was achieved in several points including but not limited to (1) RBS is justified in some patients; (2) RBS is more technically challenging than the respective primary bariatric surgery; (3) second or third RBS can be justified in some patients; (4) candidates should undergo a nutritional assessment, psychological evaluation, endoscopy, and a contrast series; (5) RYGB, one-anastomosis gastric bypass (OAGB), and SADI-S are options after gastric banding; and (6) OAGB, BPD/DS, and SADI-S are options after sleeve gastrectomy. Regarding revision for primary RYGB, the only consensus obtained was lengthening of the biliopancreatic limb as RBS option for RYGB or OAGB [13].

37.5.1 Adjustable Gastric Band

Adjustable gastric band (ABG) remains one of the most common bariatric surgeries performed worldwide and the procedure that most commonly requires revision with estimated rates of 30 to 60% [6]. Given its primary restrictive effects, reported failure rates range between 40 and 50%. For weight regain, conversion to a malabsorptive procedure is recommended, such as RYGB or BPD/DS. If the cause of weight regain can be attributed to band slippage or pouch dilation, re-banding or conversion to sleeve gastrectomy is another option [8]. For the years 2015 to 2017, the most common revision was laparoscopic gastric banding (LAGB) to SG, followed by LAGB to RYGB [14].

37.5.2 Non-adjustable Band/Vertical Banded Gastroplasty

Non-adjustable gastric bands have fallen out of favor secondary to its long-term complications. Conversion to RYGB is the procedure of choice. Conversion of vertical banded gastroplasty has been described to RYGB, SG, OAGB, and DS [6]. Conversion to RYGB remains the gold standard for both of these primary procedures.

37.5.3 Roux-En-Y Gastric Bypass

Roux-en-Y gastric bypass is one of the most common weight loss procedures performed worldwide and is considered by many to be the gold standard. Unfortunately, approximately 10–34% of patients experience inadequate weight loss or weight gain and may ultimately require revision. The most common etiology of weight regain is pouch dilation. Other reported etiologies include enlarged gastric pouch greater than 5 cm in diameter, wide gastro-jejunal anastomosis (GJA), anastomosis greater than 1 cm, GJA > 1.5 cm in diameter, dilated GJA greater than or equal to 2 cm, pouch >30 mL, pouch dilation >120 mL, weight recidivism with or without gastric fistula, gastric fistula, short-limb bypass, and hyperphagic behavior [12].

Multiple revisional surgeries have been described. In a recent systemic review and meta-analysis, distal Roux-en-Y gastric bypass (DRGB) alone showed the highest decrease in BMI at 1-year follow-up versus biliopancreatic diversion with duodenal switch (BPD/DS) or single anastomosis duodeno-ileal bypass and sleeve gastrectomy (SADI-S) at 3-year follow-up. Overall, they found maximal BMI decrease in DRGB alone, followed by BPD/DS or SADI-S, laparoscopic pouch and/or GJA resizing, and endoscopic pouch and/or GJA resizing.

37.5.4 Sleeve Gastrectomy

Sleeve gastrectomy (SG) is currently the most commonly performed bariatric procedure worldwide [1]. Its relatively simple technique and low complication rate contribute to it being preferred over some other procedures [15]. Revision is estimated in up to 30% of cases for multiple etiologies, including weight regain. Loss of restriction is one of the main anatomic factors contributing to weight regain. Although revision to RYGB or DS has been recommended as the standard of care, some studies have described revision with re-sleeve for dilation of the residual stomach as the cause [15]. The overall %EWL following re-sleeve can be up to 57% at 12 months and up to 60% at 20 months [16].

A retrospective study analyzed conversion from SG to either RYGB or SADI for insufficient weight loss or weight regain. Out of 140 patients, 66 patients underwent SG to SADI, and 74 patients underwent SG to RYGB. SADI was found to achieve 8.7%, 12.4%, and 19.4% more total body weight loss at 6, 12, and 24 months compared to RYGB for weight regain alone. RYGB is preferred when symptoms of reflux accompany weight regain [16].

For patients with super morbid obesity and weight regain after SG, in the absence of reflux symptoms, conversion to biliopancreatic diversion with duodenal switch (BPD/DS) is recommended for maximal weight loss, with %EWL ranging from 70 to 80% at 2 years [3].

37.5.5 Biliopancreatic Diversion With or Without Duodenal Switch

Biliopancreatic diversion with duodenal switch (BPD/DS) has been shown to be the most effective bariatric procedure with maintained long-term %EWL of 82.2%, 81.9%, 81%, and 83% at 2, 3, 4, and 5 years [17]. Despite its weight loss benefits, it is associated with the highest early mortality and complications at 1-year follow-up of all procedures [18]. Limited data exists on revision for weight regain at this time given its proven efficacy. Reducing the gastric volume has been described giving limited results [19].

37.6 Role and Impact of Duodenal Switch

Duodenal switch as a primary bariatric surgery has been associated with the highest %EWL estimated at 74.1, compared to sleeve gastrectomy at 58.3%EWL, RYGB at 56.7%EWL, and gastric banding at 45.9%EWL [20]. It is therefore not surprising that as a revisional procedure, it has also been shown to be associated with more weight loss. A recent retrospective study comparing SADI and RYGB for patients with failed SG found that patients who underwent SADI experienced 8.7%, 12.4%, and 19.4% more weight loss compared to RYGB at 6, 12, and 24 months postoperatively [3].

Its long-term weight loss efficacy has led to BPD/DS growing popularity as a primary and revisional bariatric surgery, experiencing a 63.7% and 114.1% growth in total cases and revision cases, respectively, from 2015 to 2017 [18].

Duodenal switch has also been shown to be the primary and revisional procedure of choice for superobese patients, classified with a body mass index of >50 kg/m^2. A retrospective study compared 83 BPD/DS and 97 RYGB procedures performed from 2002 to 2009 for patients with an initial body mass index of 55 kg/m^2. At 3-year follow-up, the mean %EWL was 63.7% after RYGB versus 84% after BPD/DS [21].

In summary, biliopancreatic diversion with duodenal switch (BPD/DS) has been shown to be beneficial as revisional surgery for select populations:

- Superobese patients.
- Weight regain following SG in the absence of reflux symptoms.

37.7 Weight Loss Following Revisional Surgery

Weight loss after revisional bariatric surgery leads to significant weight loss in the long term, rates varying per procedure performed. A single-center retrospective study for patients who underwent revisional surgery for weight regain (52.4%)

analyzed weight loss at 3-, 6-, 9-, and 12-month intervals. Patients with a primary restrictive procedure and reflux symptoms underwent conversion to either RYGB or BPD/DS and experienced 50–65.3%EWL at 3 months and 50.1–79.1%EWL at 12 months. Patients with initial RYGB underwent GJ revision for pouch or GJ abnormalities. For those without anatomic abnormalities, they underwent conversion to distal bypass. At 3 months, %EWL was 36.6 for GJ revision and 37.5% for distal revision [7].

37.8 Complications of Revisional Surgery

Revisional bariatric surgery is complex, is technically demanding, and is therefore associated with higher morbidity and mortality. Compared to primary surgery, revisional surgery has been associated with higher rates of postoperative complications, longer operative times, longer hospital stay, conversion to open surgery, readmission, and unplanned admission to the critical care unit [3, 6]. In comparing primary versus revisional RYGB, revisional surgery was associated with higher rates of leak, hemorrhage, wound infection, stricture, ulcer, perforation, and hernia [6].

A single-center retrospective study analyzed complications after revisional surgeries performed at their center for weight regain between 2012 and 2015. Of 84 patients, 43 presented for weight regain (52.4%). Complications included incarcerated ventral hernia following AGB conversion to SG, anastomotic leak and recurrent intussusception following gastro-jejunostomy revision, and stricture and marginal ulcer following AGB conversion to RYGB [7].

In summary, reported complications of revisional bariatric surgery are:

- Hernia.
- Anastomotic leak.
- Stricture.
- Marginal ulcer.
- Wound infection.
- Hemorrhage.
- Perforation.
- Obstruction.

37.9 Conclusion

Weight regain after primary bariatric surgery is multifactorial. It is imperative to establish guidelines for classifying weight gain in order to guide subsequent intervention and thus to aid bariatric teams internationally in the management of this clinical entity. Revisional surgery has been shown to be a successful treatment option for patients presenting with weight gain, with rates of weight loss nearing those seen after primary surgery. Furthermore, the importance of revisional surgery lies in its ability to readdress many of the obesity-related comorbidities which prompted the primary procedure. When indicated, it is important to tailor the type of revisional surgery to each patient. Although Roux-en-Y gastric bypass remains the most common type of revisional surgery after primary surgery of any type, duodenal switch is emerging as the revision procedure of choice for superobese patients and patients with failed sleeve gastrectomy secondary to weight regain in the absence of reflux symptoms.

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Chapter 38
Conversion of Sleeve Gastrectomy to Duodenal Switch and SADI-S

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38.1 Introduction

Sleeve gastrectomy (SG) has increasingly seduced surgeons and patients worldwide. Initially derived from classic biliopancreatic diversion/duodenal switch (BPD-DS), SG began to be employed years later as a first stage in patients with severe obesity and at high surgical risk. Based on the encouraging results, the second stage was gradually discontinued, and the SG was subsequently recognized as a stand-alone bariatric procedure. Currently, SG accounts for about 60% of all interventional bariatric and metabolic procedures worldwide [1–3]. Long-lasting weight loss, control of obesity-related comorbidities, and virtual absence of significant gastrointestinal and nutritional adverse events can help explain such expressive percentages [4, 5].

Despite the current widespread acceptance of the SG, some setbacks are still a source of heated debates in the scientific community. Food intolerance due to torsion of the axis or stenosis, worsening or onset of "de novo" gastroesophageal reflux disease (GERD), and the challenging treatment of high leaks are some examples of concern among bariatric surgeons. In addition, the ineffectiveness in controlling obesity due to inadequate weight loss (IWL) or mainly weight regain (WR) has shown worrying rates in recent times.

IWL is a disappointing outcome usually seen as soon as 6–12 months after the procedure. Its incidence is unclear, perhaps underreported, but it does not seem to have a concerning rate. On the other hand, the long-term follow-up of patients

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undergoing SG has shown a higher rate of obesity recurrence. In any case, failed SG brings intense distress to the patient and the surgical team, sometimes requiring reoperation. Several options are currently available to the surgeon in the face of weight loss failure after SG. However, the main challenge is to accurately identify which patients would actually benefit with a second procedure in the long term.

The traditional BPD-DS is a malabsorptive operation that has long been recognized as one of the most effective bariatric procedures. The single anastomosis duodenal-ileal bypass with sleeve gastrectomy (SADI-S), also called "one-anastomosis duodenal switch" (OADS), is fundamentally a variant of the BPD-DS operation that was already endorsed by both the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) and American Society for Metabolic and Bariatric Surgery (ASMBS) [6–8]. Both BPD-DS and SADI-S/OADS appear to be highly effective as primary bariatric procedures in morbidly obese patients [9–14]. However, some technical complexity, mainly related to DBP-DS, and side effects associated with malabsorption of fat-soluble vitamins, micronutrients, and proteins, as well as steatorrhea, have limited the use of large-scale duodenal switch surgeries.

Despite the limited acceptance as a primary procedure, BPD-DS and SADI-S/OADS should be seen as the natural rescue procedure in sleeved patient, since the gastric step of these two techniques has already been done, saving operative time and minimizing the risk of complications related to the SG itself. However, the bariatric community in general still seems to opt more frequently for conversion to gastric bypass, considered a less technically demanding procedure. Nonetheless, the greater technical simplicity attributed to the emerging SADI-S/OADS surgery compared to classic BPD-DS can provide a broader acceptance of duodenal switch surgery as a suitable revisional option after failed SG in the following years.

Therefore, the purpose of this chapter is to discuss duodenal switch surgery, either by two- or one-anastomosis, as a safe and feasible option to rescue patients undergoing SG and failure in obesity disease control.

38.2 Weight Loss Failure After SG

Unarguably, SG is currently considered a very effective treatment for morbid obesity. However, weight recidivism has been reported at varying rates after the sleeve. This wide variation seems to depend, above all, on the time of postoperative follow-up and on the definition adopted for the diagnosis of WR. An interesting study highlighted how the WR rates can be strongly impacted by the type of definition adopted. Six different types of definitions were applied to the same cohort of 868 patients undergoing bariatric surgery with at least 5 years of follow-up. Depending on the type of definition, WR ranged from 16 to 87% [15]. Similarly, a systematic review addressing the WR following SG showed a high variation in rates, ranging from 5.7% to 75.6%, depending on the follow-up period and the definition adopted [16].

Worryingly, the lack of a universally accepted definition seems to be the rule. A systematic review carried out to describe how the failure of bariatric surgery is commonly defined in the literature retrieved 60 studies comprising more than 4000 revisional procedures. The clear indication was provided in only 2741 cases. Among these, IWL and WR were responsible for almost 60% of the indications. Despite this relevance rate, most published studies have not precisely defined the failure of bariatric surgery, but excess weight loss (EWL) below 50% at 18 months postoperatively appeared to be the most frequently used definition [17]. An online survey using a social media platform was carried out to capture the current definitions for post-sleeve WR and what revision procedures are commonly offered in such cases. Not surprisingly, gastric bypass surgery (RYGB and OAGB-MGB) far surpassed the duodenal switch technique, whether through one- or two-anastomosis. In addition, the survey exposed the concerning lack of a scientifically robust definition for WR after SG [18].

Amid this lack of standardization, a multitude of conflicting data have been published. Data from case series followed prospectively in the short term (1–2 years) demonstrated recurrence of obesity in about 10% of patients undergoing SG. In this study, WR was defined as a recovery of at least 5% of the body weight initially lost [19], a somewhat rigorous definition. A retrospective study with longer postoperative follow-up (6 years on average) found that almost 70% of post-sleeve patients met the WR criterion, defined as at least an increase in body weight of 5–10 kg from the nadir, an equally very strict criterion [20].

Nevertheless, the variable rates of post-sleeve WR do not mirror the percentage of revision surgery, since not all patients identified as WR will need an interventional procedure. In a short-term case series of 500 morbidly obese patients who underwent primary SG, 26 individuals (5.2%) required revisional surgery due to poor weight loss ($n = 8$) or WR ($n = 18$). In this study, poor weight loss was defined by a percentage of excessive weight loss (%EWL) of less than 50% after 1 year, and WR was defined as a regain of at least 30% of lost weight or a regain of 20% of weight from the nadir [21]. Another case series also applied the %EWL as a parameter to proceed with a rescue procedure after SG. Of a total of 1300 patients, 36 (2.2%) required reoperation due to failure in weight control, defined by a %EWL below 50% after 1 year. In this study, both IWL and WR were included in the same definition [22]. In a long-term case series of obese patients undergoing SG, 4 (2.2%) of 182 patients eligible for the study underwent BPD-DS as a second-stage procedure due to IWL before reaching the endpoint. In this cohort, 114 patients (62.6%) reached 10 years of follow-up, and the WR, expressed as an increase in weight ≥ 25% from the nadir, occurred in 10.4% of patients [23]. And finally, a retrospective analysis of a prospective cohort assessed long-term outcomes of 168 patients undergoing SG. After 8 years of follow-up, 116 patients still had only the index procedure and had an average EWL of 67%. Of the remainder, 29 lost follow-up, and 23 (13.7%) patients underwent revisional surgery for WR ($n = 14$; 8.3%) or for severe reflux ($n = 9$; 5.3%) at a mean time elapsed since the initial procedure of 50 months. Of these 14 patients, 5 went to duodenal switch surgery and 1 to SADI-S/OADS [24].

Therefore, although some studies have shown alarming rates, the percentage of patients with failure in weight control requiring a revisional procedure after SG appears to not exceed 5–10% in the long term. Moreover, the criteria for indicating a reoperation remain somewhat arbitrary and surgeon-dependent. Importantly, the potential surgical risks and possible long-term benefits must be carefully weighted in each individual patient.

38.3 Reoperative Procedures for Failure in Weight Control After Sleeve

First of all, it is widely agreed that the first approach for a patient with IWL or WR must comprise complete multidisciplinary assessment and detailed investigation of the sleeved stomach. In the absence of complete loss of the restrictive effect due to huge sleeve dilation, reoperation should only be considered after the patient's commitment to the multidisciplinary team. Otherwise, new failure is often the rule, especially in the long term. Increased costs, reoperation probabilities, disappointing results, and, mainly, surgical complications appear to be higher compared to the index procedure [25, 26]. Therefore, every caution is strongly advisable before going to surgical revision.

The ASMBS Revision Task Force established a nomenclature for reoperative surgery into conversion, corrective, and reversal procedures [27]. Obviously, the sleeve cannot be subjected to a reversal procedure, since 70–80% of the stomach is removed. On the other hand, there are several corrective procedures that can be applied to the sleeve: re-sleeve, banding, seromyotomy, and axis realignment, among others.

Conversion procedures can be used in cases of complications or failure to control weight or obesity-related comorbidities. Currently, the main reasons for converting a sleeve into some other bariatric procedure are GERD and obesity recidivism. In cases of GERD, the preferred rescue procedure seems to be Roux-en-Y gastric bypass (RYGB), since the surgical design of the sleeve may be the cause of pathological reflux and, therefore, this anatomy should be changed. Notwithstanding, SADI-S/OADS can also be an acceptable revision choice for sleeve patients suffering from GERD symptoms and weight recidivism. A retrospective analysis of a prospectively collected database of patients who underwent SADI-S/OADS or one-anastomosis gastric bypass (OAGB-MGB) as a revisional procedure for weight recidivism after primary SG included 91 patients. In the SADI-S/OADS group ($n = 42$), seven patients had GERD symptoms, and 57% had either stopped or decreased their anti-reflux medications after revisional surgery. The sleeve was left untouched in all patients. It is very likely that the improvement/resolution of GERD has reflected the suitable control of the obesity disease, since at 12 months postoperatively, the average post-revisional %EWL was 51.3 in the SADI-S/OADS group [28]. Markedly, the small sample undermines more accurate conclusions.

Leaving the outcomes on GERD aside, associating only an intestinal bypass and keeping the sleeve intact can be a very simple and highly effective technical alternative for sleeve patients with IWL or obesity recurrence. In this scenario, both BPD-DS and SADI-S/OADS should emerge as the natural options for conversion (or second stage), since the SG comprises the original technique of these two procedures. According to the 32 members present in an international panel of experts to define the best practice guidelines in reoperative surgery after SG, the BPD-DS was consensually considered superior to the RYGB in terms of improving weight loss. In addition, consensus has also been reached that the SADI-S/OADS surgery can additionally be a reasonable option for treating patients with failed SG [29].

Despite the favorable arguments aforementioned, both BPD-DS and SADI-S/OADS do not seem to be the preferred procedure for failed SG. At the Fourth International Consensus Summit on Sleeve Gastrectomy, 130 expert surgeons provided data of 46,133 procedures. Although many respondents denied observing significant WR after SG at that time, if a second operation became necessary due to weight loss failure, conversion to a BPD-DS was the second most common procedure (24%), behind the RYGB (46%). A small percentage of surgeons reported opting for SADI-S/OADS (3%) at that time [30]. In sequence, at the Fifth International SG Consensus, 120 expert surgeons provided data on 117,000 procedures. The percentage of conversions caused by failure in weight loss was 4.7%. BPD-DS has been reported as the second most common choice for a rescue procedure, again behind the RYGB [31].

An online questionnaire-based survey attempted to obtain data on practices related to revision bariatric surgery. Opinions of 460 surgeons around the world concerning revision after SG have identified the RYGB surgery as the preferred procedure, followed by OAGB-MGB. Both one- and two-anastomosis duodenal switch surgeries came next, with a slightly higher percentage for choosing SADI-S/OADS [32]. More recently, another online survey regarding global variations in perioperative practices concerning SG gathered the responses of 863 bariatric surgeons from 67 countries with a cumulative experience of 520,230 procedures. The most common procedure offered to the patient for further weight loss after sleeve surgery was RYGB (51%), followed by OAGB-MGB (25%). SADI-S/OADS and BPD-DS came next, with 10% and 3.2% of the indications, respectively [33]. Interestingly, the option for revision with SADI-S/OADS surpassed the classic BPD-DS in this survey.

In general, these data perhaps reflect the greater familiarity of bariatric surgeons with gastric bypass, either with the traditional Roux-en-Y or, more recently, with that of one anastomosis, both considered technically less complex than the duodenal switch approach. In this sense, the greater technical simplicity of SADI-S/OADS can overcome this barrier and become a more chosen option in the SG revision due to IWL/WR in the near future. However, both BPD-DS and SADI-S/OADS are malabsorptive procedures with some difficulty in postoperative nutritional management, which currently has not been viewed favorably by either surgeons or patients.

Recently, a consensus meeting applied debatable issues to 29 experienced bariatric surgeons to outline areas of further research on the role of BPD-DS as a second-stage or revision procedure. Expert surgeons considered BPD-DS surgery the most appropriate subsequent operation for a committed patient with IWL after SG (88.5% agreement). Likewise, the SADI-S/OADS was also considered a reasonable option to deal with SG failure (72.4%), but technically simpler. For sleeve patients with WR and normal upper gastrointestinal series (without reflux, without enlargement), BPD-DS was the most common choice (43.3%), followed by RYGB (33.3%) and SADI-S/OADS (13.3%) [34]. In this publication, the authors reported interesting data from the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) in relation to the BPD-DS as a revision procedure. In 2017, the United States performed 1643 primary BPD-DS, an increase of 54.3% compared to 2 years ago. Notably, during the same time interval (2015–2017), the duodenal switch as a revision procedure grew 114.1%.

The first consensus statement on revisional bariatric surgery gathered 70 expert surgeons to vote on the agreement or disagreement of 39 pivotal questions regarding general aspects of revisional surgery, disregarding the index procedure. Specifically for revision after sleeve, SADI-S/OADS achieved the highest percentage of agreement (88.5%) as an acceptable option, followed by OAGB (84.3%) and BPD-DS (81.4%) [35]. In this consensus-building vote, the reason for the revision was not up for debate.

Finally, an international panel of 32 expert bariatric surgeons was brought together with the aim of providing guidelines on revisional surgery after sleeve surgery. Several causes for interventions were addressed, but one of the most controversial topics was in regard to strategies to manage poor weight control. First of all, multidisciplinary evaluation and treatment were considered mandatory before considering a revisional surgical approach, especially in the absence of anatomic abnormalities in the sleeve. For IWL or WR with sleeve enlargement/dilation or disappointing responses to multidisciplinary clinical management, conversion to standard BPD-DS has reached consensus as a safe and effective strategy. Likewise, SADI-S/OADS has also achieved agreement as a reasonable revisional procedure for treating patients with failed SG. Both procedures were deemed superior to RYGB to restore or improve weight loss [29].

Thus, although two- and one-anastomosis duodenal switch has been repeatedly pointed out as the best rescue option among expert surgeons, the general bariatric community still seems to opt more frequently for conversion to RYGB in cases of failure to control obesity after SG. The expected popularization in the coming years of a procedure with less technical complexity (SADI-S/OADS) may eventually contribute to increasing the indications for a duodenal switch surgery after failed SG.

38.4 Conversion of SG to BPD-DS and SADI-S: Surgical Technique

If no anatomical abnormalities are found in the preoperative work-up, and confirmed in the intraoperative, the approach of the sleeve appears to be needless. Indeed, it may not even be advisable, as the risk of complications related to the

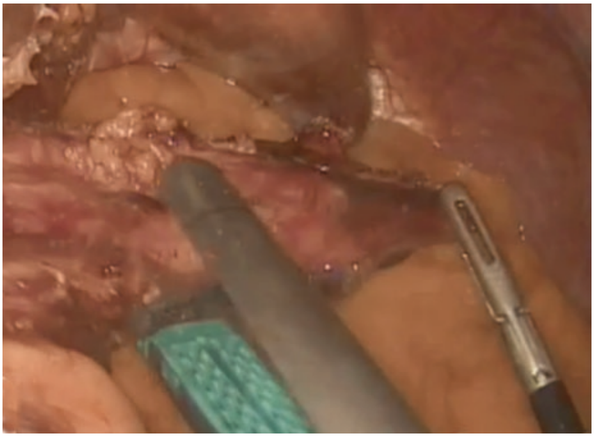

Fig. 38.1 Redundant gastric fundus (dilated) already dissected, ready for the safe positioning of the stapler (green load)

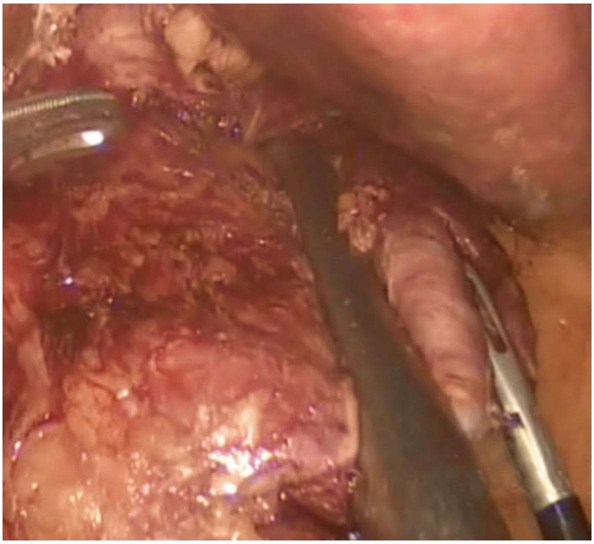

Fig. 38.2 Stapler well positioned and closed, ready for firing

procedure can potentially be increased. In some cases, whether due to pre- or intraoperative diagnosis, excision of the redundant fundus (fundectomy) may be necessary to boost further weight loss (Figs. 38.1, 38.2, 38.3, and 38.4). In cases where the entire sleeve is severely dilated, the surgeon who chooses to tighten should keep in mind that the BPD-DS sleeve appears to have been originally designed also to reduce stomach acid secretion, and not just to cause a significant restrictive effect. Therefore, the calibration of the diameter of the sleeve should be slightly looser than when the SG is performed as a stand-alone procedure. After all, the association of a strong restrictive effect with malabsorption can be dangerous for nutritional balance.

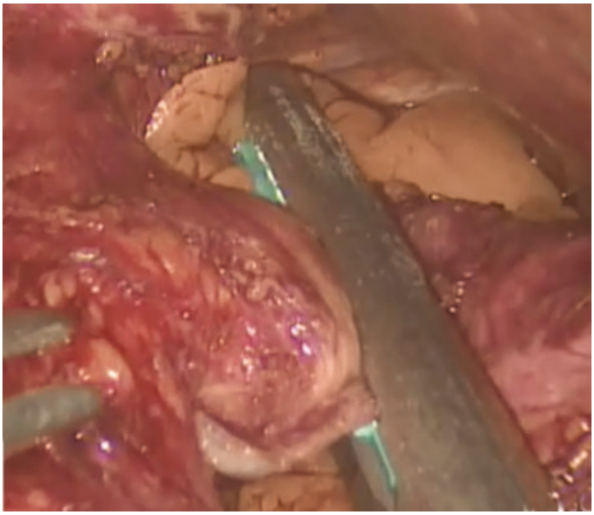

Fig. 38.3 Second firing from the stapler to complete the resection of the redundant gastric fundus (also green load). A safe distance from the abdominal esophagus must be assured

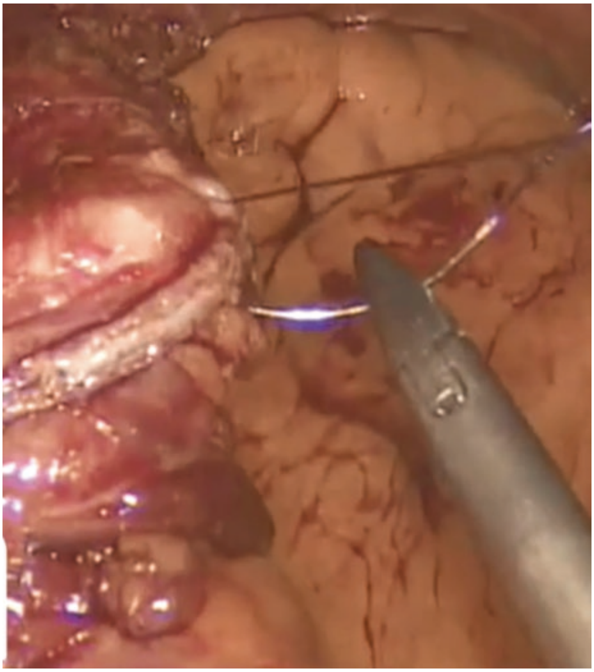

Fig. 38.4 Reinforcement of the fresh staple line by means of transmural running suture

Technical details necessary for conversion surgery such as trocar placement, techniques for duodenal mobilization, approach to the right gastric artery, duodeno-ileostomy technique (hand-sewn/stapled), length of the common channel and Roux limb in BPD-DS or the efferent loop in SADI-S/OADS, and closure of mesenteric defects, among others, are properly covered in other chapters of this book.

Although the conversion of a SG to BPD-DS or SADI-S/OADS can be less complex when compared with these same operations performed primarily, it is still a reoperation, a revisional surgery. Complication rates are generally higher on revision procedures, and, therefore, they should preferably be performed by trained and experienced hands at referral centers.

38.5 Results of Conversion from SG into BPD-DS or SADI-S/OADS

Some caution must be taken when analyzing the outcomes concerning further weight loss after revisional procedure, since published studies with inadequate comparison between different postoperative follow-up times can be easily found. Most patients who are reoperated for WR after SG have had satisfactory short-term results. Therefore, it is not fair, nor scientifically correct, to compare the long-term WR of SG with the short- or mid-term outcomes of the revisional procedure. Furthermore, duodenal switch surgeries, alongside OAGB-MGB, have become a more attractive option for revising the sleeve due to weight loss failure only recently, perhaps driven by the unsatisfactory long-term results of RYGB surgery. Therefore, substantial mid- and long-term data is not yet available.

Outcomes of revisional duodenal switch procedures after sleeve have been frequently compared with other bariatric surgeries, especially gastric bypass. In this comparison, both BPD-DS and SADI-S/OADS appear to provide higher weight loss, most likely by adding a malabsorptive component to an essentially restrictive surgery. On the other hand, malabsorption can lead to higher rate of nutritional side effects that are not commonly seen in RYGB surgery, requiring strict surveillance, especially when the efferent loop (common channel) is left less than 250 cm in length.

A systematic review carried out to compare single- or double-anastomosis duodenal switch with RYGB for further weight loss in failed SG included six retrospective studies for meta-analysis. The primary outcome was the percentage of total weight loss (%TWL). A total of 206 patients comprised the SADI-S/BPD-DS group, and an average of %TWL of 30.75 was observed after a highly variable follow-up period (median of 24 months). This weight loss was about 10% higher compared to the RYGB group. However, this significantly favorable outcome concerning weight loss seems to have occurred mainly at the expense of patients undergoing classic BPD-DS, since the comparison only between SADI-S/OADS and RYGB remained showing the superiority of the duodenal switch surgery, but without statistically significant difference [36]. Nonetheless, the small sample size in each study and lack of baseline equivalence in initial BMI between the groups before the second procedure observed in most of the studies are significant factors of high risk of bias to compare the duodenal switch procedures and gastric bypass in terms of weight loss.

One of the studies included in the meta-analysis formerly mentioned brought together the largest casuistic to compare SADI-S/OADS (*n* = 66) with RYGB (*n* = 45) as rescue surgery for failed SG. At 24 months following secondary surgery, data were available in only about 50% of patients in both groups, but the percentage of total body weight loss (%TBWL) was significantly higher in patients undergoing SADI-S/OADS (26.4% ± 10.4 vs. 6.9% ± 11.3, SADI-S/OADS vs. RYGB, respectively). Moreover, 72% of RYGB patients regained a part of their lost weight after revisional surgery, whereas SADI-S/OADS patients seem to progressively lose weight during the 2-year follow-up period. Nutritional deficiency was found in more than 60% of patients in both groups (64% vs. 62%, SADI-S/OADS vs. RYGB, respectively), despite oral supplementation being directed to all patients. Within the first year of surgery, complications were observed with rates above 15% in both SADI-S and RYGB (16.7% vs. 17.6%, respectively). Meanwhile, the authors reported two SADI-S/OADS patients underwent re-sleeve because of IWL and one additional patient underwent a duodenojejunostomy for enteral feeding due to intractable severe chronic diarrhea [37].

A retrospective matched cohort study with short-term follow-up also compared SADI-S/OADS (*n* = 42) and RYGB as a revisional procedure after SG to achieve additional weight loss. Although post-revisional percentage total weight loss (%TWL) appeared to be slightly higher in the duodenal switch group (10.6 vs. 9.5, SADI-S/OADS vs. RYGB, respectively), no significant difference was found in relation to the drop in BMI after 12 months. Interestingly, failure in obesity control was again observed after both procedures (three patients from SADI-S/OADS group and nine from RYGB group), highlighting the relevance of patient selection before going for revision [38].

Regarding the comparison with the also emerging OAGB-MGB surgery, a retrospective observational study of a prospectively collected database compared SADI-S/OADS (*n* = 42) with OAGB-MGB (*n* = 49) as a rescue procedure for post-sleeve weight recidivism. Drop in BMI and improvement in obesity-related comorbidities were similar for both procedures, although the percentage of total weight loss (%TWL) was slightly higher in SADI-S/OADS patients (26.4 vs. 21.2, SADI-S/OADS vs. OAGB-MGB, respectively) at 18-month follow-up. The complication rate was slightly lower in the SADI-S/OADS group (19% vs. 27%), but without statistical difference when compared to the OAGB-MGB group. Also, postoperative nutritional deficiencies were comparable in both groups, and no mortality was reported. These similar global outcomes are quite reasonable, since OAGB-MGB is seen as hypoabsortive operation by several bariatric surgeons. If, on the one hand, gastrojejunostomy appears to be technically easier than a duodenoileostomy, preserving the pylorus can prevent side effects such as biliary reflux and dumping syndrome. In addition, the technical design of OAGB-MGB is based on proximal exclusion (usually 200 cm), while SADI-S/OADS is based on distal inclusion (usually 250–300 cm), making the lengths of the afferent and efferent loops very different in some cases. In this study, the efferent loop in SADI-S/OADS group was 250–300 cm in length, and the extent of the exclusion (afferent loop) remained unknown. Conversely, in OAGB-MGB group, the afferent loop was 150–250 cm in length, no matter of the length of the efferent loop. Interestingly, the authors reported two OAGB-MGB patients underwent a second revisional surgery due to WR, specifically the SADI-S/OADS [28].

Another interesting comparison is between planned and unplanned duodenal switch surgery after SG. A retrospective matched study with a minimum follow-up of 2 years (mean of almost 5 years) showed that the staged BPD-DS for management of poor weight loss after SG had similar outcomes regarding weight loss, obesity-related comorbidity control, and complications than primary BPD-DS. Revisional surgery after SG was considered when patients were meeting one of the following criteria: excess weight loss (EWL) less than 50%, weight regain of 25% of EWL, for the management of a potentially reversible comorbidity, or reached a weight plateau at an unsatisfactory level. The same limb lengths were used for one- and two-stage duodenal switch, that is, alimentary limb of 150 cm and common channel of 100 cm. After conversion, an additional 41% EWL and 35% of remission rate for diabetes were obtained in this group of patients, reaching similar rates as primary BPD-DS. Although the loss of a statistically significant difference between EWL rates has been achieved after 2 years of conversion, the weight loss curves of the two procedures equaled at the 81% EWL level at 72 months postoperatively. In this period, data were only available in 28% of the patients who underwent staged BPD-DS. There was no significant difference in protein malnutrition and nutritional deficiency rates between the two groups. Likewise, no significant difference in complication rates was observed between the different approaches, including for the overall complication rate for staged BPD-DS [39].

Similar safety and effectiveness rates also seem to be also applicable when comparing planned and unplanned SADI-S/OADS. A multicenter retrospective study compared ninety-three 2-stage SADI-S/OADS patients, or because of weight loss failure after SG (n = 64; unplanned) or as a surgical strategy for super obesity (BMI > 50 kg/m^2) (n = 29; planned). The time elapsed since SG was predictably shorter in planned than unplanned surgical group (8.9 months vs. 46 months, respectively), and the planned patients were obviously heavier at baseline (48.6 kg/m^2 vs. 40.1 kg/m^2, respectively). Prior to conversion, none of the patients with failed SG had apparent dilation of sleeve seen in the armed assessment; therefore, only the intestinal step was performed in the entire series. After 24 months of the second stage, data on weight loss were available in just over half of the patients (52.9%). Nonetheless, about 65% of EWL was observed in both groups, with no statistically significant difference between planned and unplanned two-stage SADI-S/OADS. Similar rates of resolution of comorbidities and low rates of complications have also been observed [40].

38.6 Summary

The conversion (or second stage) of the SG into duodenal switch surgery, whether by one- or two-anastomosis, appears to be quite safe and provides sustained obesity control. Accordingly, duodenal switch surgery should be considered the natural rescue procedure for a failed sleeve, mainly because the sleeve is already part of the original surgical technical design. The limited acceptance among bariatric surgeons so far may be explained by the feared postoperative side effects of malabsorption and the greater technical demand. In this regard, the promising widespread use of SADI-S/OADS may partially overcome this barrier and increase the accomplishment of duodenal switch surgery as a suitable option for failed SG in the near future.

Key Learning Points

- Both BPD-DS and SADI-S should be naturally seen as following procedure after failed SG, since the sleeve gastrectomy is already part of the original technical design of the duodenal switch surgery. The sleeve can be left untouched in most cases, saving operative time and reducing the rate of sleeve staple-line-related complications.
- Conversion (or second stage) from sleeve to BPD-DS or SADI-S for inadequate weight loss or weight regain seems to have encouraging outcomes in the short- and mid-term. However, robust long-term data is still lacking.
- Unplanned BPD-DS and SADI-S in sleeved patients with failure to control obesity disease appear to be as safe and effective as primary or planned two-stage duodenal switch surgery.
- Despite the consensus among expert surgeons regarding the higher effectiveness of duodenal switch surgery over gastric bypass, the general bariatric community seems more comfortable with gastric bypass as a rescue procedure for failed SG.
- The less technical demand of the one-anastomosis duodenal switch (SADI-S/OADS) can potentially help to increase the acceptance of this technical option by bariatric surgeons in the near future.
- Revision of failed SG to the different modalities of duodenal switch surgeries should preferably be performed by trained and experienced surgeons at referral centers.

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Chapter 39
Gastric Band Revision to Duodenal Switch

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39.1 Introduction

In 1993, Belachew et al. first described the laparoscopic placement of an adjustable gastric band (LAGB). After approval by the FDA in 2001, Lap-Band, a laparoscopic adjustable gastric band (LAGB), became very popular as weight loss procedure across the globe, by the end of the first decade of the century. With the time, the research-proven complications, risks associated with procedure, and limited benefits in the long term are the reason for decline in following decade. Complications encountered after LAGB include band slip, band erosion, complications with the port or tubing and, more often, failure to achieve required weight loss along with resolution of co-morbidities, requiring removal and revision.

Compared with other obesity operations, failure rates for LAGB are reported to be as high as 40–50% with revision rates of 20–30% [1–3]. One such study of Asian population has reported reoperation rate of 25% after LAGB [4]. Inadequate weight loss and surgical complications are main indications for reoperation following primary LAGB. Many options for conversion procedure are available and studied, such as laparoscopic sleeve gastrectomy (LSG), laparoscopic Roux-en-Y gastric bypass (LRYGB) and biliopancreatic diversion with duodenal switch (BPD/DS).

In 1987, DeMeester and colleagues described the duodenal switch procedure (DS), as a surgical resolution for bile reflux, primary or post gastrectomy/gastroduodenostomy. Further, Hess introduced this procedure with Scopinaro's BPD, as restrictive and malabsorptive procedure for morbid obesity by performing 75%

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longitudinal gastrectomy (to reduce acid secretion and to reduce volume) and extension of the Roux limb (to decrease absorption).

Although BPD/DS showed promising results, high technical expertise required to perform laparoscopy and feared metabolic complication (protein-calorie malnutrition and other nutrient deficiencies) due to malabsorptive property of the procedure remain the reason for slow popularity, contrary to LAGB, which gained widespread and speedy popularity.

As a primary bariatric procedure when combined. BPD/DS) is the most effective procedure concerning the mean percentage of excess weight loss (70%) and decrease in obesity-related co-morbidities (80%) [5–8]. The results of conversion after LAGB failure have been studied by different authors. A study of laparoscopic revision from Lap-Band to duodenal switch showed that it is a safe and more effective alternative to gastric bypass who have failed Lap-Band procedure [9], whereas another such study concluded that weight reduction was not more beneficial than with laparoscopic RYGB, although procedure-specific nutritional problems were more common after BPD/DS [10]. This chapter aims to share our data outcomes and experience of BPD/DS as a revision procedure after failed LAGB as primary procedure.

39.2 Materials and Methods

At our centre, post LAGB, revision procedures were considered for patients who had failed to attain 25% excess weight loss (%EWL) at the end of 3 years. Patients who had complications related to band were excluded from the study. Patients who were not operated at our centre, but presented with failure after LAGB, were also included in this study.

The BPD/DS was chosen as a revision procedure, after discussion with patients, because it shows promising results in terms of weight reduction and resolution of obesity-related co-morbidities.

All patients were evaluated preoperatively and postoperatively by the multidisciplinary team (nutritionists, endocrinologist, surgeons, physician, pulmonologist, anaesthetist and psychiatrist).

Factors that were taken into account for deciding BPD/DS as a revisional procedure were age of the patient, BMI at the time of the primary procedure (i.e. gastric banding), related co-morbidities, absence or presence of a large hiatal hernia, the ability to take multivitamin and mineral supplements on a long-term basis and having type 2 diabetes mellitus with C-peptide levels below 3 or history of diabetes more than 10 years.

39.3 Preoperative Preparation

Patients were assessed for pre-LAGB BMI and associated co-morbidities. Post LAGB nadir weight loss achieved BMI Prior to revision. All patients received counselling for success rate of revisional procedure and their compliance post BPD-DS. Along with blood screening, plain radiographs and contrast studies of the upper abdomen were done, and we performed intra-op upper GI endoscopies with carbon dioxide for insufflations. Deep vein thrombosis (DVT) prophylaxes were given to all patients, as a routine protocol, either in the form of compression stockings, DVT pumps and low molecular weight heparin.

39.4 Surgical Technique

The technique starts with band removal involving full dissection of the band. Mobilization of greater curvature of the stomach starts first towards OGJ. The mobilization continues further down to the gastroduodenal artery or 3 cm from the pylorus (whichever comes first). In order to avoid any bleeding or tears, meticulous and careful dissection is necessary around the duodenum. After mobilization, the duodenum is transected using a stapling device. After the transection procedure, it continues with gastric resection to create a loose sleeve with the bougie size 38 and over. The common limb (CL) measurement starts at the ileocecal junction without stretching the bowel. A suture marker is placed at 350 cm, indicating what is to become the CL. The small bowel is transected using a linear cutter stapler 150 cm from the ligament of Treitz indicating BP limb. The mesentery is partially divided with the harmonic scalpel. The biliopancreatic limb (BPL) and AL are joined by a side-to-end anastomosis at the 350 cm marker. Now an alimentary limb is brought up for hand-sewn duodeno-ileal anastomosis. Hernial spaces are closed.

39.5 Results

Nine patients underwent BPD/DS) after unsuccessful LAGB was 3 years. Mean age was 44.3 ± 3.4 years (range, 25–62), with 22.2% men. Their pre-LAGB mean weight was 132 ± 4.5 and mean preoperative BMI was 51.4 ± 4.3 kg/m^2 (Table 39.1), and the mean excess weight was 63 ± 13 kg. The pre-BPD/DS mean body weight was 125 ± 19 kg, the mean BMI was 47.1 ± 6 kg/m^2, and the excess weight was 58 ± 12 kg. Two patients (22.2%) were lost to follow-up. The number of patients with complete follow-up at 6 six years was seven patients. The reasons for the loss to follow-up were migration for one and unknown for one patient.

The primary endpoint was the mean %EWL as a measure of the efficacy of BPD/DS after LAGB failure. Concurrently, the BMI decreased from 42.5 ± 6 kg/m^2 to 30 ± 4.9 kg/m^2 in 6 years. The initial mean body weight before LAGB was

Table 39.1 Demographic data

	Characteristic
Age (years)	44.3 ± 3.4
Gender M:F	9 (77.8%): 2 (22.2%)
Weight (kg)	132 ± 4.5
BMI (kg/m^2)	47.1 ± 6

132 ± 4.5 kg and had decreased to 125 ± 19 kg after LAGB, for a %EWL of 18%. The body weight decreased further after BPD/DS to 89.5 ± 11 kg after 6 years (Fig. 39.1). The total weight loss calculated from the period before BPD/DS to years after BPD/DS was 35.5 kg and corresponded to an additional %EWL of 55%. After LAGB and subsequent band removal plus BPD/DS resulted in a total weight loss of 42.5 kg with a %EWL of 71.2% (52.2%, 61.5%, 75.3%, 74.4%, 72.3% and 71.2% at six, respectively shown in Fig. 39.2). These results show that patients unsuccessfully treated with LAGB still responded well to BPD/DS.

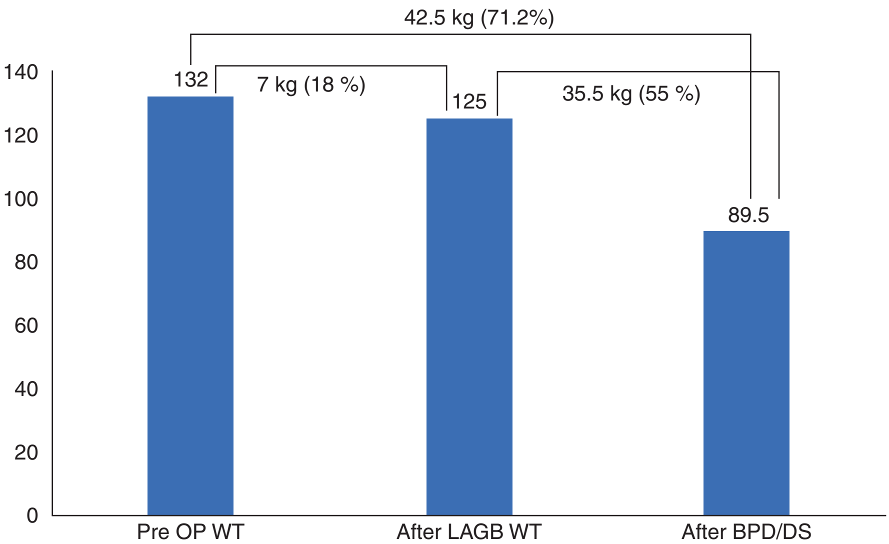

Fig. 39.1 Weight loss pattern (after LAGB and after BDP/DS)

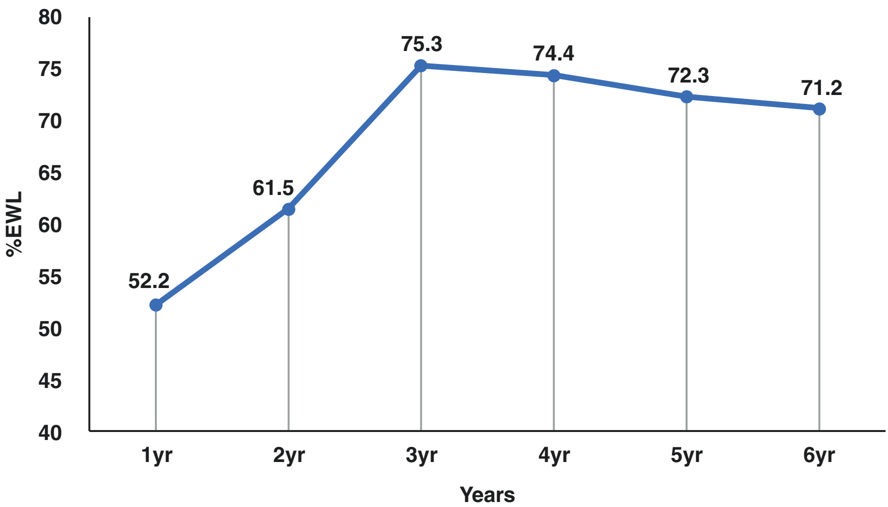

Fig. 39.2 After BPD/DS %EWL pattern

Table 39.2 Co-morbidities

	Pre-OP	LAGB		BPD/DS	
	N	*N*	Resolution of co-morbidities	*N*	Resolution of co-morbidities
T2D	3	1	2 (66%)	3	100%
HTN	4	2	2 (50%)	3	2 (66.6%)
OSA	7	5	5 (71%)	7	100%
DLS	6	5	5 (83.3%)	5	4 (80%)
OA	6	3	3 (50%)	4	2 (50%)

Preoperatively, 33.3% ($n = 3$) had diabetes, 44.4% ($n = 4$) had hypertension, 77.7% ($n = 7$) had OSA, and 66.6% ($n = 6$) had dyslipidaemia and OA. Weight reduction after post-LAGB and BPD/DS, however, showed a clear tendency towards a reduction in co-morbidities (Table 39.2).

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Chapter 40
Endoscopic Treatment of Weight Regain in Duodenal Switch

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40.1 Introduction

Obesity is a complex multisystemic disease with negative health implications, being associated with comorbidities such as type 2 diabetes mellitus (DM2), arterial hypertension, cardiac diseases, asthma, and obstructive sleep apnea, being the fifth risk factor for mortality in the world [1].

Lifestyle and dietary changes are ineffective in controlling obesity in the long term, and bariatric surgery (BS) is more effective in maintaining weight loss [1]. However, a degree of weight regain (WR) is common after patients reach their lowest weight, with up to 20–25% of them facing an important struggle with WR after surgery—with loss of quality of life and return of associated comorbidities. Despite this, insufficient weight loss (IWL) is more frequent in the indication of revision surgeries [2].

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It is essential to define the difference between WR and IWL. IWL occurs when the loss of excess weight (% EWL) is less than 50% in the 18 months after BS. Weight regain is the progressive weight gain that happens after an initial weight loss success. However, there is no consensus on these definitions, and further studies are needed to more uniformly delineate the clinical significance of WR, indicating when an intervention would become necessary [2].

Among the several BS available, biliopancreatic deviation (BPD) is considered the most effective, producing marked weight loss and reducing associated comorbidities [1].

Biliopancreatic diversion (BPD) and biliopancreatic diversion with duodenal switch (BPD-DS) are bariatric surgeries used effectively in morbid obesity and metabolic disorders composed of a restrictive and a disabsorptive mechanism. However, they are techniques with prolonged operative time and a high rate of postoperative complications [3]. BPD was designed to be performed in a single step to decrease the absorption of fats in a long-lasting manner, avoiding weight regain. In BPD-DS, distal gastric resection was replaced by a vertical sleeve with preservation of the pylorus, reducing possible side effects, such as rapid emptying. In the early days, surgery was considered difficult to be performed in a single stage in very obese patients, leading doctors to perform it in two stages, initially with resection of the gastric sleeve without making the anastomosis, a technique that became popular. Marceau et al. compared separate components of BPD-DS, including 48 DS and 53 vertical gastrectomies, studying the role of each component of the BPD-DS, and concluded that each step contributes independently to a metabolic improvement [4]. BPD-DS preserves the antrum and pylorus, in addition to the first part of the duodenum, avoiding initial complications associated with Scopinaro surgery such as marginal ulcers, vomiting, diarrhea, and micronutrient deficiency [1].

To simplify the BPD-DS, in 2007, the single-anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) was created, a technique with a single anastomosis but maintaining the results and principles of the BPD-DS [3]. A non-randomized study that followed the results of patients undergoing BPD-DS or SADI-S for 2 years demonstrated similar rates of diabetes remission, with similar metabolic improvement and weight loss [3].

The rate of weight regain is low in these procedures, as they have a disabsorptive component that is very difficult to circumvent. However, over time, intestinal adaptation can increase the absorption of carbohydrates with villous hypertrophy. However, the cumulative incidence for IWL is very low compared to other techniques. Strain et al. evaluated 284 patients undergoing BPD-DS, and after 9 years of surgery, about 10.9% had IWL, with a rate of 2.2% in the first year of follow-up [5]. The reasons for a new weight gain involve investigating psychological and nutritional issues, alcohol consumption, and new habits on the part of patients. This context results in obesity but with nutritional complications, especially in the overweight [6].

Revisionary surgery in those with inadequate weight loss undergoing BPD-DS is controversial, and there is no consensus on whether the joint loop should be reduced or the volume of the gastric pouch. Due to the difficulty of revising the distal anastomosis, one option is to reduce the volume of the gastric sleeve. The revision of the common loop length can lead to weight loss, however, at the expense of poor protein nutrition. Weight loss may not occur and still cause complications. Studies of weight regain in BPD-DS are scarce because, often, the performance of revision surgery occurs due to protein malnutrition and excessive weight loss. Despite this, Gagner et al. reported a case of revision surgery in a 47-year-old morbidly obese woman (BMI = 67 kg/m^2) who had undergone a laparoscopic BPD-DS, losing 80% of her excess weight, with a resolution of several comorbidities after 17 months. However, she regained weight after this period (BMI = 29 kg/m^2). After finding a dilated pouch in a contrast examination, she underwent revision surgery to create a new gastric sleeve with a 60 F bougie. The patient evolved with weight loss, maintaining a BMI of 22 kg/m^2 and 61 kg, 10 months after revision surgery, without postoperative complications [7].

Revision surgery is helpful in patients with insufficient weight loss and those with weight regain, but it can be a difficult task [8]. *Endoscopic sleeve gastroplasty (ESG)* is a minimally invasive procedure that arises in this context and may be a less invasive therapeutic alternative to reduce gastric pouch. Laparoscopic re-suture is a valid option after an initial failure in LSG, and further studies are needed to analyze the efficacy of the endoscopic technique and its importance in cases of WR associated with DS and SADI-S.

Topart and Becouarn, in a literature review, found sparse literature correlating WR with BPD and BPD-DS, probably due to the low incidence of this adverse event, with rates of 0.5–2.78% in BPD. In revision surgery, there is no consensus on the size of the common loop. However, the common loop can be shortened as an option, resulting in a smaller loop in contact with the ingested food or a reduction in the gastric pouch [9].

Nedelcu et al. analyzed 61 patients who underwent laparoscopic re-sleeve after a mean interval of 37.5 months after the primary laparoscopic sleeve. Patients were selected due to insufficient weight loss (28 patients), weight regain (29 patients), and gastroesophageal reflux disease (GERD) (4 patients). The re-sleeve was proposed after volumetric analysis of the gastric pouch, with cases of primary dilation (dilated pouch in barium examination) and secondary (residual volume above 250 mL after volumetric computed tomography study) being selected. All were submitted to laparoscopic re-sleeve without intraoperative complications. The average BMI decreased from 39.4 kg/m^2 to 29.2 kg/m^2, with an average percentage of excess weight loss (% EWL) of 58.3% ($P < 0.0004$) [10].

In patients already submitted to previous LSG, reLSG can be indicated when the CT scan volume method demonstrates a volume greater than 250 cm^3 of the remaining stomach. In smaller volumes, malabsorptive surgeries are indicated [11]. Thus, in cases of BPD-DS and SAID-S, although there is no consensus, in the future, this volumetric measure could guide the indications for endoscopic suture in the control of WR.

In a multicenter international cohort evaluated in 9 services, from 2014 to 2019, Maselli et al. evaluated the data of 82 patients with weight regain after LSG who underwent a revision endoscopic sleeve gastroplasty (R-ESG) with an OverStitch device (Apollo Endosurgery, Austin, Texas, USA). Of the sample, 92.7% were women with an average age of 42.8 years and an average weight of 128.5 kg (±57.5 kg). The average number of sutures performed was four. After re-suturing, the TBWL rate was 6.6%, 3.2% of which in the first month, with 10% TBWL being reached in 72.5% of the patients. Thus, it is concluded that R-ESG can assist in WR after LSG before choosing more invasive revision surgeries [12].

In a prospective study by Neto et al., 233 patients from 4 bariatric centers in Brazil, submitted to ESG using OverStitch, with grade I and II obesity, were evaluated for post-procedure weight loss, resulting in a 17.1% TWL in 6 months and 19.7% in 12 months [13].

In ESG, the endoscope is introduced to assess the dilated areas of the remaining stomach, outlining the site to be sutured. The OverStitch system (Apollo Endosurgery, Austin, Texas, USA) is then coupled to a double-channel endoscope. The suture starts at the anterior wall, at the level of the anterior notch. Sutures start from the distal body at the angular incisure to the proximal body. The procedure is performed with the patient under general anesthesia [12, 13].

40.2 Conclusion

Weight regaining is not frequent in surgeries with a disabsorptive component such as BPD, BPD-DS, and SADI-S because the disabsorption component is challenging to transpose. However, even at low rates, it deserves attention and studies to find the best treatments.

ESG appears as an option in cases of remaining dilated stomachs, which may contribute to the treatment of weight regain. It is a feasible alternative to revision surgery, being a less invasive technique, avoiding new changes in the intestinal loops already reorganized.

Further studies are needed to reach a consensus on the definitions of IWL and WR—necessary to guide the diagnosis and better conduct in the presence of these complaints in the postoperative period of bariatric surgeries.

Despite the weight regain, which occurs mainly in superobese, these patients, because they have a disabsorptive component as a component of the bariatric surgery performed, may be at the same time obese due to a caloric increase ingest however with a lack of essential nutrients, which may result in patients with high weight but with nutritional problems. Thus, the investigation of psychological causes, multidisciplinary assessment, and nutritional monitoring are fundamental in the desired treatment.

ESG comes as a promising technology in cases of weight regains in disabsorptive surgeries. Studies involving the technique in the cases of WR and IWL of these surgeries should be carried out to evaluate the benefits of this therapeutic choice.

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Chapter 41
Conversion of Gastric Bypass to Duodenal Switch

Gary Aghazarian, Romulo Lind, and Andre Teixeira

41.1 Introduction

The most common bariatric procedure in 2013 was the Roux-en-Y gastric bypass (RYGB); however, there is a trend in reducing its proportion worldwide, while sleeve gastrectomy is rising [1]. Due to its wide use and rates of weight regain or insufficient weight loss, RYGB patients with failure of treatment can become even more common over the next several years. For this reason, bariatric surgeons should know how to correctly evaluate and treat these patients.

41.2 Gastric Bypass Failure

The most commonly used criterion for failure is an excess weight loss lower than 50%, although there is no uniform or internationally recognized definition for what constitutes failure of bariatric surgery. Some authors described failure of the procedure based on weight regain or an inadequate excess weight loss. The recurrence of comorbidities can indicate a failure of surgery [1]. This theory can hold true even in patients who present an adequate excess weight loss (EWL). Several studies have shown rates of up to 54% failure to lose weight or weight recidivism. RYGB patients can have 23% of weight regain from nadir weight [2]. Therefore, the necessity of reoperation is based upon inadequate excess weight loss, weight regain, and/or lack of comorbidity improvement.

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41.3 Surgical Options

There are many surgical options described including banding, gastric pouch revision, gastrojejunal anastomosis revision, conversion to distal gastric bypass, and endoscopic revision. Conversion to biliopancreatic diversion with duodenal switch (BPD-DS) is an alternative to get the best long-term weight loss and control of comorbidities [1]. This procedure is complex and technically challenging due to the several steps required to accomplish the surgery. As described in detail below, the surgeon must take down the gastrojejunostomy, reestablish the gastrogastric continuity, perform the sleeve gastrectomy, reverse the jejunojejunostomy, and complete the duodenal switch. The procedure can be done in a single- or two-step manner [3].

41.4 Surgical Treatment

Using the da Vinci Xi robotic platform, this procedure is performed using the following trocars placed along the same transverse axis: 8 mm at the right midaxillary line, 12 mm at the right midclavicular line, 8 mm superior to the umbilicus, 12 mm at the left midclavicular line, and 8 mm at the left midaxillary line. A 5 mm trocar is entered at the subxiphoid area for placement of a liver retractor.

With the patient in the Trendelenburg position, running the small intestine approximately 250 cm from the ileocecal valve, the surgeon will mark this point of the ileum with a Vicryl stitch. The small intestine just proximal to this suture is then marked with a skin marker. Prior to docking the robot, the patient is placed in reverse Trendelenburg position. The robot is then docked at the patient’s side.

41.4.1 Part 1: Gastrogastrostomy Creation

First attention is directed at the gastrojejunostomy. Adhesions are taken down to clearly identify the gastric pouch, gastric remnant, and alimentary (Roux) limb of the gastric bypass. Using a linear stapler, the Roux limb is transected at the gastrojejunostomy. A side-to-side anastomosis is made between the gastric pouch and gastric remnant using a linear stapler in order to restore the normal anatomy of the stomach. If the tissue is too thick for the stapler, a hand-sewn anastomosis in a two-layer fashion will be warranted. After creation of the stapled anastomosis, the common gastrostomy is closed with a running absorbable suture in a one- or two-layer fashion. A 40 French (F) ViSiGi tube is passed through the anastomosis to ensure it is not too tight.

41.4.2 Part 2: Sleeve Gastrectomy

Using the bipolar vessel sealer energy device, the greater curvature of the stomach is devascularized and mobilized approximately 4–6 cm from the pylorus superiorly to the left crus of the diaphragm. After mobilization, the 40 F ViSiGi tube is passed into the antrum in order to guide gastric division. If a hiatal hernia is noted during the procedure, repair is indicated to reduce postoperative gastroesophageal reflux and retained elements of the stomach leading to impaired weight loss. Creation of the gastric sleeve utilizes a thick tissue cartridge with a linear stapler. Stapling must be conducted in the same horizontal plane to avoid functional obstruction caused by a spiral-sleeve contour. Stapling along the bougie should not be overly tight, as improper staple firing may occur. The stapling will begin 4–6 cm above the pylorus to spare much of the antrum. The stapling should be performed approximately 1 cm away from the bougie to create a sleeve that is not as tight as a traditional sleeve gastrectomy. The duodenal switch patient will endure both restriction from the sleeve and malabsorption from the switch component. A “looser” sleeve will help to ensure that these patients do not become malnourished from providing too much restriction.

41.4.3 Part 3: Reversal of Jejunojejunostomy

The previous jejunojejunostomy is divided using the linear stapler. The distal end of the biliopancreatic limb is reconnected to the proximal end of the gastric bypass Roux limb. This anastomosis is performed in a side-to-side fashion [3]. The common enterotomy is closed via stapler or with an absorbable suture.

41.4.4 Part 4: Duodenoileostomy Creation

Duodenal Transection: Excessive visceral fat may complicate the dissection, and bleeding can blur the tissue planes. Due to this, the duodenal transection can be technically demanding; however, it is critical to minimize excessive duodenal devascularization and injury to the duodenum and pancreas. With lateral retraction of the antrum to linearize the first portion of the duodenum, free the peritoneum on the inferior and superior portions of the duodenum, until the duodenum fuses posteriorly with the pancreas. A curved instrument such as the tip-up fenestrated grasper can be used to create this retroduodenal tunnel. After the tunnel is created, a Penrose drain can be placed around the duodenum to help aid with exposure. Posteriorly through this window, a stapler cartridge can be applied while avoiding the gastroduodenal artery. The duodenal stump staple line is inspected for bleeding and/or poor perfusion. Reinforcement of the staple line usually is not necessary unless there is any concern for healing.

Duodenoileostomy Creation: The ileum marked at 250 cm from the terminal ileum is brought superiorly to the first portion of the transected duodenum. If there appears to be too much tension in reaching this point, the greater omentum can be opened toward the patient's right, allowing the ileum to be connected with the duodenum. If significant tension still remains on the alimentary limb, it can be brought through a mesocolic window opposed to the omental window. Using an absorbable suture, the ileum is lined up to the duodenum by creating the posterior outer row of the anastomosis.

The duodenoileostomy anastomosis may be implemented with many techniques; understanding each technique allows for surgical flexibility depending on differing anatomy. The techniques include hand-sewn technique and linear stapler technique. If the procedure were to be done via the laparoscopic approach, a third technique is available utilizing the circular stapler, which is detailed in Chap. 28.

The hand-sewn technique constructs more consistent sizing of anastomosis than either technique involving stapler use. Enterotomies are made along the entire length of the duodenum and ileum using the robotic scissors with monopolar energy. The inner layer of the anastomosis is created with an absorbable suture starting with the inner posterior row. The inner layer is completed with anterior closure. The suture from the posterior outer layer may be run along the anterior aspect of the connection to complete the two-layer anastomosis. The ViSiGi tube is passed into the antrum of the stomach with administration of methylene blue dye and air to test the anastomosis for leak or stricture.

In the linear staple technique, an enterotomy is made in the ileum and duodenum. A stapler is inserted, but due to difficult alignment of the stapler to form the anastomosis, two firings are often necessary. Lastly, the common enterotomy is hand-sewn closed. Due to these angulation challenges, there is inconsistency in the size and shape of anastomosis with this method.

Alimentary Limb Creation: Using the linear stapler, the ileum just proximal to the anastomosis is transected along with a portion of its mesentery to prevent undue tension on the duodenoileostomy. The alimentary limb is then counted for 125 cm starting proximally at the duodenoileostomy toward the terminal ileum. At the 125 cm mark, a suture is used to approximate the alimentary limb to the distal biliopancreatic limb for creation of the ileoileostomy.

41.4.5 Part 5: Ileoileostomy Creation

A second suture may be placed between the alimentary and biliopancreatic limb to aid with insertion of the linear stapler. Using the robotic scissors with monopolar energy, small enterotomies are made in each limb. A linear stapler is inserted to create a side-to-side functional end-to-side anastomosis. The common enterotomy is closed using a single-layer stitch to avoid narrowing of the anastomosis. Lastly, the mesenteric defect is closed.

41.4.6 Part 6: Surgery Completion

The robotic instruments are removed, and the robot is undocked from the patient's side. The abdomen is irrigated and suctioned dry. A drain is placed near the duodenal dissection and duodenal stump. The sleeve gastrectomy specimen is delivered from the abdomen; the fascia at the 12 mm ports and skin incisions are closed.

41.5 Postoperative Care

Telemetry and the use of continuous pulse oximetry can aid in the detection of early postoperative complications. Patients are NPO with IV fluid administration until the following morning. Patients should be placed on chemoprophylaxis for venothromboembolism and should ambulate within 4 h of the surgery. Patients with obstructive sleep apnea should utilize their at-home airway device to maintain patency. Spirometry and other respiratory therapy may be utilized to decrease incidence of pneumonia and atelectasis following surgery [4].

An upper gastrointestinal study is performed on postoperative day 1. A drain amylase level is sent to assess for pancreatic injury. If both these studies are within normal limits, the patient may be started on a phase one bariatric diet.

Many patients may be discharged on the second to third postoperative day. Others, especially those with longer, more extensive procedures, may require an extended stay. The patients may have less predictable comorbidities. For 2 weeks following the operation, patients will stay on a puree diet and transition to solid foods over the course of one month.

For 2 weeks after surgery, patients are instructed to take Eliquis 2.5 mg twice daily for prophylaxis against portal vein and lower extremity deep vein thrombosis.

For one month after surgery, patients are instructed to take:

- Proton pump inhibitor
- Multivitamin with iron
- Vitamin D
- Calcium citrate
- B complex vitamin
- 80–90 g of protein daily (as a liquid)
- Vitamin A (indefinitely)

These patients are followed regularly in the office with laboratory blood work at the 3-month, 6-month, and 1-year postoperative mark. Depending on the patient condition and any vitamin/nutritional deficiencies, the follow-up period can be extended to every 6 months to 1 year thereafter.

41.6 One Stage Vs. Two Stage

As with any extensive procedure, the patient must be able to withstand the stress of the operation from a physiological standpoint. There are several factors that should persuade a surgeon to perform the conversion in a one-stage versus two-stage operation. Preoperatively, if the patient has any signs of physiologic compromise (coronary artery disease, pulmonary disease, chronic renal failure, etc.), they may be better suited to undergo the conversion in two stages.

Intraoperatively, there are many factors that can weigh into this decision. If the gastric pouch is less than 4 cm in size, these patients are at an increased risk of gastrogastric anastomotic leak. For this reason, the surgeon should complete up to part 2 (sleeve gastrectomy) or part 3 (reversal of jejunojejunostomy) and complete the second stage at a later date, usually 3–6 months postoperatively. Other intraoperative factors that may persuade toward a two-stage operation are listed below:

- Physiological compromise in the patient
- Patients unlikely to tolerate prolonged general anesthesia
- Presence of adhesions
- Hepatomegaly
- Liver cirrhosis
- Torque on instruments [5]

41.7 Traditional Vs. Single Anastomosis

Revision to BPD-DS (traditional duodenal switch) can be done in one or two stages and involves four anastomoses: gastrogastrostomy, duodenoileostomy, ileoileostomy, and jejunojejunostomy (to reconnect the old Roux limb) [6]. The single-anastomosis duodenal-ileal bypass (SADI-S) was introduced by Sanchez-Pernaute et al. in 2007 [7]. The reason for this modification was to eliminate the distal ileoileal anastomosis. The rationale for removing this portion of the procedure was to decrease the operative time as well as the added risk for leak, obstruction, or internal hernia through the newly created mesenteric defect. Several reports with up to 5 years of follow-up have demonstrated the safety and efficacy of this procedure [8].

However, the SADI-S has not been universally embraced. As of March 2020, the American Society for Metabolic and Bariatric Surgery (ASMBS) updated its stance on the single-anastomosis duodenal switch stating "…the ASMBS has reached the conclusion that SADI-S provides similar outcomes to those reported after classic

DS and should therefore be endorsed…." Upon this review, the committee found that the currently available peer-reviewed literature did not suggest outcomes that will differ substantially from those seen with the classic DS [9].

Moon et al. (2019) found evidence to suggest that conversion to BPD-DS may result in faster weight loss than conversion to a SADI-S, but both procedures provided significant additional weight loss after conversion from RYGB [10]. For this reason, it is imperative for the bariatric surgeon to consider the SADI-S as a legitimate procedure for conversion from gastric bypass. This especially holds true when operative times are prolonged. As stated above, there may be an overall benefit to only performing three anastomoses (gastrogastrostomy, duodenoileostomy, and jejunojejunostomy) as opposed to four for which further research is warranted.

41.8 Results

Due to the complexity of the conversion of the RYGB to SADI-S and BPD-DS, the procedure is not commonly performed. For this reason, the research is limited in the safety and efficaciousness of the conversion. Parikh et al. (2007) demonstrated dramatic weight loss after revision, with EWL of 62.7%, overall mean weight loss of 35.5 kg, and mean BMI decrease of 10.5 kg/m^2. The comorbidities resolved completely in all patients, and no mortality or reoperation for leakage or malnutrition was reported [7]. The sample size for this study included 12 patients for analysis.

Halawani et al. (2017) demonstrated a mean EWL of 64.1% and mean BMI decrease of 9.8 kg/m^2. Their results indicated that conversion of failed RYGB to BPD-DS is laparoscopically or robotically safe and effective [11]. This retrospective chart review included nine patients.

41.9 Conclusions

The conversion from RYGB to duodenal switch is a feasible surgery. With careful patient and procedure selection, great excess weight loss and improvement of comorbidities can be obtained. However, it has not gained wide acceptance due to the complexity of the procedure and the concern for long-term severe malnutrition. Further research is warranted to better understand the long-term effects of this conversion.

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Chapter 42
Management of Duodenal Stump Blowout

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42.1 Introduction

Duodenal switch has been shown to provide the highest excess body weight loss of all bariatric surgeries, but along with these benefits comes increased risk of perioperative complications including duodenal stump blowout (DSB) [1]. DSB is an infrequent but potentially disastrous complication after duodenal switch which involves loss of integrity of the closure of the duodenal stump. It can lead to severe diffuse inflammation in the peritoneal cavity and global sepsis if not treated promptly. There are multiple treatment options for stump blowout depending on the severity of the leakage and inflammation present. These include a conservative management strategy with antibiotics and parenteral nutrition or invasive management including percutaneous drain placement and surgical reoperation.

42.2 Presentation of Stump Blowout

DSB can occur in any operation involving creation of a duodenal stump, such as gastrectomy or duodenal switch. Patients typically present with vague symptoms such as tachycardia, nausea, vomiting, fatigue, and abdominal pain. The abdominal pain can vary in location and severity with no pathopneumonic pattern. On physical exam, the patient's abdomen may be distended, tympanic, and tender. There may be signs of peritonitis such as rebound tenderness, rigidity, and guarding. The patient may also show signs of dehydration or anemia if there has been recurrent emesis or associated hemoperitoneum [2, 3]. If the patient has a surgical drain, there may be

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bilious drainage observed which can be seen in the color of the output or determined via laboratory analysis. Findings consistent with bile include elevated bilirubin and amylase from the drain fluid. One cohort study of DSB found a median time of diagnosis of 13 days with the longest time to diagnosis being postoperative day 75 [4]. Therefore, a high index of suspicion should be maintained with any patient who has had a recent creation of a duodenal stump.

42.3 Diagnosis of a Blowout

Diagnosis of DSB is most commonly accomplished with a combination of clinical signs, laboratory studies, and cross-sectional imaging. Laboratory studies are nonspecific but may show electrolyte abnormalities, anemia, and leukocytosis. Commonly utilized imaging modalities include X-rays or CT scan with or without IV or PO contrast. Plain films may show signs of small bowel obstruction, oral contrast extravasation, or presence of a fistula. Abdominal CT may show inflammation around the duodenal stump and/or a fluid collection (Fig. 42.1); aspiration or drainage of the peritoneal fluid will demonstrate

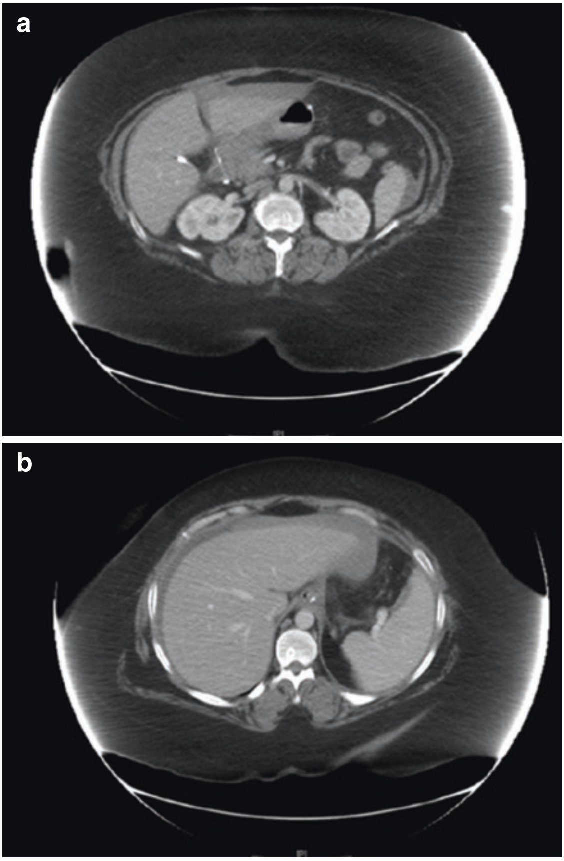

Fig. 42.1 Representative CT (**a**, **b**) showing inflammation around the duodenal stump and peritoneal fluid collection in a case of DSB after duodenal switch. (From Nelson et al. 2015)

bilious contents. Less commonly, exploratory laparotomy can be used to make the diagnosis of DSB, but the authors recommend against this in clinically stable patients. Diagnostic surgical exploration can be performed if clinical suspicion remains high or the patient is clinically unstable or declining. Significant inflammation around the duodenal stump can make surgical diagnosis difficult, and multiple explorations may be necessary if clinical status continues to decline [2–4].

42.4 General Management of a Stump Blowout

Identification and understanding of techniques to manage duodenal stump blowout is a key factor in the effective treatment of these patients. Once the diagnosis of DSB is made, it is imperative to promptly intervene. It is important to provide IV fluids, electrolyte replacement, and supplementary nutritional support and begin drainage as early as possible [5]. This is important because early detection of duodenal stump blowout, through identification of presenting signs and symptoms of the condition, can greatly improve the management outcomes of these patients [4]. Figure 42.2 provides a general algorithm in patients with post-gastrectomy

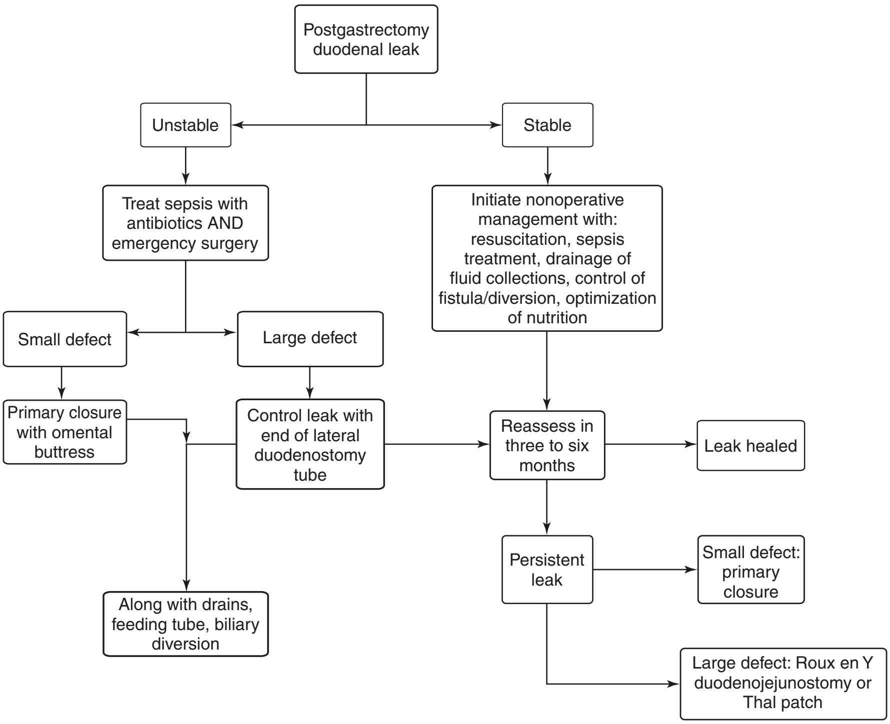

Fig. 42.2 General management flowchart algorithm for patient with a post-gastrectomy duodenal leak

duodenal leakage, a phenomenon that can be synonymous with DSB. Aside from conservative measures, there are a multitude of approaches to manage and treat duodenal stump blowout, depending on the condition of the patient and severity of the DSB. In this section, we will discuss when to utilize each approach, summarize each technique, and present possible problems associated with each type of management.

42.5 Conservative Management

Conservative management consists of starting broad-spectrum antibiotics and parenteral nutrition early in the patient's course in addition to percutaneous drainage using a tube duodenostomy [3]. It is generally the preferred approach in stable patients and should be implemented immediately after a diagnosis of DSB is made unless other serious secondary complications are present such as sepsis, bleeding, or undrained abscesses [4]. When utilizing a percutaneous drain, the conservative approach led to resolution of leakage in 92.3% of patients with a healing time ranging from 17 to 71 days [6]. If the conservative approach fails or serious secondary complications are present, then the surgical approach should be considered [6].

42.6 Percutaneous Approach

The percutaneous approach is typically coupled with the conservative approach, but it can also be coupled with a surgical approach after an operation to repair a leaking duodenal stump. Percutaneous drainage can involve drainage of abscesses or be utilized as a duodenostomy. It is most useful if the conservative approach fails and a re-laparotomy is impossible while also being an effective method to control postoperative infection [6]. Not only can percutaneous drains be utilized as a drainage method but they can also be utilized to lead to stoma formation in the perforated site of the stump which leads to spontaneous closure of the DSB [7].

While radiology can be utilized to place drains postoperatively, another simple method of drainage is Foley catheters. One study examined the utilization of Foley catheters as drains after DSB and found some advantages such as allowing early oral intake by preventing additional leakage via filling of the Foley catheter balloon with a reduction in the duration of hospitalization [7]. To utilize a Foley catheter, first a pigtail catheter is inserted for initial drainage of the DSB fluid; once the size of the fluid cavity is reduced and the fistula tract is opacified, then a Foley catheter is inserted to close the fistula tract. Requirements necessary for successful Foley catheter usage are sufficient length of time needed for pigtail catheter drainage before Foley catheter insertion and Foley catheter removal only after the enterocutaneous fistula tract has completely matured [7]. The optimal amount of time needed with pigtail drainage prior to Foley catheter placement is currently unknown.

Patients who might benefit most from this approach include those with severe adhesion, frozen abdomen, carcinomatosis peritonei, or obesity [7].

A combination of the conservative and percutaneous approaches can be used for 4–6 weeks prior to pursuing a surgical strategy. This should be guided by the condition of the patient as if they are not improving or worsening, surgical intervention may need to be approached sooner [6].

42.7 Surgical Management

Surgical management of DSB can involve draining, closing, or resecting the blowout, and it is most frequently utilized in patients with more severe conditions. Some of these include diffuse peritonitis, intra-abdominal hemorrhage, major wound disruption, bleeding duodenal ulcer, and abdominal compartment syndrome [4, 7]. The need for reoperation is associated with higher mortality and requiring longer ICU care, but this may be due to the patients already being in critical condition when the operation occurs [4]. Reoperation may also be ineffective if done soon after the first operation because of postoperative edema, inflammation, and dense adhesion [7]. The exact surgical procedure that can be implemented depends on the size of the leak, extent of the abscess, and status of the patient [3].

The most common procedure is an exploratory laparotomy which allows for examination of the abdomen in combination with drainage, closure, or resection of the duodenal stump [3]. Currently, a large series comparing these interventions are lacking, and no preferred intervention is known. Therefore, clinical judgment at the time of operation is of utmost importance in each case.

Drainage is one of the possible avenues to explore when assessing treatment for a DSB. One example is the usage of a Malecot catheter for control of a DSB. A 20 F Malecot catheter can be inserted into the duodenum and over-sewn with a purse-string suture, in situations where inflammation is present, for drainage of a blowout and decompression of the lumen [8]. Other types of drains may be used as well. The key to surgical drainage procedures is examination of the entirety of the abdomen with adequate washout and wide drainage of the blowout. Closure can be attempted as well at the time of surgical exploration but is generally inadvisable as sutures may not hold due to surgical inflammation and edema. Some have suggested that staples should be utilized instead of sutures for closure [5]. However, the authors would caution that tissue flaps, sutures, and staples are difficult to utilize in this patient population due to the inability of these friable tissues to hold these repairs. In this scenario, the goal should be source control and washout, without definitive repair.

Resection is another surgical strategy to manage a blown duodenal stump and can be performed if there is irreversible damage to the distal resection point of the duodenum in cases such as gastric cancer. However, the remaining tissue is at risk for tissue breakdown and poor healing due to surrounding inflammation [2]. To perform a duodenal resection, an extended Kocher maneuver is performed with detachment of the first and proximal second part of the duodenum from the pancreatic head through ligating small vessels and fibrous connections [2]. After the surgical procedure is done, it is recommended to lower the intraluminal pressures in the duodenal stump through retrograde decompression via tube duodenostomy [2, 3]. Triple tube drainage composed of a tube gastrotomy, retrograde tube duodenostomy, and feeding jejunostomy, typically performed after duodenal perforation, can also provide extra damage control of the affected area by providing diversion and decompression of all enteric secretions in cases of DSB [9]. In patients who are not fully treated at their primary laparotomy, re-exploration and washout can be performed [3]. Re-exploration may be most useful in patients with a large amount of peritoneal contamination or who developed abdominal compartment syndrome. Again, the authors recommend washout, drainage, and time over a resection or an attempted repair of the injury.

42.8 Special Considerations in Duodenal Switch

Bariatric patients present specific difficulties in both the diagnosis and management of DSB. Due to their size, cross-sectional imaging with CT or MRI can be difficult to obtain, and the quality of the exam is lower due to the patient's fat content [10]. Not only that, patients with morbid obesity, while overweight, may also be nutritionally depleted leading to issues with wound healing [11]. It's also well known that morbidly obese tend to present with a less concerning physical exam with tachycardia at times being the main sign of intra-abdominal leak.

Management of bariatric patients presents a variety of difficulties. First of all, conservative treatment has been shown to be very successful in duodenal stump leaks (intravenous antibiotics, drainage, and parenteral nutrition) [4], but this approach may be inadequate for patients with morbid obesity or complete stump blowout. The bariatric population is also more susceptible to infectious and non-infectious complications which can be triggered by a stump blowout and lead to extensive peritonitis requiring invasive management [12].

Drainage of the duodenal stump early may be the most important factor in treating duodenal stump blowout to limit the spread of inflammatory factors into the peritoneal space, and this is usually done using a pigtail catheter into the periduodenal space or a Foley catheter inserted into a duodenostomy [5]; however, this can prove to be a challenge with morbidly obese patients due to the level of central adiposity present. This can lead to difficulty placing drainage tubes due to the thickness and composition of the abdominal wall as well as difficulty placing trocars for laparoscopic intervention [10].

As mentioned previously, reoperation should only be considered in cases of widespread peritonitis or hemoperitoneum when it is essential to stabilize patients in critical condition, as there are much higher mortality rates (up to 56% mortality rate with patients undergoing one or more reoperations) associated with surgical intervention than conservative treatment [4]. Given the difficulty of performing open operations on the bariatric population, this high mortality rate for invasive intervention may be even higher in bariatric patients. When surgical intervention is indicated, it is important to be able to quickly locate and access the duodenal stump to repair the blowout. This can be challenging if the duodenum has retracted into the retroperitoneal space or in the setting of bariatric patients who have high levels of visceral adipose tissue. A Kocher maneuver may be required to better mobilize the duodenum for easier access. The Kocher maneuver involves dissecting the peritoneal attachments on the right of the duodenum so that it is free to be reflected to the left or, in the case of duodenal stump blowout, mobilization for ease of repair.

Not only is the mechanical exploration of bariatric patients more difficult due to their size, there is also a component of ischemia that obesity brings with it. With bariatric patients, increased visceral adiposity can also lead to ischemia around the duodenal stump because fat tissue is hypo-perfused relative to other tissues and prone to poor oxygenation [10]. This can lead to increased risk for infection in obese patients as the oxidative mechanism of killing bacteria is impaired in and around large collections of fat tissue.

Another extremely important note for the duodenal switch population is that they usually have comorbidities that require medications that increase susceptibility to bleeding such as heparin derivatives for DVT prophylaxis [10]. Obese patients are prone to DVT after surgery due to decreased circulating antithrombin III and decreased thrombolytic activity [13] and therefore need more DVT prophylaxis, putting them at risk for increased bleeding after surgery. This can be especially dangerous if there is a rupture of a blood vessel near the duodenal stump because in a patient with impaired hemostasis, it could impair the surgeon's ability to visualize the stump for repair during reoperation, and it remains a danger in the postoperative phase.

In addition to the traditional two-anastomosis duodenal switch, another type of duodenal switch that is gaining popularity is the single anastomosis duodeno-ileal bypass (SADI). In this procedure, a sleeve gastrectomy is performed similarly to BPD-DS; however, instead of the Roux-en-Y configuration of the small intestine with a 100 cm common channel after the duodeno-ileal anastomosis, a loop of distal ileum is brought up to connect directly to the transected duodenum to create a single anastomosis with a 300 cm common channel. The creation of one less anastomosis in the SADI means there is statistically less likelihood of downstream obstruction or leakage leading to peritonitis or duodenal stump blowout; however, studies to date show that there are comparable levels of complications between the two procedures as well as comparable levels of weight loss [14].

As it can be challenging to make the diagnosis for the litany of reasons mentioned above, the authors recommend placing a drain over the biliary stump at the time of surgery. The drain is both diagnostic of the duodenal stump leak while at the same time providing source control and can be therapeutic. Outside of pancreatic surgery, this is one of the few times the authors recommend leaving an abdominal drain in place on a primary gastrointestinal surgery.

42.9 Conclusion

Duodenal stump blowout is a dreaded complication of duodenal switch, and it is important for physicians to understand how to manage and treat patients effectively when it happens. Early identification and intervention are essential for the prevention and mitigation of severe secondary complications. Diagnosis with clinical signs, laboratory studies, and cross-sectional imaging gives a window into the severity of the patient's condition and leads to the decision for conservative or invasive management. As diagnosis is challenging, the authors recommend leaving a surgical drain over the stump at the primary surgery. Conservative treatment is the best option for stable patients; however, if the patient becomes unstable, then a surgical approach may be required. In the conservative approach, percutaneous drain placement is usually paired with antibiotics and parenteral nutrition. Invasive management is most useful in critically ill patients with intra-abdominal hemorrhage, major wound disruption, bleeding duodenal ulcer, and abdominal compartment syndrome. Duodenal switch is a powerful tool for excess weight loss in bariatric patients, but this comes at an increased risk for complications such as duodenal stump blowout. It is imperative for bariatric surgeons to be familiar with the presentation and management of DSB in order to ensure patient safety and successful outcomes.

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Chapter 43
Duodenoileal Anastomosis Testing

Ramon Vilallonga, Sergi Sanchez-Cordero, and Marc Beisani

43.1 Introduction

Gastrointestinal leak is one of the most serious complications following bariatric surgery. The rates of leaks after bariatric surgery vary from 0 to 7% after sleeve gastrectomy (SG), 0 to 5.6% after Roux-en-Y gastric bypass (RYGB), and 0.7 to 8% after biliopancreatic diversion with duodenal switch (BPD-DS) [1]. Despite the decreasing worldwide incidence over time, gastrointestinal leak remains a significant cause of morbidity and mortality after bariatric surgeries [2]. The etiology of leaks is multiple but generally falls into mechanical/tissue causes or ischemic causes, both of which involve intraluminal pressure that exceeds the strength of the tissue and/or staple line.

The diagnosis of a gastrointestinal leak after bariatric surgery can be challenging. The patient's presentation varies according to the type and timing of the leak and also the patient's systemic inflammatory response. The clinical presentation, signs, and symptoms are highly variable, ranging from asymptomatic to septic shock [3, 4]. An early detection is associated with a better outcome, and a high index of suspicion is the cornerstone in the diagnosis [2]. However, patients with morbid obesity may show equivocal presentations, leading to late diagnosis and

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potentially catastrophic consequences [3, 4]. As a major complication following bariatric surgery, routine intraoperative leak tests should be always considered and could be an especially relevant aspect considering the legal environment in some countries.

Traditionally, leak tests have been a way to rule out intraoperative technical mistakes or other issues leading to leaks. Different techniques have been developed with the aim of identifying a suture line leak. The most common are air insufflation or methylene blue dye injection through a naso- or orogastric tube and an intraoperative upper gastrointestinal endoscopy. More recently, a green indocyanine (ICG) leak test has also been introduced, and some other authors have described a double transoral test, including methylene blue and ICG [5]. Regardless of the type of test used, intraoperative identification of a leak should warrant an appropriate repair and retesting before completion of the operation and can help to easily prevent severe postoperative complications.

However, we do not have an ideal intraoperative leak test, and its utility during bariatric surgery is controversial. Some studies have shown that the use of a routine intraoperative leak test was not associated with a decrease in the incidence of postoperative leaks [6, 7]. The reality is that there is no high-quality clinical evidence, not to mention prospective randomized studies, to suggest that any such interventions significantly decrease leak incidence after bariatric surgery. In fact, some authors have pointed out that the use of routine leak tests that increase the intraluminal pressure may damage the fresh suture line. However, both hand-sewn and stapled suture lines have a burst strength well in excess of any intragastric pressure likely to be created by a brief intraoperative leak check, be it air, liquid, or an intraoperative endoscopy [8]. Moreover, a study including multiple data showed no evidence of either benefit but also no harm of intraoperative leak test in patients who underwent SG, RYGB, or BPD-DS [1].

Although it may not be 100% reliable, leak testing is not likely to create iatrogenic damage to properly constructed fresh suture lines [1, 8]. So, given the potential benefit of detecting and correcting immediately a suture leak, and the small effort that the test implies when the team is used to do it, we strongly recommend to introduce one in the routine performance of the duodenal switch and its variants. Besides, the medico-legal aspects should also be taken into consideration [9].

43.2 Methylene Blue Test (Fig. 43.3)

The methylene blue test consists of injecting the dye through a previously placed orogastric tube located at the antrum of the gastric sleeve, in order to inflate the cavity and see if any blue leaks out of the lumen. It is a very straightforward test that, when performed by a trained surgical and anesthetic team, may take less than 2 min to complete. It does not have a high sensibility, but, when positive, it allows to identify and immediately repair inadvertent technical mistakes.

Its sensibility may be increased by occluding the distal aspect of the duodenoileal anastomosis with an atraumatic clamp. The inflated ileal loop not only confirms that the dye has effectively gone through the pylorus but also allows an adequate pressure to be applied to the anastomosis. Injecting air through the tube after the blue and placing a clean gauze all along the suture lines before the injection can also increase the sensibility of the test, especially on the posterior aspect of the anastomosis, where leaks can be harder to detect.

43.3 Water-Air Leak Test (Fig. 43.1a and b)

The water-air leak test requires a little more preparation than the blue test, as water needs to flood the supramesocolic space, covering the anastomosis. It is recommended to position the patient in forced Trendelenburg to minimize the water required to completely cover the suture lines. This way, bubbles escaping from the lumen after air injection through a nasogastric tube would be easily identified.

As air escapes easily than liquid, air tests are believed to be more accurate than blue tests, although there is no good-quality data to support that impression. On the other hand, the exact location of the leak may be harder to identify.

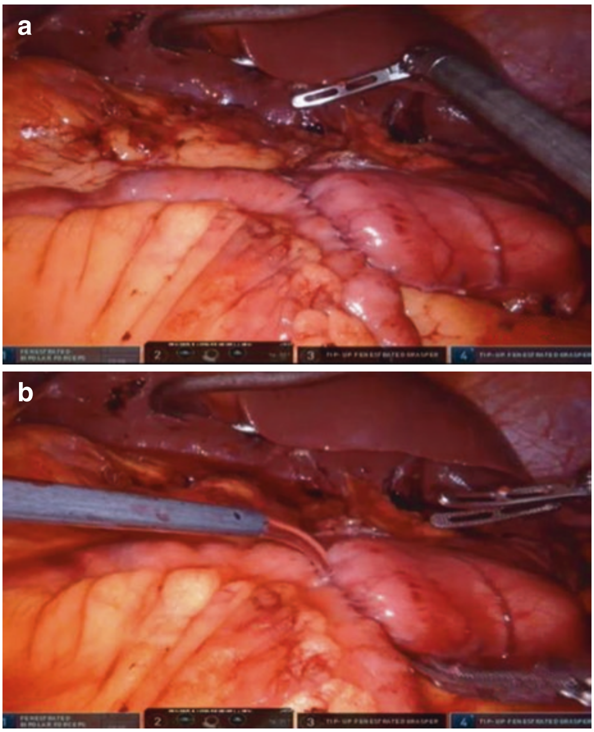

Fig. 43.1 (**a** and **b**) Water-air leak test

43.4 Intraoperative Endoscopic Direct Visualization

Intraoperative endoscopic exploration allows to simulate an air test with the insufflation of the endoscope and also to directly visualize the suture lines. It offers the advantage to not only rule out the presence of a leak but also intraoperative bleeding or any anastomotic stenosis or mucosal ischemia. On the down side, it requires the equipment to be readily available in the operating room, as well as the proper training.

43.5 Indocyanine Green Test and Combination of Blend and Endovascular Test (Fig. 43.2a and b)

More recently, bariatric surgeons have been including a novel leak agent blend. This novel blend is done with 2 mL of methylene blue and 5 mg of ICG [5]. This blend is mixed in 100 mL of sterile water and placed into a syringe. Then, the anesthesiologists can inject all the content through a previously placed nasogastric tube, at the level of the antrum of the stomach, blowing the stomach and the duodenoileal anastomosis. At this time of the procedure, ICG cameras must be

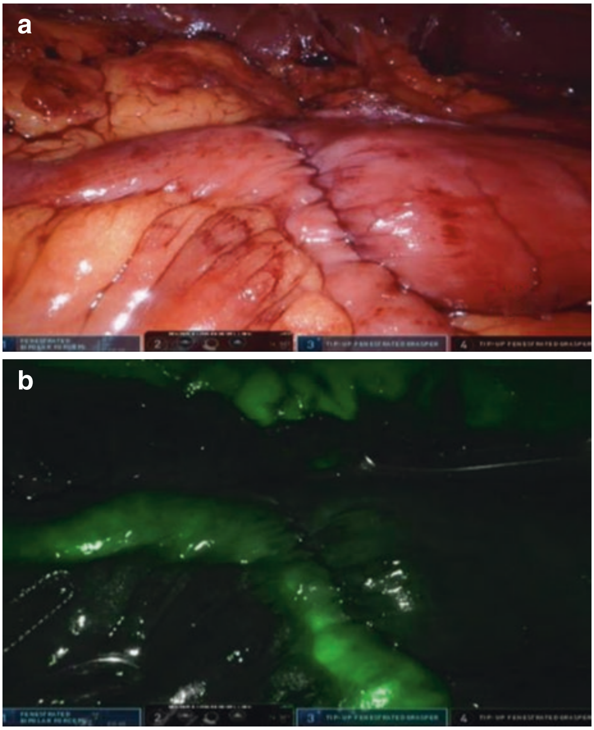

Fig. 43.2 (**a** and **b**) Indocyanine green test and a combination of blend and endovascular test

activated to detect any leaks coming from the lumen of the gastrointestinal tract at the level of the anastomosis. After injecting all the content, another 50 mL of air could be injected, adding pressure to the test (Fig. 43.2a). ICG should only be detected inside the lumen of the gastrointestinal tract. Then the surgeon needs to switch to a normal view of the camera, looking for blue on the surgical field (Fig. 43.2b).

There is little experience with this kind of blend test in bariatric surgery. Hagen et al. [5] reported 95 blend tests in RYGB, finding no test-related adverse event. They observed four patients (4.2%) with an abnormal ICG leak, but not blue extravasation. However, the interpretation of these findings is controversial. More data is necessary to clarify if the use of the ICG camera adds some value when testing for intraoperative leaks.

Another interesting characteristic of ICG is that it allows us to observe the blood supply of the tissues. In that line, an interesting variation of the previously described test would be adding 4 mg of ICG intravenously, which would confirm the adequate vascular supply of the duodenoileal anastomosis, that could be compromised in case of section of the right gastric artery (Fig. 43.3). There is currently no meaningful data on using the ICG to check the vascularization of this anastomosis, but this type of transoral and vascular test has been described previously in colorectal and esophagogastric surgery [10, 11] and seems to offer some benefit.

Nowadays, there is still a lack of technology when measuring ICG fluorescence. It would be useful to quantify the emission, in order to objectively evaluate tissue vascularization and especially to determine if an anastomosis could be in risk of postoperative leak according to the observed intraoperative images. Novel technology of ICG fluorescence in many fields is arising to determine its utility in the future. Moreover, clinical aspects and biological parameters would need to be estimated according to the general status of each patient [12, 13].

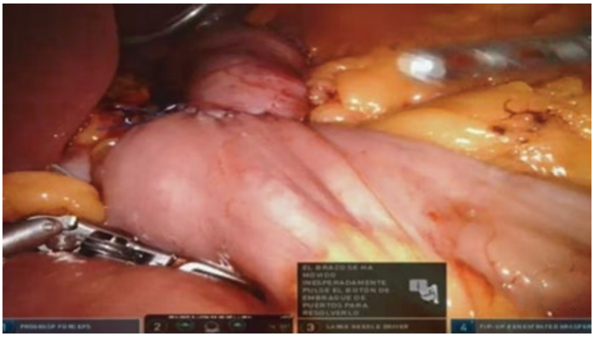

Fig. 43.3 Methylene blue test

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Chapter 44
Closing the Mesenteric Defects

Phil Vourtzoumis, Francois Julien, and Laurent Biertho

44.1 Introduction

Bariatric procedures that involve alterations in gastrointestinal absorption do so through bypassing a predetermined length of the small intestine. There are a variety of intestinal configurations that widely depend on the type of procedures performed (e.g., Roux-en-Y vs. loop). However, these intestinal anastomoses share a common theme of creating a "space" within the abdominal cavity known as a mesenteric defect. These defects are usually formed when two opposing edges of intestinal mesenteries are in close proximity, as a result of a new gastrointestinal anastomosis.

In the advent of laparoscopic bariatric surgery and the popularity of malabsorptive or hypoabsorptive procedures, there has been an ongoing debate regarding the management of mesenteric defects at the index operation [1–3]. The major concern that evolves around these defects has been the association with an increased rate of internal hernias [4]. Factors such as absence of adhesions, loss of mesenteric fat, and variety in surgical techniques can be attributed to this increasing likelihood [5]. Small bowel obstructions secondary to an internal hernia through mesenteric defects are sometimes difficult to diagnose and can be a dreaded postoperative complication that can eventually progress to small bowel ischemia.

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This chapter will focus on the management of mesenteric defects during a laparoscopic biliopancreatic diversion with duodenal switch (BPD/DS) and its derivatives, the single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) and the stomach intestinal pylorus-sparing (SIPS) procedures.

44.2 Experience from the Roux-en-Y Gastric Bypass

In order to further discuss the management options, it is important to highlight where most of our understanding of this topic has evolved from.

The breadth of the literature surrounding the experience of mesenteric defects in bariatric and metabolic surgery mostly stems from the laparoscopic Roux-en-Y gastric bypass (LRYGB). The two most common spaces created during an antecolic approach are known as the Petersen defect (space created between the Roux limb and the transverse mesocolon) and the defect at the jejunojejunostomy. An additional third potential defect can also be encountered through the transverse mesocolon during a retrocolic approach.

Internal hernia rates after LRYGB can range from anywhere between 0.2 and 9% [6]. Currently, there is no clear standardized consensus toward the technical management of mesenteric defects (closure vs. non-closure), and given the heterogeneity of clinical practice, comparisons of surgical outcomes are difficult. There are many non-comparative studies in the literature describing less internal hernia rates with the closure of mesenteric defects. There are also studies advocating that closure of mesenteric defects can be facultative, as there is no difference between groups [7]. Some believe that a wide open mesenteric defect will actually decrease the risk of strangulation secondary to an internal hernia.

A recent comprehensive systematic review and meta-analysis examined closure vs. non-closure of mesenteric defects in LRYGB [8]. They identified a total of 12,640 patients from 2 randomized controlled trials (RCTs) and 6 retrospective cohort studies. Their analysis concluded that closure of mesenteric defects was associated with lower risks of internal hernia and reoperation for suspected small bowel obstruction compared with non-closure of mesenteric defects. Observational studies demonstrated a lower risk, 2% vs. 10%, in the closure group compared to the non-closure group. Also, the two RCTs showed a lower risk as well, 2% vs. 7%, in the closure groups [9, 10]. Interestingly, there may be an associated higher risk of small bowel obstruction not related to an internal hernia and early small bowel obstruction in the closure groups. This last observation was from only two studies, of which one showed no difference between groups; therefore, this remains to be studied further given the low level and uncertainty of the evidence.

44.3 Experience in Duodenal Switch/Derivatives

The BPD/DS and its derivatives are very effective malabsorptive procedures that offer sustained weight loss and provide impressive reversal of obesity-related comorbidities. Although these procedures only make up roughly 1% of the total procedures performed worldwide, there has always been a great interest in their promising long-term results from experienced centers [11]. In order to discuss the associated mesenteric defects, it is important to highlight the differences encountered anatomically in these procedures compared to the LRYGB.

The standard BPD/DS is a combination of a sleeve gastrectomy and a Roux-en-Y intestinal bypass. In this procedure, there is a common channel of 100 cm and a total alimentary limb of 250 cm. The alimentary limb is connected via an end-to-side duodeno-ileal anastomosis, roughly 2–3 cm distal to the pylorus. Given this anatomic configuration, we expect to encounter a mesenteric defect at the common channel anastomosis with the biliary limb (ileo-ileostomy defect) and a Petersen defect from an anti-colic Roux limb duodeno-ileal anastomosis. Similar to LRYGB, most technique descriptions discuss the closure of the ileo-ileostomy defect; however, the Petersen defect closure is often still debated. It seems, though, that findings from the experience in LRYGB may have most likely been translated over to these procedures and have convinced surgeons on the routine closure of these defects.

On the other hand, the SADI-S and the SIPS are fairly new procedures. They are believed to be simplified alternatives to the BPD/DS with less potential malabsorptive/malnutrition complications and, of course, one less anastomosis. The SADI-S was first described by Sanchez-Pernaute and Torres in 2007 and has now evolved to consist of a sleeve gastrectomy with a common channel of 250–300 cm via a loop duodeno-ileal anastomosis [12]. In 2013, Cottam and Roslin described the SIPS procedure, which consists of a similar anatomical configuration; however, the common channel is longer, measuring 300 cm [13, 14]. Generally speaking, these procedures claim to minimize and/or eliminate the risk of an internal hernia given the single "loop" anastomosis configuration. Torres describes that, after a one-loop reconstruction, the rate of internal hernia is reduced to almost nil [12]. In their series, there was no single case of internal hernia; however, they lacked long-term follow-up. Bekuzarov et al. recently published a series comparing SADI-S 250 cm vs. standard BPD/DS and reviewed their 5-year results [15]. They observed a lower rate of small bowel obstructions in SADI-S vs. BPD/DS; however, there was never any mention of complications secondary to internal hernias. They simply state that there was never a need to close the mesenteric defect to prevent internal hernias. It is believed that since there is no division to the small bowel and/or mesentery, the loop duodeno-ileal anastomosis provides a large open contiguous "space" which makes it rare for the occurrence of an internal hernia.

Over the years, there has been a multitude of publications debating the importance of mesenteric defect closure in LRYGB [1–3, 6, 9, 10]. However, there is very limited data in the literature regarding the same for laparoscopic BPD/DS and its derivatives. This may be a reflection of the highly specialized nature of this procedure. When reviewing the literature, for BPD/DS and its derivatives, there are a few case reports discussing internal hernias through mesenteric defects. There are no available randomized controlled trials, systematic reviews, or meta-analyses.

Khwaja et al. reported a case series of four patients who underwent laparoscopic BPD/DS and who presented with symptomatic Petersen hernias [16]. Prior to this case series, their group always closed the ileo-ileostomy defect, but did not close the Petersen defect. They reported 4 out of 158 patients (2.5%) with Petersen hernias that required surgery. One of these cases unfortunately resulted in a laparotomy and resection of an ischemic alimentary limb. They since then now advocate on the routine closure of all mesenteric defects and describe this as simple and pragmatic.

Other reported rates of internal hernias post-laparoscopic BPD/DS in the literature have been from Silecchia et al., whereby 2 of 27 (7.4%) patients were operated for an internal hernia [17]. However, details regarding operative technique of defects and the type of hernia were not mentioned. Comeau et al., in 2004, highlight their experience with symptomatic internal hernias in patients having undergone LRYGB and laparoscopic BPD/DS [18]. Their internal hernia rate was 3.3% (35/1064), and from this, 6/248 patients (2.4%) had undergone a BPD/DS. Interestingly enough, 94.3% of the internal hernias were in patients who did not have primary closure of their mesenteric defects. The authors therefore recommend that the best course of management in prevention is to routinely close all mesenteric defects. Another prospective review by Al-Tai et al. observed a 5% internal hernia rate in patients undergoing BDP/DS and all of these patients did not have primary closure of their mesenteric defects [19].

One of the reasons why many advocate for the SADI-S is because of the single loop anastomosis that theoretically eliminates the risk of an internal hernia [20]. Recently, Surve et al. published, in 2020, a case report of the very first reported Petersen internal hernia in a SADI-S patient [21]. This hernia was reduced and the Petersen defect was closed. Although it may be a rare occurrence indeed, the possibility of this complication is still present. Another interesting case report by Summerhays et al., in 2015, described a case of an internal hernia after a revisional laparoscopic SADI-S [22]. In this case, there was an adhesion causing the afferent limb of the loop to rotate 180° in a counterclockwise fashion toward the right side of the abdominal cavity creating a small bowel obstruction. Though this was not a typical Petersen hernia, some may express that if the mesenteric space underneath the anastomosis was closed, this may have prevented this volvulus type of twisting from the anastomosis.

44.4 Closure Techniques

Given the evidence, most surgeons can agree that closure of mesenteric defects at the initial operation can help minimize the risk of potential future postoperative internal hernia complications. Although it does not absolutely eliminate the risk, at least everything was done initially to prevent this. It is unclear, however, on the long-term integrity of these closures over time given the significant weight loss patients experience, which is associated with less mesenteric fat, and the possibility of space opening. There is a definite learning curve involved in closing these defects, all while also ensuring minimal complications secondary from the closures themselves. Most studies have mentioned that in experienced hands, routine closure is safe [2]. There is no significant addition to operative times, and there is also no significant difference in complication rates such as bleeding from the mesentery, bowel obstruction related to kinking at the anastomosis, or possible stitch bezoar/abscess [3].

Closure of mesenteric defect techniques may vary from surgeon to surgeon, and for the most part, these techniques strongly depend on training experiences. Over the years, given the rise in bariatric surgery cases, especially the LRYGB, we have seen a diverse set of described closure methods, such as closure of mesenteric defects with an absorbable or non-absorbable suture, the type of suture material used, whether it is an interrupted or running fashion, closure with clips, and closure with staplers or topical adhesive compounds [8, 23]. Given the art of surgery, these various techniques may vary from surgeon to surgeon and therefore so do respective surgical outcomes. In order to better understand the effectiveness of each technique, there needs to be ongoing self-assessment of surgeon/center outcomes. With that said, this heterogeneity in the literature may make it rather difficult to declare a "standard of care." Currently, there is no standard when it comes to mesenteric defect closures; however, the majority of the evidence aims to recommend that routine closure of all mesenteric defects with a non-absorbable running suture is safe and minimizes the risks of internal hernia postoperatively [8].

In our institution, our policy has been to close all mesenteric defects, whether in a laparoscopic RYGB, BPD/DS, or SADI-S procedure. We are a bariatric and metabolic surgery center, specializing in a high volume of laparoscopic BPD/DS. In 2013, Biertho et al. published a consecutive series of 1000 BPD/DS [11]. Since the 1990s, the procedure of choice was an "open" BPD/DS, and in 2006, there was the introduction of the laparoscopic BPD/DS. There was a total of 772 laparotomies and 228 laparoscopic BPD/DS. Of these cases, there was a total of four patients that were operated on for a repair of an internal hernia.

With regard to the closure of the mesenteric defects during a laparoscopic BPD/DS, the following principles are usually taken into consideration. Given some variability between surgeons in our institution, the agreed-upon standard for our closures is the use of a 2.0 non-absorbable suture in a running fashion. The suture material can vary from a Prolene, barbed, or Ethibond.

44.5 Ileo-ileostomy Defect (See Video 44.1)

The ileo-ileostomy defect closure is performed, from a caudad to cephalad direction, after a stapled side-to-side anti-peristaltic anastomosis is created and handsewn closure of the common enterotomy. This anastomosis usually lies in the patient's right mid-abdominal cavity. Typically, our patients are operated in a split leg position with the option of having the left arm tucked to their side if possible. For the creation of the ileo-ileostomy, we are usually on the patient's left side, and the same goes for the closure of the mesenteric defect. The assistant, on the left side as well, will typically retract the anastomosis toward the right upper quadrant using the stay suture, initially placed to line up and expose the small bowel for the anastomosis. The common channel and the biliopancreatic limb are then retracted laterally on either ends to expose the root of the mesentery, like opening a book. Once the defect is exposed, the suture is started at the root of the mesentery, ensuring that no opening at this area is left. This part of the closure is crucial in order to avoid a potential small space for herniation. The closure is then completed in the direction toward the small bowel, all while avoiding deep suture bites into the mesentery and ensuring equal symmetrical distances along the way. Care must be taken to ensure one is not travelling too posteriorly, in order to avoid twisting of the small bowel. Some surgeons may also choose to complete this closure in a purse-string fashion. Once we have reached the top of the small bowel, one or two serosal bites are taken to approximate both ends of the small bowel in order to completely close the defect. The suture is then tied to itself, or a small metal clip is placed if using a barbed suture. Careful inspection of the anastomosis is recommended to ensure no kinking, twisting, or narrowing of the lumen.

44.6 Petersen Defect (See Video 44.2)

The Petersen defect during a laparoscopic BPD/DS is closed using a very similar approach. This space is usually found in the right upper quadrant of the patient. It is directly beneath the anti-colic duodeno-ileal anastomosis, between the alimentary limb and the transverse mesocolon. The closure can be addressed from the patient's left side or in between the legs. In order to gain adequate exposure, the omentum to the right of the anastomosis is reflected upward and over the transverse colon, taking care to not pull more transverse colon through the space than necessary. The assistant will grasp the transverse mesocolon to expose the base of the Petersen defect within the mesocolon and small bowel mesentery. The first bite of the suture is generally anchored on the lateral edge of the mesocolon then traveling toward the base and onto the alimentary limb mesentery. The closure is completed in a running fashion, moving toward the transverse colon and alimentary limb junction. Sometimes, incorporation of the omentum is needed to ensure the complete closure of the space at the apex.

In our center, we also use the same principles when closing the SADI-S Petersen defect. This space can sometimes be wider depending on the base of the mesentery and transverse mesocolon given the nature of the loop anastomosis. In our experience with Petersen defect closures for BPD/DS, we are comfortable closing this space in a SADI-S; even though the theoretical risk for an internal hernia is minimal, it has not been shown to be zero (see Video 44.3).

44.7 Tips and Tricks

All mesenteric defect closures are never the same from patient to patient. In order to ensure success during these closures, adequate exposure is key, along with the skillful coordination from your assistant. Familiarity and operative experience will also allow you to judge the variable integrity of the mesentery available for your closures from patient to patient. Difficult mesenteric closures can be expected in some morbidly obese patients with large amounts of intra-abdominal fat or with friable mesentery that tears in diabetic patients. What is crucial in these cases is taking all the time necessary to perform a proper and long-lasting closure.

The following are some technical tips that can help along the way. When using a non-barbed suture, in order to avoid tying a knot initially, we place a knot at the end of the suture with a clip in order to secure the suture within the mesentery and avoid it ripping through. If there is tension or a heavy mesentery, you can use a clip to keep the closure snug as you sequentially travel upward. If you encounter bleeding within the mesentery due to a deep suture bite, it is best to securely snug the defect closed at the area and place a clip at the site of bleeding. This will usually control any bleeding and avoid an expanding hematoma. Lastly, depending on the position of the ileo-ileostomy, sometimes it can be possible and easier to approach the closure of the defect from posteriorly, if easily presented.

44.8 Summary

The complications of internal hernias in bariatric surgery are sometimes difficult to diagnose and can be catastrophic. Over the years, there has been convincing evidence highlighting the routine closures of mesenteric defects in laparoscopic malabsorptive surgeries. Most of this knowledge stems from the LRYGB; however, it can and should be easily translated over to laparoscopic BPD/DS and its derivatives. There has definitely been a trend of rising internal hernia rates since the switch of these surgeries being done laparoscopically. Even though we cannot predict the long-term integrity of mesenteric defect closures, most bariatric surgeons will agree that they find comfort knowing they have done everything technically to minimize the risk of postoperative complications for their patients. We also realize the heterogeneity in surgical practice from surgeon to surgeon. This chapter does not by any means declare these recommendations as a standard of care. Rather, we aim to highlight the importance of all mesenteric defect closures. We also recommend surgeons to actively self-assess their outcomes and share their experience with others. This will eventually allow us to better understand the intricacies and subtleties of techniques and can further help us stride toward possibly developing a standard of care when dealing with mesenteric defects in bariatric surgery.

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Chapter 45
Preventing Surgical Complications

Catherine Chung and Rana Pullatt

Duodenal switches comprise about 0.9% of bariatric surgeries across the United States and are quickly gaining popularity [1]. Performing these operations whether traditional duodenal switch or single anastomosis duodeno-ileal bypass is not without complications; however, there are ways to mitigate these complications during preoperative care, intraoperative technique, and postoperative care. Reducing complications, particularly gastrointestinal leaks, can reduce the rates of readmission, reoperation, and associated mortality. Gastrointestinal leaks occur at about 0.5–5%. Leaks most commonly occur at the duodeno-ileostomy at a rate of 2.6% [2, 3].

45.1 Preoperative Prevention

Identifying patients who qualify for a duodenal switch is of utmost importance to ensure proper patient selection to undergo a major lifestyle-changing operation. A duodenal switch calls for a sleeve gastrectomy as the first step of the operation. An esophagogastroduodenoscopy is recommended for all patients being considered for a duodenal switch to evaluate for gastroesophageal reflux disease and Barrett's esophagus. Having either may require more follow-up in patients undergoing a duodenal switch.

Many bariatric surgery candidates have cardiovascular disease comorbidities and obstructive sleep apnea (OSA). Attaining cardiac and pulmonary clearance to undergo anesthesia is necessary to prevent intraoperative and postoperative complications such as deep venous thromboembolism (DVT), pulmonary embolism (PE),

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and myocardial infarction [4]. Almost all patients have OSA, and patients should have testing completed to evaluate for CPAP requirements. Patients should be instructed to know their settings and bring their CPAP masks to be used postoperatively.

This patient population is frequently inactive with low exercise tolerance, giving them a higher chance for having a DVT. During the initial clinic visit, ruling out a DVT should be done with history and physical exam, and if clinical suspicion is high, then a bilateral lower extremity ultrasound would be advisable. To aid with intraoperative retraction of the liver, a low-calorie diet for at least 2–3 weeks is recommended to reduce the size of the liver [5]. By having a smaller and lighter weight liver, it is easier to reach the angle of His to complete the sleeve gastrectomy and also perform the dissection around the duodenum to enable duodenal transection.

45.2 Intraoperative Techniques

The single anastomosis duodeno-ileal bypass with sleeve gastrectomy procedure, first illustrated by Sanchez-Pernaute et al., was able to simplify the duodenal switch [6]. This operation eliminated the ileo-ileostomy and lengthened the common channel compared to the traditional BPD-DS. This approach reduces long-term malabsorption and malnutrition by providing increased absorptive capability [3] and eliminates a mesenteric space that could cause internal hernia and potential bowel necrosis when not managed in a timely fashion. Patients exhibit decreased nutritional deficiencies and malnutrition compared to traditional duodenal switch and comparable outcomes to gastric bypass [7, 8]. These morbidly obese patients with massive visceral obesity have limited intra-abdominal space for insufflation and working space causing difficulty in creating the ileo-ileostomy during a traditional duodenal switch. By creating only a single anastomosis in the SADI, it can result in lower incidence of bowel injury given there is less tissue handling and manipulation of the stapler.

Creating a generous sleeve volume reduces the risk of staple line leak of the sleeve gastrectomy as the sleeve of a DS is a lower-pressure system than a narrow gastric conduit in a stand-alone sleeve gastrectomy. The larger gastric conduit in a BPD-DS also allows patients to also eat an adequate volume of food and receive sufficient protein to reduce rates of protein-calorie malnutrition.

A duodenal leak is a feared complication given the morbidity and mortality associated. This can be prevented by improving surgical technique in tissue handling and reducing tension. In performing the duodenal dissection, reducing the amount of cautery used can help prevent a thermal injury and a delayed leak. If it is deemed that the reach of the ileum to the duodeno-ileal anastomosis is difficult, then dividing the right gastric artery may relieve tension at the duodeno-ileal anastomosis, and the gastric conduit is sufficiently supplied by the left gastric artery and the rich submucosal plexus of the stomach. This strategy of dividing the right gastric artery can be used on a case-by-case basis. It must be noted that dividing the right gastric artery may result in a temporary dusky appearance of the divided duodenum, and this usually resolves by the end of the case, and the conduit can be safely anastomosed. A second strategy is to divide the greater omentum and bring the ileum in a loop fashion and construct the anastomosis in an omega loop fashion and then convert the omega loop configuration to a Roux configuration. The third strategy which is used in rare cases is to create the anastomosis in a retrocolic fashion. The final strategy to reduce tension at the duodeno-ileal anastomosis is to mobilize the terminal ileal mesentery from the retroperitoneum, and placing the patient in a Trendelenburg position facilitates this.

There are several methods to construct the DI anastomosis: stapled, hand sutured, robotically assisted, single layer, or two layered. Care must be taken to perform an adequate caliber anastomosis if any of the techniques are used. The author's preference is to use a single-layer hand sutured technique. In the conventional duodenal switch, the caliber of the bowel is narrow for the ileo-ileostomy unlike a jejunojejunostomy in a gastric bypass as the proximal jejunum has a much larger caliber than the ileum. This may result in a higher incidence of obstruction at the ileo-ileostomy, especially when the common enterotomy closure is achieved in a stapled fashion. We recommend that the common enterotomy closure be performed sutured to avoid obstruction at the ileo-ileostomy. The author's preference for creating this anastomosis is with a bidirectional staple fire with white loads after enterotomies are performed and the common enterotomy is closed perpendicular to the bidirectional fires of the stapler, resulting in an H-shaped anastomosis. In creating the duodeno-ileal anastomosis in a SADI, care must be taken to prevent kinking of the loop duodeno-ileal anastomosis at the afferent limb by placing sutures anchoring the afferent limb of the loop DI to the gastric conduit.

Internal hernias are a common complication postoperatively. These can be prevented by closing the mesenteric spaces at the ileo-ileostomy and at Petersen's space, between the Roux limb mesentery, the transverse colon, and the retroperitoneum. Failure of closure of these spaces contributes significantly to the increased rates of internal hernias [9]. We recommend closure of all mesenteric spaces with a running permanent suture in accordance to other studies as well [10, 11].

Bleeding is another common complication both intraoperatively and postoperatively that can be prevented. The rate of acute postoperative blood loss anemia is 0.99% [12]. Postoperative bleeding carries the highest risk of requiring ICU admission and reoperation and is the source of the second highest risk of mortality [13]. The sleeve gastrectomy staple line is the most common source of postoperative bleed in a duodenal switch patient. Reinforcing the staple line with suture, clips, or peristrips helps reduce this risk [14]. In performing the duodenal dissection, taking care to identify the gastroduodenal artery (GDA) is necessary to prevent major intraoperative bleeding. The GDA can be injured as a result of excessive dissection during division of the proximal duodenum or postoperatively from an anastomotic leak. During this dissection, it is again recommended to reduce the use of thermal energy devices to prevent ischemia and delayed thermal injuries to the duodenum and to use gauze sponges introduced laparoscopically to control minor bleeds. Care must also be taken to prevent inadvertent injury to the head of the pancreas by overzealous and aggressive dissection much to the right of the gastroduodenal artery in an attempt to gain more duodenal length. This could result in a pancreatic leak which can cause significant postoperative morbidity. It is very important to take care not to injure the spleen when performing the sleeve gastrectomy; this can be very difficult to control in these super obese patients. Care must be taken to obtain proper exposure of the short gastric arteries before division, and this is greatly aided by placing the patient on a low-calorie diet preoperatively to reduce the size of the liver. Trocar placement must be done carefully to avoid injury to the epigastric vessels. At the end of the case, ensuring adequate port site hemostasis is recommended.

The duodenal dissection can result in injury to the bile duct especially in super morbidly obese patients. During this dissection, direct visualization is recommended, taking care to not blindly push an instrument to encircle the duodenum. Using ICG intraoperatively may aid in delineation of the bile duct. Intraoperative recognition is critical to assist in timely repair if a bile duct injury does occur. Biliary injury or cystic stump leak can happen during duodenal switches and in SADI patients if a cholecystectomy is routinely performed. This procedure is difficult to accomplish given the retraction of the liver and fatty infiltration. This is where a low-calorie diet introduced preoperatively can be beneficial. We recommend performing the duodenal switch or SADI procedure alone and perform a cholecystectomy after significant weight loss is achieved, when clinically indicated. Pancreatitis can result from excessive or aggressive dissection during the duodenal dissection around the head of the pancreas. This can occur when the fusion planes of the first portion of the duodenum are not recognized. Care should be exercised in identifying these planes.

45.3 Postoperative Care

During the immediate postoperative days, patients are recommended to have adequate oral intake of about 64 oz of fluids and over 80 g of protein to ensure adequate nutrition. DVTs are the highest risk of mortality in the duodenal switch patients [13]. Low-molecular weight heparin is indicated for all patients in addition to early ambulation to prevent DVTs. A shorter length of stay, allowing patients to return to their home environments is important in reducing this risk as well.

If leaks are identified early, stenting is recommended for traditional duodenal switches with the addition of IR-guided drain or surgical washout and drainage when indicated clinically. These stents need to be secured possibly by taking full-thickness bites proximally with an endoscopic suturing system to prevent stent migration. For leaks that occur after a SADI, we recommend oversewing of the leak if small and identifiable or conversion to a Roux-en-Y configuration traditional duodenal switch if it is a large defect to divert the bile from the anastomosis. Stenting is not feasible after a SADI given the new anatomy with two lumens at the duodeno-ileostomy. An afferent loop obstruction in a SADI if a patient has abdominal pain and a CT scan shows dilation of the afferent limb, this must be treated expeditiously as ignoring this may result in a disastrous duodenal stump blowout and potential mortality. If an afferent limb obstruction is diagnosed, then an attempt can be made to see if the anastomosis can be unkinked by placement of anti-obstruction sutures, and this must be confirmed by on table endoscopy. If this is unsuccessful, then the safest strategy would be to convert this patient to a traditional DS.

45.4 Conclusion

As duodenal switches and SADI become increasingly performed, it is of paramount importance to use the techniques described during each phase of care to minimize preventable complications.

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Chapter 46
Malabsorptive Complications

Donna Bahroloomi, Sharon Zarabi, Amanda Becker, and Mitchell Roslin

46.1 Introduction

The duodenal switch (DS) was developed in the 1980s as a modification of the biliopancreatic diversion (BP) procedure and combines elements of restriction and malabsorption to achieve weight loss [1]. This procedure is one of the most complex in bariatric surgery and has demonstrated the highest reported weight loss in long-term studies and meta-analysis [2, 3]. BPD/DS has also been highly effective in treating comorbid conditions, including hypertension, diabetes, lipid disorders, and obstructive sleep apnea [4].

On the other hand, the DS has some of the highest rates of nutritional complications when compared to gastric bypass, sleeve gastrectomy, and other restrictive procedures [2–4]. The nutritional effects of the DS depend on the length of the alimentary limb and the common channel. The length of the alimentary limb correlates with protein absorption, while increased size of the common channel reduces fat malabsorption [5]. Important factors to consider in DS patients include

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hypoproteinemia, chronic diarrhea, electrolyte and micronutrient deficiencies, hyperparathyroidism, nephrolithiasis, and gastroesophageal reflux disease (GERD). Understanding the mechanisms of malabsorption that occur in all patients undergoing DS is paramount to the successful long-term management of these patients. It is therefore essential for patients undergoing malabsorptive operations to understand the need for adherence with a strict follow-up plan.

46.2 Long-Term and Nutritional Complications

Intestinal bypass increases the risk of frequent bowel movements, flatulence, anorectal pathology, micronutrient deficiency, divalent cations, and hypoproteinemia [6]. When assessing the true nutritional status of patients, it is essential to understand that patients with morbid obesity often have excess fat but decreased lean muscle and vitamin stores. In fact, these patients can often present nutritionally malnourished with lack of reserve. This state of "high-calorie malnutrition" is due to a preoperative diet that is generally high in processed foods with limited nutritional value resulting in inadequate ability to utilize calories efficiently [7].

Therefore, postoperative nutritional counseling and monitoring with long-term blood work including total protein, iron, calcium, fat-soluble vitamins, and PTH is essential to the success of the post-surgical patient [8]. During office visits, review of systems should include assessment for new onset of numbness, weakness, lethargy, and the number and consistency of bowel movements. The vast majority of primary BPD-DS and SADI-S patients move their bowels 2–4 times per day and adapt to the surgical procedure with little difficulty [8, 9]. Thorough physical examination should include measurement of muscle strength. One simple test is to have the patients stand from a sitting position without assistance from the arms. As the gluteal muscle is one of the largest in the body, it will atrophy early if intake is poor [10].

46.2.1 Anatomic Effects on Nutrition

A major concern of the DS is the consequences of shorter bowel length causing diarrhea, perirectal complications, and protein and vitamin deficiency. The nutritional effects of the DS depend on the length of the alimentary limb and the common channel. The length of the alimentary limb correlates with protein absorption, while increased size of the common channel reduces fat malabsorption [5]. During revision surgery, the common channel is usually elongated, allowing for a longer segment of bowel for absorption of food. Most DS revisions report a 100 cm common channel elongation, while Scopinaro recommended a 150 cm increase for BPD [11].

In order to further study the etiology of high revision rates after index BPD procedures, Topart et al. conducted a literature review comparing the rate of revisions after DS and BPD [12]. This study demonstrated that the rate of revision was 0.5–4.9% for DS and 3–18.5% for BPD [12]. In their review, the chief reason for reoperation was found to be protein malnutrition, which accounted for 43–60% of the revision procedures [12]. Similarly, Hamoui et al. reported a series of DS requiring revision. Results of this series revealed that the most common indications for revision were malnutrition (20/33), diarrhea (9/33), metabolic abnormalities (5/33), abdominal pain (3/33), liver disease (2/33), and emesis (2/33) [13]. The revision surgery was successful for those having the operation to reduce chronic diarrhea, with the median number of daily bowel movements being reduced from 5 to 1 [13]. Almost all patients had improvement in albumin levels to >3.5 g/dL except for one patient whose albumin increased from 2.5 to 2.8 g/dL [13].

This idea is further demonstrated by Lebel et al. in a study which compared the DS with 200 cm common channel vs. 100 cm common channel and discovered that the longer channel group had lower severe protein deficiency (11% vs. 19%). Furthermore, patients with the longer channel required vitamins A and D supplementation ($p < 0.05$). Patients also had fewer bowel movements (2.0 vs. 2.9, $p = 0.03$) with no significant decrease in weight loss [14]. This data suggests that some of the main complications of the DS can be possibly reduced with lengthening the common channel while still maintaining significant weight loss [14].

46.2.2 Hypoproteinemia

Optimization of protein intake after surgery should be the primary nutritional goal after DS. During periods of rapid weight loss, the body will need to conserve lean body mass to support an increased metabolism and the ability to burn calories. High-quality protein sources increase satiety as well as aid in tissue healing. It is generally recommended that patients consume 80–100 g protein/day (1.0–1.5 g/kg IBW) [15]. While this high quantity may be difficult to achieve in the first post-surgical liquid diet phase, protein shakes and liquid supplements are important dietary adjuncts that support this goal. Ideally, protein-rich meals should be distributed throughout the day. In one analysis of patients undergoing DS, Strain et al. found a rate of 7.3% nutritional deficiency, 5.1% of which required TPN [2]. At 9 years, 30% of patients were protein deficient, with 20% of patients having low albumin levels [2].

The most concerning sequelae of hypoproteinemia is extensive peripheral edema. When this occurs, treatment is mandatory. Peripheral and systemic edema are one of the leading indications for revision following BPD-DS and can occur following SADI-S [6]. In severe forms, clinical presentation can be similar to kwashiorkor (edema, hypoproteinemia, anemia, and fatty infiltration of the liver) [16]. When assessing a patient with concern for hypoproteinemia, a physical exam can be notable for swelling in the legs, perineum, abdomen, and upper extremities [16]. These patients are best managed by the use of total parenteral nutrition (TPN) supplementation.

46.2.3 Chronic Diarrhea

The most common theory regarding the etiology of chronic diarrhea following SADI-S or BPD-DS is malabsorption of fat [5]. In reality, multiple synchronous potential causes likely contribute to diarrhea. In addition to malabsorption of fat, partial gastrectomy and increased rate of emptying can exacerbate preexisting lactose sensitivity [17]. Carbohydrates that are easily ingested by the intestinal flora can cause bacterial overgrowth, increased fermentation, and watery diarrhea [18]. Subtle protein sensitivities such as to gluten can also become more symptomatic [17].

The key to diagnosis of factors contributing to chronic diarrhea is the detailed assessment of the patient's oral intake, characteristic of the stool, and the temporal relationship of intake to bowel movements. For example, fat malabsorption or steatorrhea has been well-documented and characterized by abundant dense stool that floats [19]. However, post-DS patients will always have increased fecal fat in the stool; thus, unless fecal output is monitored with 24-h collection and controlled diet, monitoring of fecal fat is rarely helpful for management. Watery diarrhea following a bariatric procedure is more often associated with malabsorption of carbohydrates [17]. Lactose deficiency presents with frequent watery diarrhea 40 min following eating [19]. Additionally, when carbohydrates are poorly absorbed, they enter the colon where they undergo fermentation by bacteria, causing small intestinal bacterial overgrowth (SIBO). Buildup of gas (such as methane) contributes to bloating, increased flatulence, and reabsorption into the circulation [19]. SIBO can be diagnosed by breath test for lactulose and can be treated with antibiotics [20, 21].

A variety of treatments can help alleviate symptoms of chronic diarrhea. Initial remedies include alteration of diet and the use of motility agents such as Imodium and Lomotil. A histamine-2 blocker and proton pump inhibitor should be prescribed. Diet regimens should emphasize a low-fat diet which limits short-chain carbohydrates that are poorly absorbed in the small intestine and more likely to cause fermentation. This regimen is described as the fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAP) diet [22]. Additionally, increased fiber intake and supplementation should be encouraged. If diarrhea persists, other medications that have been utilized include clonidine, octreotide, and GLP-1 agonists. The GLP-1 agonists delay gastric emptying and reduce motility [23]. The GLP-2 analogue teduglutide is rarely used following bariatric surgery [24]. Although its use leads to short-term gut hypertrophy and increased absorption, it is expensive and must be used indefinitely, or the effect dissipates

[24]. Therefore, if surgical revision is practical, it is preferred, and the use of GLP-2 analogue is reserved for patients that do not have a surgical alternative [24]. If patients continue to suffer from refractory chronic diarrhea and continued poor nutritional parameters, consideration should be given to surgical reconstruction following nutritional repletion. Nutritional optimization prior to surgery often requires several weeks of parenteral nutrition and can be monitored using prealbumin levels [25].

46.2.4 Electrolyte Repletion and Refeeding Syndrome

Refeeding syndrome is a potentially life-threatening complication of hasty nutritional optimization that can be commonly missed in DS patients who have had significantly decreased intake for prolonged periods of time [26]. Refeeding syndrome develops when the reintroduction of carbohydrates leads to insulin release and an increase in adenosine triphosphate production, for which phosphate and magnesium are required (magnesium acts as a co-factor) [27]. As a result, potassium and phosphate are shifted into cells, leading to phosphate depletion that causes an increase in magnesium excretion in the urine [27]. This process results in hypophosphatemia, hypokalemia, and hypomagnesemia that leads to refeeding syndrome [27]. High clinical suspicion should be maintained in bariatric patients, as failure to treat refeeding syndrome can lead to serious multisystem complications, including fatal cardiac arrhythmia, hypoglycemia, and abnormal fluid shifts [28].

Treatment of refeeding syndrome begins with hospitalization and gradually increasing calorie infusion via parenteral nutrition. Thiamine must be given prior to administering any high dextrose solution or concentrated feeding. Placement of an enteral feeding tube should be delayed until edema resolves and nutrition improves. With severe hypoalbuminemia, leaky gut is common [29]. Thus, the best approach is the slow initiation of total parenteral nutrition that has 100 g of amino acids and 40 g of fat and limits dextrose to 140 g or less [30]. Synchronously, diuretics can be given with albumin to maintain fluid balance and improve peripheral edema [30]. Daily labs including electrolytes should be checked and repleted. When the patient is able to tolerate a diet, calorie counts and number and consistency of bowel movements should be recorded.

Often, endoscopy and CT scan are performed to ensure no mechanical cause of decreased intake. Colonoscopy can be considered to assure other synchronous causes such as inflammatory bowel disease are not contributing factors. Parenteral administration should be maintained until values are normalized and PO intake improves or there is plan for surgical revision. Whereas outtake issues are resolved with surgery to expand surface areas, intake issues are much more difficult to solve with surgery. Involvement with mental health providers is important. Appetite stimulants can be tried. If nutritional status cannot be maintained following resuscitation, revision with feeding tube is suggested.

46.2.5 Micronutrient Considerations

Optimizing postoperative patient outcomes and nutrition status begins within the preoperative process. Intensive preoperative nutritional counseling is crucial to gauge patients' motivation, predicted compliance, and ability to change habits. Patients should be educated before and after surgery on the expected nutrient type, dietary behaviors, and weight loss goals to support long-term outcomes. Invasive alterations to physiology, digestion, absorption, metabolism, and excretion are associated with higher nutrient deficiencies and should be reviewed with patients [31].

Laboratory markers are imperative for completing the initial nutrition assessment and continued in follow-up care. Baseline values help distinguish between postoperative complications, deficiencies related to surgery, and noncompliance with recommended supplementation. Any nutrient deficiencies identified presurgery should be repleted following the RDA in addition to any individualized recommendations. Common deficiencies include the following.

46.2.5.1 Vitamin A

Vitamin A deficiency has been reported to be at 52% at 1 year and 69% at 4 years after DS [32]. Early symptoms of vitamin A deficiency are night blindness and changes in conjunctiva of the eyes [32]. Treatment includes 10,000 IU PO. Iron, zinc, and protein levels need to be corrected to normalize vitamin A levels [32]. Vitamin A deficiency has been found to be associated with low serum prealbumin. Vitamin A levels should especially be monitored in postoperative pregnant patients, and beta-carotene should be used for repletion in this population [33].

46.2.5.2 Calcium and Vitamin D

Calcium and vitamin D are important for bone formation, blood coagulation, muscle contraction, and myocardial conduction. An acidic environment and adequate levels of vitamin D are needed for proper absorption of calcium and other minerals. Limited intake and/or decreased absorption of one or both can lead to osteopenia, osteoporosis, and/or osteomalacia. While calcium and vitamin D deficiencies have higher incidences after malabsorptive procedures, bone mineral depletion directly correlates with the amount of weight lost in an individual, regardless of the cause of weight loss [34]. Calcium citrate supplementation is preferred as it requires minimal acid for absorption, and a supplement including magnesium and vitamin D enhances absorption. DS patients require higher calcium doses than other bariatric surgery patients, typically 1800–2400 mg divided into doses of 500 mg per dose. Vitamin D deficiency is prevalent even before weight loss surgery with reports of

16–57% [34, 35]. Vitamin D supplementation may consist of up to 50,000 IU weekly for up to 9 weeks and 5000 IU daily thereafter [36]. Parathyroid (PTH) is the best indicator of calcium status; when PTH increases, bone resorption of calcium increases in order to maintain normal blood levels of calcium. It is generally recommended that the PTH level be kept below 100 pg/mL to reduce the risk of metabolic bone disease [36]. Bone density should be tracked serially. Blood work should include a minimum of annual albumin, calcium, PTH, and 25-OHD levels to assess bone health. It is important to note that elevated PTH values are commonly found in patients who have had DS or RYGB even with normal vitamin D levels and no change on bone density scans. The significance is not yet known.

46.2.5.3 Folic Acid

Typically 100 mcg of folate is excreted in bile daily; most is reabsorbed in the upper third portion of the unaltered small intestine but may be absorbed throughout the entire small bowel [37]. Since much of the small bowel is bypassed, daily excretion of folate is greater, and deficiency may occur rapidly without adequate supplementation of minimum 400 mcg daily which can be found in multivitamins [38]. Folate and vitamin B12 are codependent, and deficiency of either can contribute to macrocytic anemia [39].

46.2.5.4 Zinc

Zinc deficiency can be suspected with hair loss, poor wound healing, diarrhea, glossitis, dermatitis, and hypogeusia [40]. Zinc deficiency may arise due to lack of absorption in the proximal jejunum, intolerance to zinc-rich foods such as meat, and fat malabsorption. Supplementing with elemental zinc of 30–50 mg daily or every other day may be suggested [40].

46.2.5.5 Iron

Iron deficiency anemia is the most common micronutrient deficiency following DS [12]. Iron absorption is compromised due to reduced stomach size and less exposure to hydrochloric acid. Furthermore, the principal sites of iron absorption (duodenum and proximal jejunum) are bypassed in the DS [41]. It is important to rule out other causes of anemia, such as deficiency of protein, vitamin B12, folate, selenium, zinc, and copper [42]. The 2016 ASMBS Nutritional Guidelines recommend 150–200 mg of elemental iron in the form of ferrous fumarate, sulfate, or gluconate for treatment in iron deficiency through repletion [43]. If oral supplementation is not effective, intravenous iron infusions containing ferric gluconate may be necessary.

46.2.6 Metabolic Bone Disease

All bariatric procedures that bypass the duodenum and proximal intestine can increase the incidence of osteomalacia, osteoporosis, osteopenia, and secondary hyperparathyroidism [40]. Calcium absorption is compromised as it is preferentially absorbed in the duodenum and proximal jejunum. Vitamin D absorption is hindered by bile diversion. In general, supplements are effective in mitigating damage and helping achieve. However, if there is increased malabsorption, then calcium will bind to fatty acids increasing the rate of depletion [44]. To normalize, parathyroid hormone will increase recruiting calcium from your bones. Rising PTH reduces phosphate. To minimize the risk of hungry bones, it is essential to optimize calcium and vitamin D [44]. Routine monitoring and serial bone density are suggested.

46.2.7 Nephrolithiasis

Another risk of surgically induced malabsorption is nephrolithiasis. This condition is exacerbated by increases in oxalate circulation postoperatively. In cases of fat malabsorption, calcium will bind to free fatty acids creating a soap-like consistency. This environment leaves oxalate free, allowing it to be more freely absorbed by the colon. Oxalate then enters the bloodstream, is filtered by the kidney, and binds to calcium inside the urinary tract. This process can result in stones or calcinosis of the kidney [31]. Prevention includes a low oxalate diet with appropriate protein intake. Additionally, calcium supplementation is prescribed to improve calcium binding to oxalate. Finally, brisk hydration to prevent hypovolemia is essential [31]. Early detection is necessary, as poorly controlled or recurrent nephrolithiasis can progress overlying urosepsis to renal failure.

46.3 Conclusion

The DS is an effective modality for the promotion of weight loss in patients with morbid obesity. The DS has the highest rate of weight loss while bariatric surgeries are performed today but is also associated with the most significant malabsorption and nutrition abnormalities. Important factors to consider in DS patients include chronic diarrhea, electrolyte and micronutrient deficiencies, hyperparathyroidism, nephrolithiasis, and GERD. Understanding the mechanisms of malabsorption that occur in all patients undergoing DS is paramount to the successful long-term management of these patients. It is essential for patients undergoing malabsorptive operations to understand the need for adherence with a strict follow-up plan.

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Chapter 47
Postoperative Psychological Assistance

Hélio Tonelli and Andréia Minski

47.1 Introduction

Obesity is an important public health problem for which pharmacological, behavioral, and surgical treatments are currently available [1]. Biliopancreatic diversion with duodenal switch (BPDDS), along with gastric bypass (RYGBP), is among the surgical techniques leading to weight loss and its maintenance over time [2]. BPDDS includes three specific components: (1) a longitudinal gastrectomy, providing caloric restriction and decreasing acid production while maintaining normal gastric emptying; (2) a 250 cm total alimentary limb whose role is to reduce caloric absorption; and (3) a 100 cm common channel where the bolus mixes with biliopancreatic juices, resulting in decreased absorption of protein and fat [3].

As with any surgical technique, BPDDS outcomes are more satisfactory when a patient undergoes regular multidisciplinary follow-up after surgery. Indeed, 20% of bariatric patients achieve <50% excess weight loss after surgery, largely due to psychological issues regarding general psychopathology (for instance, depression and anxiety); dysfunctional eating behaviors (DEB) like binges, food addictions, and emotional eating; as well as some personality traits where impulsivity is a central phenomenon [4]. Such conditions need to be properly identified in the preoperative evaluation and treated when they persist despite having been managed before surgery, in order to guarantee the best results in terms of weight loss.

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There are to date no studies designed specifically to compare the efficacy of different psychotherapeutic approaches for patients undergoing BPDDS. Notwithstanding, insights from studies on the behavioral treatment of obesity may shed light on the alternatives available to such patients. Different psychotherapeutic techniques aim at providing a mental structure allowing one to reach the main goals of the treatment, i.e., losing and maintaining weight and/or controlling DEB. Such techniques employ different approaches for the goals to be achieved; for instance, psychoeducation techniques comprise interventions to change habits or lifestyles [5], while cognitive behavioral strategies aim at cognitive restructuring [5, 6], through the evaluation and modification of thoughts, beliefs, emotions, self-attributions, self-esteem, and self-efficacy related to weight loss [7]. Interpersonal psychotherapy (IPT) for obesity, in turn, is a therapeutic modality focused on interpersonal processes and aims at increasing social support, reducing interpersonal stress, facilitating emotional processing in social contexts, and increasing social skills [8]. Therapeutic techniques based on transcendental meditation, such as mindfulness, have been increasingly employed for the treatment of obesity, helping to attenuate automatic eating as well as to improve reactions to cravings and impulsivity, in addition to regulating the relationship between negative emotions and emotional eating [9]. Additional psychotherapeutic approaches that have been increasingly studied include dialectical behavior therapy (DBT) and other techniques regarding emotion regulation (ER). Such techniques are based on the affect regulation model, according to which DEB are triggered by negative emotions and, in some patients, may be relieved through binge eating [10]. In this sense, ER-based techniques assist in the development of healthy strategies of ER and, consequently, in reducing DEB in patients with obesity.

47.2 Cognitive Behavioral Therapy (CBT)

A recent review of the literature on CBT for bariatric patients [11] found that the method is effective in promoting weight loss by reducing DEB and improving depression and anxiety symptoms, at least 2 years after surgery. CBT techniques should be differentiated from interventions to change habits or lifestyles, although there is not always a clear distinction between them [5]. Habits/lifestyle change interventions comprise actions to stimulate dietary changes and physical activity [5], which may use behavioral approaches such as self-monitoring, goal setting, stimulus control, problem-solving, and relapse prevention [5–7]. CBT techniques, in turn, use such strategies associated with a *cognitive* component of the therapy aiming at cognitive restructuring [5, 6].

Self-monitoring is considered one of the pillars of the behavioral treatment of obesity [12]. Systematic recordings of diet, weight, and exercise seem to increase the awareness of behaviors leading to weight gain [13], predicting weight maintenance after bariatric surgery, along with the ability to control eating impulses [14]. Patients must be taught to set clear and tangible goals, since it directs attention and effort, minimizes the effect of distractors, as well as increases energy, motivation, and persistence for them to be achieved [15]. Goal setting is acknowledged as an evidence-based behavioral change strategy, due to its specific, measurable, and palpable characteristic [16]. DEB in people with obesity is influenced by a phenomenon studied in animals, called cue-potentiated eating [17] or, in humans, unplanned eating, which is defined by a much more intense behavior of searching for food after an exposure to environmental food cues. Stimulus control interventions improve DEB by helping patients to identify and modify such cues [18]. Structured problem-solving techniques comprise, in essence, methods to assist patients in identifying personal problems underlying specific symptoms leading to DEB and, consequently, to weight gain and in developing suitable skills to solve these problems [19, 20]. The technique encompasses different phases, beginning with the delimitation of the problem, its clarification, and the elaboration of a plan to approach it, being complemented by a clear establishment of objectives, besides the encouragement to the description of available proposals targeting at the resolution of the problem [19, 20]. It is common for patients searching for obesity treatment to have very vague, unreal, or hard-to-solve problems, as well as poorly defined or intangible strategies to deal with these problems. Although controversial, the phenomenological similarity of DEB in obesity with substance use disorders seems frequently unescapable. Such similarity is supported by a series of neuroimaging findings showing superposition of neural pathways in both conditions [21]. Thus, just as what occurs with substance addicts, individuals with obesity need assistance in order to avoid relapses and to learn to deal with loss of control. In this sense, it is essential to add that diets stimulate a predominantly cognitive control over food, which is easily lost when one has to deal with a negative affect or an environmental stressor, leading to the abandonment of diets, when not to eating disorders [22]. Weeks to months before DEB emerge in an individual on a diet, dysfunctional emotions and cognitions may already sign that a relapse is on the way. Teaching patients to recognize and develop skills to deal with these negative mental states is the primary goal of relapse prevention. Signs of cognitive relapses include cravings and thoughts about places, people, and things associated with past substance or food uses, associated with minimization of the consequences of a relapse. Physical relapse, in turn, occurs when a patient has already engaged in DEB, with varying levels of lack of control. Loss of control over eating has been identified not only in major eating disorders, such as bulimia nervosa and binge eating disorder, but also in conditions such as *grazing*, *nibbling*, or *snack eating*, which could be considered subsyndromal eating disorders [23], where small amounts of food are recurrently consumed without planning between meals. It is important to keep in mind that many dietary programs endorse several meals per day or small low carb snacks between meals and that such orientations might be subverted as subsyndromal eating disorders by some patients with obesity.

CBT for patients with obesity employs all of the techniques discussed above associated with a cognitive component, which encompasses the evaluation and modification of thoughts, beliefs, emotions, and motivations regarding weight loss. Beliefs, the primary therapeutic target of CBT, can be defined as probabilities that a proposition about the world is true [24]. They are mental representations of expectations about the world and things, have a predictive role, and need to be updated in order to increase their predictive and representational roles [24]. Therefore, the role of the CBT therapist in the treatment of obesity is to help patients update deeply rooted dysfunctional beliefs about eating and about their abilities to control eating impulses and lose weight. Dysfunctional beliefs like *being thin are not for me*, *I do not deserve to be thin*, or *I will never be able to adhere to a physical exercise routine* consolidated throughout a history of multiple attempts and failures in previous weight loss programs and can endanger the outcomes of bariatric surgery. They need to be properly evaluated and corrected (or *updated*). In this process of evaluating and modifying false beliefs, patients should be taught to monitor their dysfunctional and automatic thoughts, apply corrections, create healthier alternative responses to them, value minor achievements, and react differently to any weight gain, hence increasing their self-efficacy [7]. Failures in previous treatments may favor erroneous beliefs about bariatric surgery, including BPDDS, such as the idea of a treatment that does not require any effort on the part of the patient, which usually results in failure to achieve the expected goals.

47.3 Interpersonal Psychotherapy (IPT) for Obesity

Eating behavior is strongly associated with feelings of pleasure, excitement, and happiness, as well as with relief from displeasure, anhedonia, or unhappiness, reflecting a peculiar relationship between eating and emotion/affectivity, which is highlighted within interpersonal contexts. Indeed, patients with obesity frequently complain about feelings of loneliness, isolation, and not-belonging behind their DEB, which may be consequences of ostensive rejection, stigma, and social exclusion throughout their lives. IPT aims at increasing social support and social skills, reducing interpersonal stress, as well as facilitating ER in social contexts. Group IPT is comparable in efficacy to group CBT in the treatment of overweight patients with binge eating disorder. Studies have shown the efficacy of IPT in preventing weight gain in adolescents with high risk for obesity in adulthood [25]. Additionally, family-focused interpersonal approach helped overweight and obese pre-adolescents with loss of control over eating reduce psychological distress with a positive impact on eating behavior [26]. Although there are no studies on the efficacy of IPT in patients who underwent BPDDS, the results above suggest that it is very likely that this method particularly those patients with DEB.

47.4 Mindfulness

Automatic and unconscious thoughts, emotions, and motivations often lie behind intrusive ruminations about the future, the past, and other people [27], leading to dysfunctional psychological and behavioral styles. Mindfulness meditation addresses these mental states through the cultivation of a non-judgmental psychological state centered in the present, in which every thought, feeling, or sensation that arises in consciousness must be accepted as it actually is [28]. Some encouraged attitudes in mindfulness meditation include an impartial witnessing stance of one's own experiences, avoiding thoughtless conclusions and not falling into the temptation of trying to anticipate things, being open to new possibilities, and accepting how things are here and now. Such a stance involves, from the neuropsychological point of view, psychological operations of reconfiguration of attentional processes, corporal consciousness, and cognitive reappraisal of reality [28]. In the treatment of obesity, mindfulness techniques seem very effective in attenuating automatic eating present in many obese patients, as well as in improving reactions to cravings and impulsivity, in addition to regulating the relationship between negative emotions and DEB, resulting in better control of weight [9]. Although research findings on the effectiveness of mindfulness meditation on weight reduction are promising, there is still little evidence that such favorable results are long-lasting [9].

47.5 ER-Based Methods

Recent studies have shown that ER, defined as the repertoire of cognitive strategies used to influence emotions in ourselves or others [29], plays a crucial role in the emergence of DEB. Anger, loneliness, and other emotions, particularly those related to interpersonal experiences, are important components in the origin and perpetuation of DEB in individuals with obesity [30, 31], particularly those with ER deficits. Ultimately, such individuals would be more prone to eat palatable foods in order to minimize the expression of aversive emotional states arising from their social environments.

ER incorporates intrinsic and extrinsic psychological processes such as monitoring, appreciating, and changing the magnitude of the emotional reactions [32]. One of the most studied ER models encompasses two mechanisms, *cognitive reappraisal* and *expressive suppression* [33]. The former, considered the most adaptive, involves the cognitive effort of modifying the emotional potential of a given condition, redefining it in non-emotional terms, while the latter covers the modulation and control of the behavioral emotional response. Both strategies require some ability to perceive and reflect on one's own emotions, a capacity that is not evenly distributed among the general population [34]. Recent findings show that DEB, as well as restrictive eating behaviors present in anorexia nervosa, result from maladaptive alternatives to regulate or suppress unpleasant emotions [33]. In the same way as individuals with eating disorders, individuals with obesity seem to have greater difficulty in identifying and describing their own feelings, in addition to presenting an externally oriented thinking, which is characterized by a style of perceiving and thinking disconnected from emotions [35], typical of alexithymia, a transdiagnostic condition encompassing difficulties in identifying and describing one's own emotional states [36]. Alexithymia seems to result from interoceptive deficits disrupting the appropriate interpretation of internal signs of hunger, proprioception, tiredness, and temperature [36]. Interoceptive deficits in alexithymia may derive from inflammation secondary to obesity affecting the brain [37]. Thus, patients with obesity scoring high in instruments assessing alexithymia would find it difficult to differentiate anger from tiredness, hunger, or fever. Impairments of one's emotion identification present in alexithymia interfere with the accomplishment of emotional regulation strategies such as cognitive reappraisal and affective suppression, leading to emotion regulation with food, addictive substances, gambling, shopping, or pornography, for instance. Such impairments also disrupt the adequate processing of social information, damaging the social regulation of emotion.

DBT is an integrative intervention originally developed to tackle dysregulation in highly suicidal, self-injurious individuals with borderline personality disorder (BPD) [38]. Due to being successful in ER in such patients, it has been applied to comorbidly diagnosed individuals with BPD and DEB, with promising results [38]. DBT combines CBT strategies with techniques from other orientations such as mindfulness [39] and may be delivered individually or in group, as well as associated with phone coaching and therapist consultation [40]. The technique comprises four modules of skills to be developed: distress tolerance, ER, mindfulness, and interpersonal effectiveness [40]. Regarding ER, many adaptive strategies may be rehearsed by a trained DBT therapist assisting patients with ER deficits, some of them were discussed in details above. DBT's programs include reappraisal, problem-solving, and acceptance, the latter addressed in mindfulness. Such strategies, which are considered protective against psychopathology, including DEB, contrast with non-adaptive ER strategies comprising expressive and thought suppression, avoidance, and rumination [41].

Although DBT has been studied extensively in individuals with DEB, be they obese or not, only three studies recently addressed the efficacy of DBT in bariatric patients. Delparte et al. [39] found that a brief DBT skills training group as an adjunctive intervention to traditional interventions in a bariatric pre-surgical program could aid in minimizing DEB as well as that bariatric patients receiving DBT may have a better weight loss trajectory than those receiving only traditional interventions. Gallé et al. [42] found that DBT was more effective than usual treatments in reducing both weight loss and comorbidities in patients showing BPD traits and DEB, who underwent gastric bypass or laparoscopic adjustable gastric banding. Himes et al. [43], in turn, studied a group intervention utilizing both CBT and DBT techniques, showing that the intervention helped patients who underwent gastric bypass reverse their pattern of weight regain. At the time this chapter was written, there were no published studies on DBT in patients undergoing BPDDS.

47.6 Final Considerations

Psychotherapeutic treatment options for patients undergoing BPDDS are still poorly studied; for this reason, techniques for which there is more evidence of efficacy for the treatment of obesity should be preferentially adopted in this population. To date, psychotherapies based on CBT, IPT, mindfulness, and DBT were the most studied, with studies showing its effectiveness, particularly in patients presenting DEB. However, it is important to keep in mind that methodological limitations of many studies make it difficult to generalize the results. Obesity should be seen as a multidimensional phenomenon, where behavior is only one of its many variables, whose complexity increases the challenge imposed on whichever professionals are involved in their understanding, treatment, and prevention. DEB in bariatric patients, possibly their most studied psychopathological issues regarding risk of weight regain, may be explained as trait-dependent or state-dependent conditions. This means that obesity *directly* causes behavioral deviations, through several neuro-physiopathological mechanisms, such as low-grade systemic inflammation, (state-dependent) processes that might affect the brain, damaging neurotransmission systems regulating mood, impulsiveness, and behavior. Such processes can be reversed with weight loss, as shown by some studies on the effects of bariatric surgery on the central nervous system [44]. However, trait-dependent conditions such as temperament, personality, and individual coping styles lie behind the various ways obesity *indirectly* alters an individual's behavior. Thus, certain temperamental characteristics may increase the odds of DEB in patients with obesity [4], defining, likewise, the chances of therapeutic success. For instance, conscientious and self-controlled individuals may adhere better to post-surgical routines; otherwise, neurotic, impulsive, and reward-sensible individuals, personality traits related to increased impulsivity and, consequently, increased risk of DEB, have higher chances of unfavorable outcomes [4]. Further studies on psychological treatment for patients undergoing BPDDS need to be performed, for instance, to clarify which psychotherapeutic techniques are most effective and safe, both on short and long term, as well as whether they are best done when performed individually or in group.

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Chapter 48
Surgical Management of Leaks

Ariel Shuchleib, Mario Shuchleib, and Elias Chousleb

48.1 Introduction

Bariatric surgery is the most efficient therapy for weight loss and management/resolution of multiple medical comorbidities.

Without a doubt, the biliopancreatic diversion with duodenal switch (Fig. 48.1) or one of its variants with a single anastomosis (Fig. 48.2) is the most powerful bariatric surgery in terms of weight loss and resolution of comorbidities [1, 2]. Despite its great efficacy, this procedure and its derivatives are not even 1% of the total bariatric surgeries performed worldwide according to the IFSO global registry [3].

We believe that two of the main reasons why this procedure is seldomly performed are that, even with the single anastomosis, the duodenal switch is more technically challenging to perform than other bariatric surgeries. Secondly, and more relevant for this chapter, it is due to the fact that short- and long-term complications are higher with these procedures.

Before we begin to talk about the management of a complication, it is important to understand how often it presents, in order to be able to appreciate the magnitude of the problem.

In a large multicenter study led by a group from the bariatric medicine institute in Utah with over 1300 patients in whom a primary SADI was performed, they

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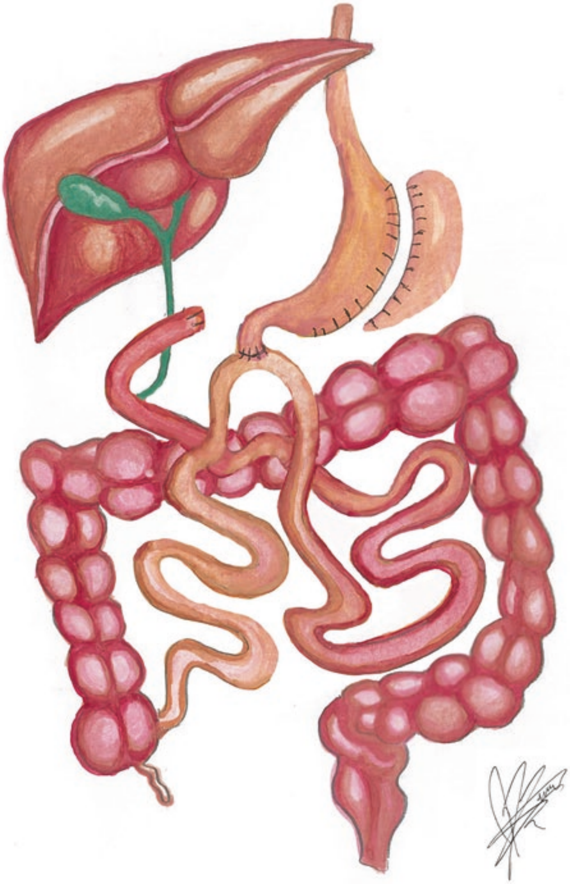

Fig. 48.1 Anatomical configuration of a traditional biliopancreatic diversion with duodenal switch (BPD-DS)

reported a leak rate of 0.6% [4]. In an earlier and a significantly smaller study, that same group reported a leak rate of 3.2% on primary BPD-DS [5]. In a series of 345 patients, Rabkin reported a 3.2% leak rate, of which 2% came from the staple line and 1.2% from the duodenoileostomy (DI) [6].

As it would be expected, experience reduces the complication rates significantly; Biertho initially reported a 3% leak rate on a 1000 patient series, 1.5% coming from the staple line and the rest from the DI. Three years later that same group reported a 0.9% leak rate, 0.7% from the DI and 0.2% from the sleeve staple line [7, 8].

When performing revisional surgery, particularly while converting a gastric bypass to a BPD-DS or SADI, the risk of complications is significantly higher; anecdotally the incidence of leaks after that procedure is around 20%; for that reason some experts recommend against doing this procedure altogether. While converting a sleeve to a single anastomosis or a traditional DS, short-term complication rates should be similar to the ones with a primary procedure since the area where the new anastomosis is taking place has not been manipulated.

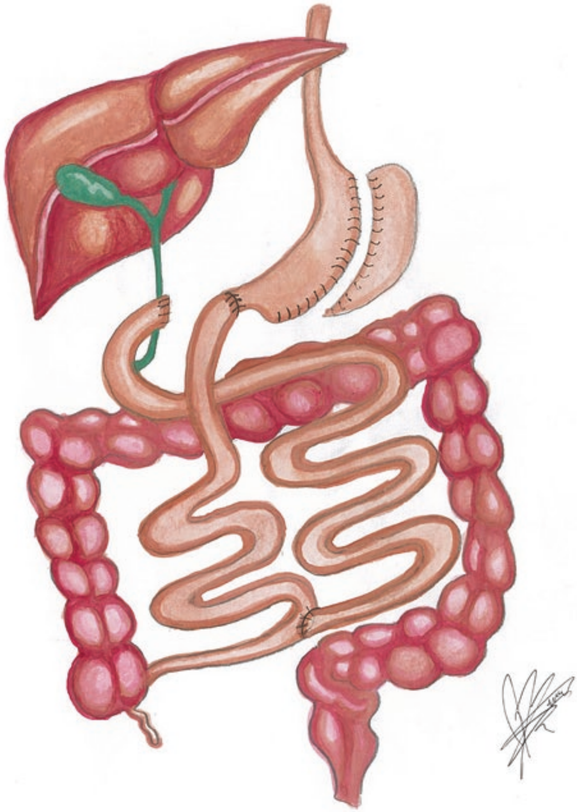

Fig. 48.2 Anatomical configuration of a single anastomosis duodenal switch (SADI)

When a SADI is performed, there are three potential sites from which a leak may arise, and identification of it will be important. It could come from the sleeve staple line, the duodenoileostomy (DI), or the duodenal stump; when a BPD-DS is done, there's also a potential leak site at the jejunoileostomy (JI).

As a general rule, leaks can be classified as acute (less than 7 days), early (1–6 weeks), late (7–12 weeks), or chronic (>12 weeks) [9].

The same way as it happens with other bariatric procedures, the presence of a leak might not be apparent with the abdominal exam alone. Leaks should be suspected in patients with sustained tachycardia, hypotension, hypoxemia, or fever. Imaging will be required in order to identify the leak site. CT scans with PO and IV contrast can be used as well as a UGI series.

If the leak is coming from the duodenal stump inflammation, air or a collection could be appreciated in the scan; however, due to its location, contrast extravasation won't be observed, and sometimes a nuclear scan is required for a definitive diagnosis.

Surgical management is usually reserved for very early leak, unstable patients and patients who fail to improve with less invasive techniques (conservative management, endoscopic techniques, interventional radiology procedures, or a combination of them) and, lastly, for definite management when a surgical revision is required.

In this chapter we'll primarily describe the surgical treatment since the other interventions are reviewed in different chapters from this book.

48.2 Early Surgical Management

Regarding the surgical management, there aren't any absolute rules since management will be dictated depending on the patient's condition, the amount of inflammation around the tissues, and location and size of the leak and if a distal obstruction is present. As a general rule, no leak/fistula will be able to heal as long as there is a downstream obstruction. For this reason, it is important to ensure that there isn't an area of stenosis, kinks, intraluminal hematoma, or any adhesions causing an obstruction distally while trying to correct a leak.

Regardless of the location of the leak, when it presents in the first 1–2 days, it usually happens due to a technical issue or a stapler malfunction. In those situations, particularly on the first day if there isn't a lot of inflammation, the leak could potentially be corrected surgically. Depending on the location, it could be fixed with stitches at the anastomosis or at a staple line. In these cases, the abdomen should be washed out, and drains should be left in place. In our opinion, if the area of the leak is accessible to do a leak test, it should be done after the correction.

Other than the previously described scenario in which the leak presents very early, most of the times correction at the time of the first procedure won't be possible since tissues will be significantly inflamed, and even if the tissues are closed at that time, the leak will reappear, and the defect might grow since there may be more tissue ischemia.

In those scenarios, the main purpose of the procedure is to control the source of the infection and create a controlled fistula with drains, so the overall state of the patient improves.

48.3 Leak from the Sleeve

Fortunately, leak rates from the sleeve of the duodenal switch appear to be lower than in a primary sleeve. While comparing the incidence between leaks in sleeves, despite not being a direct correlation, leak rates after a primary sleeve have been reported to be between 0.75 and 3% which is significantly higher than what is observed in the BPD-DS or SADI [10]. This is expected since the sleeve in a duodenal switch is calibrated with a larger bougie, which has been shown to decrease the leak rate [11].

Leakage from the sleeve either as a primary procedure or as part of the duodenal switch most commonly presents on the upper third of the stomach, and in the majority of cases, if there isn't a technical issue or a stapler malfunction, the leak is related to narrowing of the sleeve at the level of the incisura. This increases the back pressure and creates a leak on the weakest point at the angle of His [12].

As was mentioned previously in this chapter, if the patient is unstable, the first step would be to do a surgical intervention. This could be done either open or laparoscopically depending on the expertise of the surgeon and the condition of the patient. Additionally, to the washout and drainage of the abdomen, if the leak site is found and is big enough, a T-tube drain can be inserted to control the leak better [13] (Fig. 48.3).

However, if the opening is not obvious, extensive dissection looking for it should *not* be done since this could generate more trauma to the already inflamed tissues and could worsen the situation [13].

If the patient is stable before attempting a definitive management with surgery, less invasive radiological and endoscopic procedures should be attempted. When there isn't a distal obstruction, the patient is stable, and the leak is contained,

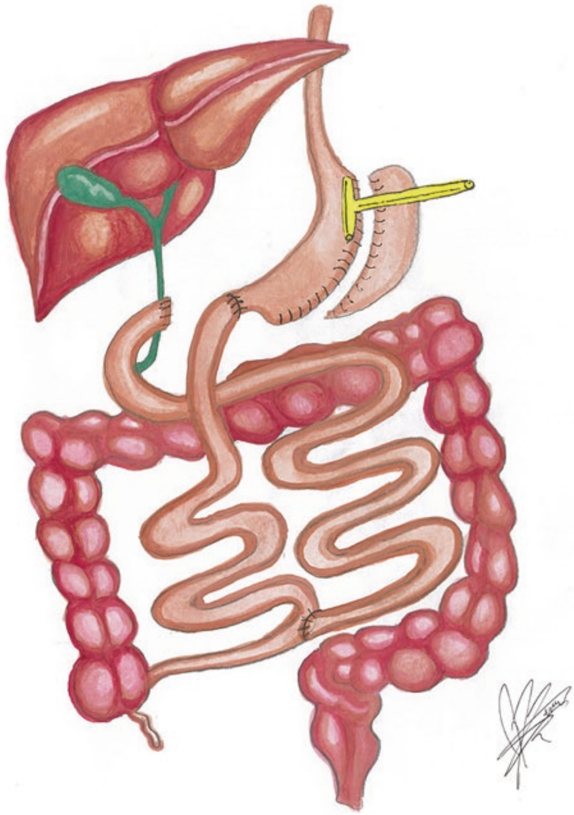

Fig. 48.3 Placement of a T-tube on the leak site from the sleeve gastrectomy

conservative management can be attempted with antibiotics, NPO status, and either distal feeding with a nasojejunal tube or TPN.

From the radiological standpoint, the main intervention that is performed is a drainage if there is either an abscess or the leak is not contained and it drains freely into the abdomen.

Multiple endoscopic techniques exist to try to resolve the problem. Since they will be explained with further detail in a different chapter, they will just be briefly mentioned. If there is a narrow area at the incisura, it's important to dilate this area first before doing any additional therapies; otherwise the leak site is unlikely to heal. Some of the other options that can be used are self-expanding stents, endoluminal vacuum therapy, endoscopic internal drainage, septotomy, or some other techniques less used like fibrin glue or over the scope clips. The efficacy of the different techniques varies significantly [14].

When those therapies fail, then a definitive surgical management should be done, ideally when the patient is stable and with a better nutritional status. Traditionally, three surgical alternatives exist for patients that have a sleeve leak. Those procedures are fistulojejunostomy, conversion to a traditional Roux-en-Y gastric bypass if the level of the leak is not too high, and, lastly, an esophagojejunostomy with a RY configuration when the leak is high.

Converting this procedure into a RY is probably the best option (Fig. 48.4), if all the less invasive procedures fail, the anastomosis to be created could be either a

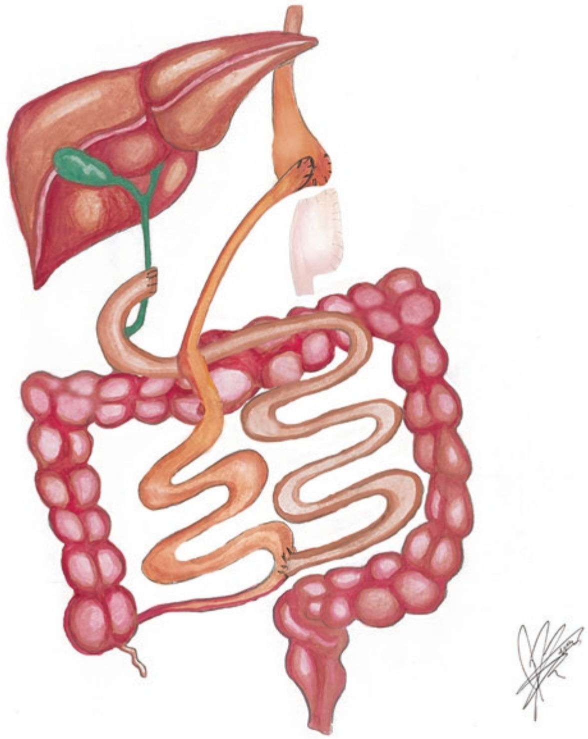

Fig. 48.4 Conversion of a BPD-DS to a Roux-en-Y gastric bypass

gastrojejunostomy if the site of the leak is low and there's enough healthy stomach to perform it or an esophagojejunostomy if the leak is located proximally in the stomach.

In order to be able to do this, we would have to perform a distal gastrectomy and bring up the same alimentary limb that was used for the DI. If a SADI was performed, a conversion to a traditional DS will be required [15].

As expected, the potential for complications are not negligible after these surgeries; extrapolating data from esophagojejunostomy even if performed by experts, leak rate from that anastomosis could be anywhere between 7.7 and 16% [16].

In the setting of a DS, a fistulojejunostomy would be possible (Fig. 48.5) by dividing the biliopancreatic (BP) limb and anastomosing the distal end of it to the fistula and the proximal end at least 50–100 cm distal on the same BP limb. However, despite being feasible, we wouldn't consider doing this procedure as a first option since there are multiple anastomosis and potential spaces for internal hernias that could lead to even more complications and potentially could affect weight loss and the metabolic effect of the surgery, since the food will be in contact with bile and pancreatic enzymes earlier.

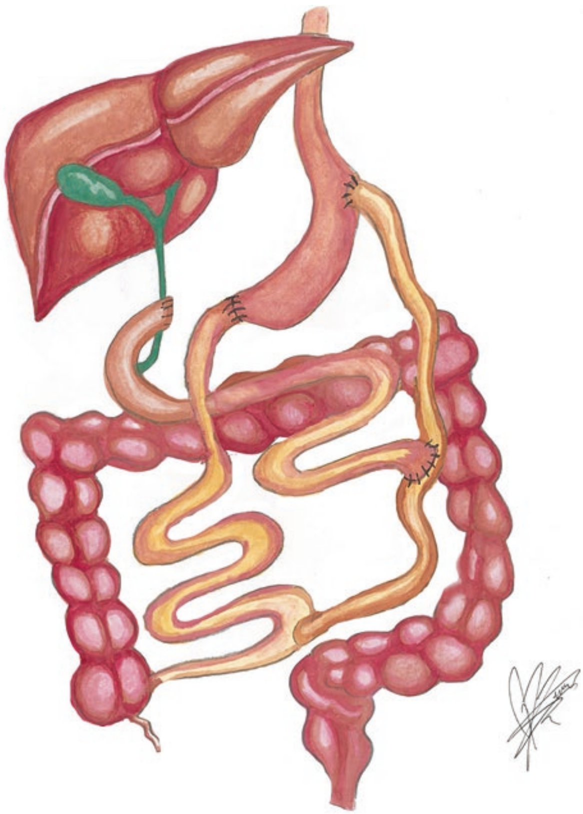

Fig. 48.5 Creation of a fistulojejunostomy by dividing the biliopancreatic limb

48.4 Leak from the Duodenoileostomy

As it was mentioned earlier in this chapter, a very early leak could be managed by repairing the anastomosis, if the tissues are healthy, and not too much inflammation is present. Most of the time, in the acute setting, this will not be possible, and washing out and draining will be the basis of its management.

If the hole is apparent and primary closure is not an option due to the state of the tissues or the patient, we could also consider placing a T-tube in this area to make it a controlled fistula.

Controlling a fistula from a SADI could be more difficult than controlling one from a traditional DS since bile and pancreatic fluid will be constantly passing through it. This will not only increase the volume of the fluid leaking but can give more inflammation due to all the enzymes and the potential irritation from the bile.

One alternative to control the fistula better would be converting the SADI to a traditional DS; this would be done by transecting the afferent limb close to the area of the anastomosis and anastomosing it distally into the newly created alimentary limb at least 1 m away from the ileocecal valve. Converting the procedure to a BPD-DS allows for an endoscopic stent to be placed through the leak (Fig. 48.6). If

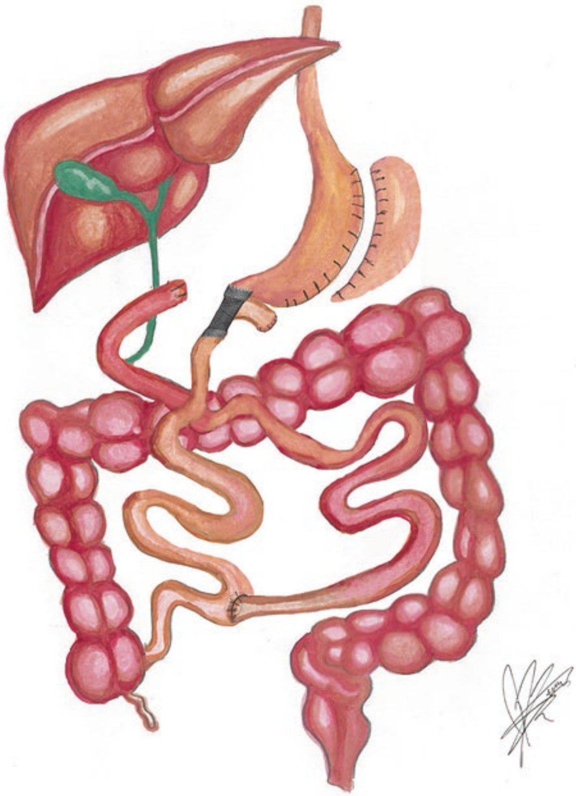

Fig. 48.6 Conversion of a SADI to a BPD-DS by dividing the afferent limb and reanastomosing it distally with a subsequent stent placement at the leaking duodenoileostomy

a stent is placed over a single anastomosis, this could easily occlude the afferent limb and potentially burst the duodenal stump.

When the less invasive alternatives fail, conversion to a gastric bypass with a distal gastrectomy will be required, all the affected area is excised, and a gastric pouch is confected; since the distal stomach will be in discontinuity, it has to be excised, and healthy tissues should be used to do the gastric bypass [17].

48.5 Leak from the Duodenal Stump

Duodenal stump leak was one of the most feared complications from the open area when surgery for peptic ulcer disease (PUD) was rampant. At that time, mortality after a stump leak could have been as high as 77%; luckily as time went by, mortality decreased significantly [18].

The incidence of this problem is significantly lower than what was reported in the past because our instruments and staplers are better, we have more knowledge about the consequences of devascularization the stump, and probably the most important one is that we are operating on healthy tissues unlike what used to happen in the past when these operations were performed for either cancer or PUD.

Incidence of this problem is around 1.5% in the setting of a bariatric surgery; the reason why this happens is either a technical problem like staple malfunction, thermal injury, extensive skeletonization of the stump, and staple line hematoma [7] or due to a distal obstruction, intraluminal hematoma, adhesions to either other loops of bowel or the abdominal wall, and narrowing of the distal anastomosis, among others [18].

Due to the risk of adverse outcomes, management of this type of complications should be done as early as possible. As with any other acute process, the main treatment would revolve around controlling the leak, managing the infection, and keeping the area decompressed in order for it to heal.

Since this is an uncommon complication from a procedure that is not done so often, not much is written about the management of these complications in this setting, but we can extrapolate the data.

In cases where the tissues look healthy and the distal obstruction was removed, it is possible to close the defect or re-staple the stump; in most cases this won't be possible, so a tube duodenostomy can be placed. This could be a direct placement of a tube—either a Malecot catheter or even a Foley—in order to control the spillage. If there isn't any access to the hole due to the inflammation, a lateral tube duodenostomy can be done on the second portion of the duodenum [19] (Fig. 48.7).

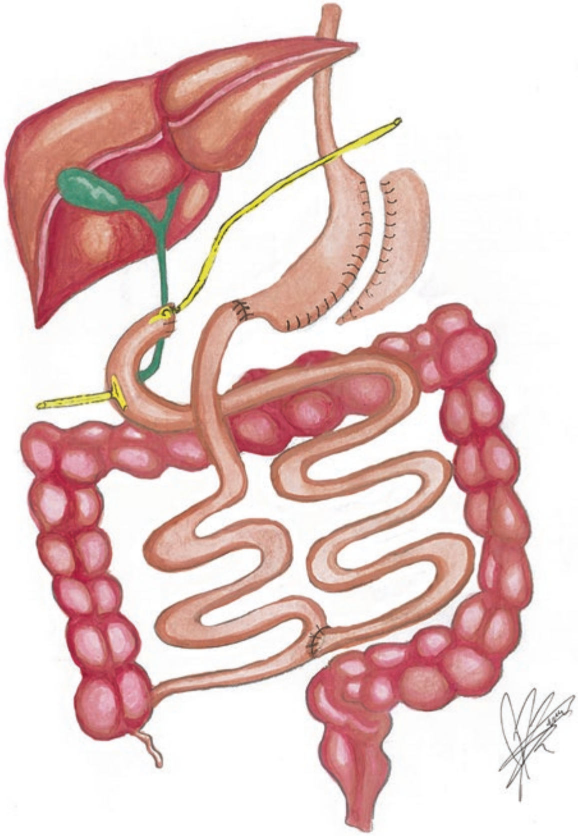

Fig. 48.7 Drainage of the duodenal stump by either placing a catheter straight into the leaking site or lateral into the second portion of the duodenum

48.6 Leak from the Jejunoileostomy

This complication is one of the reasons some authors prefer a single anastomosis procedure, so it can be avoided altogether. As is mentioned before in this chapter, since this complication doesn't occur very frequently, and the duodenal switch is not performed that often, the recommendations for this complication will be extrapolated from gastric bypass data.

The frequency of a leak from a jejunojejunostomy (J-J) is significantly lower than on other sites in the GI tract since the small bowel is more forgiving than the stomach and even more than the esophagus. In a prospective study with over 3000 patients from four tertiary centers, leaks from a jejunojejunostomy happen in the 0.27% [20].

Diagnosis of a J-J leak takes longer to achieve since there won't be contrast extravasation; in general the time for diagnosis can double from the time it takes to diagnose a gastrojejunal leak. Historically, mortality from a J-J leak was as high as 40%, and one of the most important factors was the delay in diagnosis.

When this complication occurs, conservative management is not advisable as a general rule. Firstly, anastomosis is mobile and isn't fixed like the gastrojejunostomy, duodenojejunostomy, or the duodenal stump, so placing a radiologic drain might be hard. Secondly, reaching it with endoscopic procedures will be complicated due to its location. For those reasons we consider that if a leak is diagnosed on the JI, surgical intervention should be the first therapy [21].

Laparoscopic exploration can be attempted as long as the patient's clinical condition allows it, and the first step would be to revise the area of the leak. If the tissues look healthy or there was a technical problem, the anastomosis can be repaired primarily. If this isn't the case, then the anastomosis has to be redone. Since most times we have enough bowels, the anastomosis can be taken down completely to remove all the affected tissue, and two anastomoses will be needed to reconnect the patient.

Our preference is to do an end-to-end anastomosis on the alimentary/common channel in an attempt to restore the original anatomy; we perform this with a handsewn technique. Then we do an end to side anastomosis at least 10–15 cm away from the newly constructed anastomosis also with a handsewn technique. If needed, two side to side stapled anastomosis can be done; however, if a CT is performed in the future and the patient is being seen by one other than his surgeon, it might have the appearance of a dilated bowel resembling an obstruction, and an additional defect on the mesentery with a potential hernia site will be created.

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Chapter 49
Internal Hernias and Bowell Obstruction

Admar Concon Filho, Laisa Simakawa Jimenes, Stephanie Kilaris Gallani, and Marina Andrade Macedo Pacetti Miranda

49.1 Introduction

Bowel obstruction is a familiar but challenging complication to surgeons. Its real incidence is underestimated, and there is still a lot of controversy on how to avoid it, especially among bariatric surgeons.

It is classified as early obstruction when it occurs in the 30-day postoperative period.

The incidence of this complication ranges from 1 to 12% of every abdominal surgery [1].

Regarding the etiology, the majority of the cases are due to adhesions. Other causes are internal hernia, volvulus, intra-abdominal infection, anastomotic leak, fascial dehiscence, and intussusception. After a laparoscopic approach, port site hernia and internal hernia must be remembered [1].

Classically, bowel obstruction presents itself as abdominal pain, which can be intermittent or continuous, nausea, and vomiting after eating, besides stopping elimination of flatus and feces.

Laparoscopic Roux-en-Y gastric bypass (RYGB) is the golden standard on treatment for morbid obesity [2–4]. When compared to the open technique, some of the advantages of laparoscopic approach are less postoperative pain, decrease hospital stay, and faster return to daily activities [3, 4].

In the specific scenery of bariatric and metabolic surgery, bowel obstruction is also a frequent complication, with its incidence ranging from 1 to 16% in patients undergoing RYGB [2].

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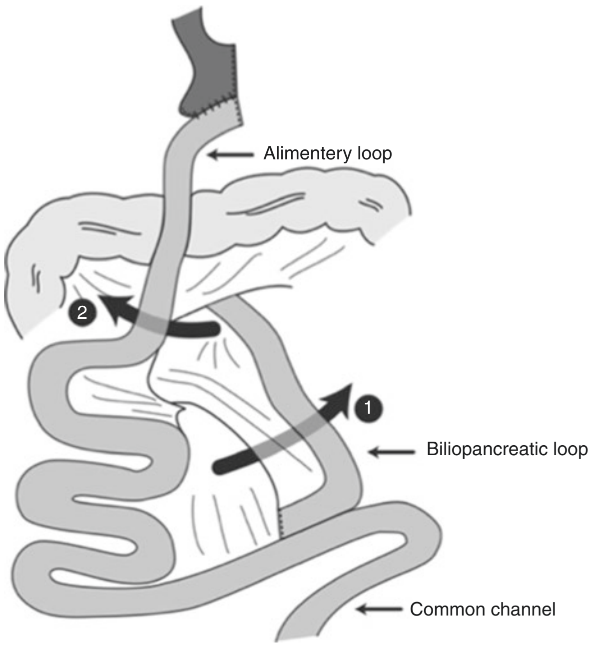


Fig. 49.1 (1) Mesenteric defect and (2) Petersen's defect [5]

The main cause of bowel obstruction after RYGB is the bowel herniation through mesenteric defect, as in Petersen's space or in the jejunostomy defect [2–7]. The risk of internal hernia is higher with the laparoscopic approach, ranging from 0.5 to 11% [3–7].

There are three possible anatomical sites through which intestinal loops can herniate (Figs. 49.1, 49.2, and 49.3):

1. Defect in the meso-jejunostomy in the jejunum (JJ)
2. Transverse mesocolon defect in retro procedures colic (MT)
3. Petersen's hernia (PH): defect located behind the Y-handle of Roux; between the transverse mesocolon and the Roux loop mesentery

Petersen's space was first described by Md. Walther Petersen, a German surgeon, during the 1990s. It's the space formed between the Roux loop and the transverse mesocolon. Petersen's hernia is the most common hernia after RYGB, with an incidence of 0.9–5% [6] (Figs. 49.4, 49.5, and 49.6).

Internal hernia can occur any time, for life long. Thus, no study was able to demonstrate its real incidence, due to insufficient follow-up [7]. However, we know that most cases occur from 1 to 2 years after surgery, coinciding with the period of greatest weight loss [4, 5].

Other causes are jejunojejunostomy-related problems (kinking of the anastomosis, hematoma and intraluminal blood clot, and adhesions [2]).

Internal hernia is the main cause of abdominal pain in the late postoperative period [6]. It's presentation varies from nonspecific symptoms, like intermittent

Fig. 49.2 Closure of mesenteric defect [5]

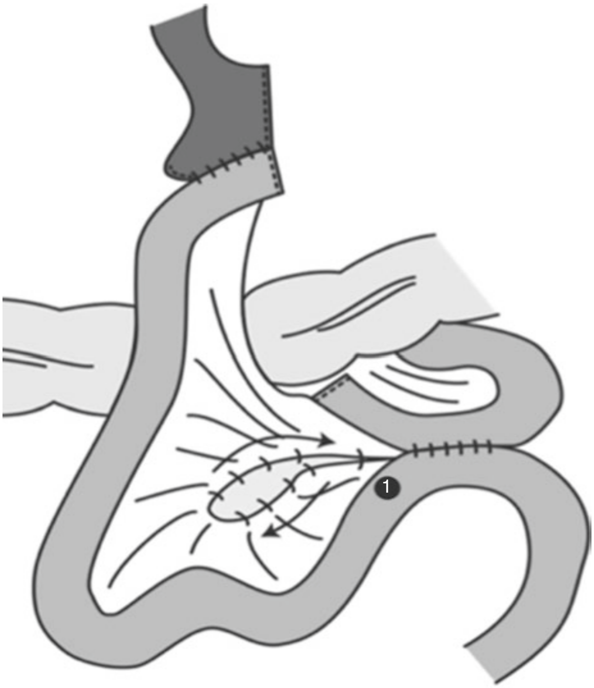


Fig. 49.3 Closure of Petersen's defect [5]

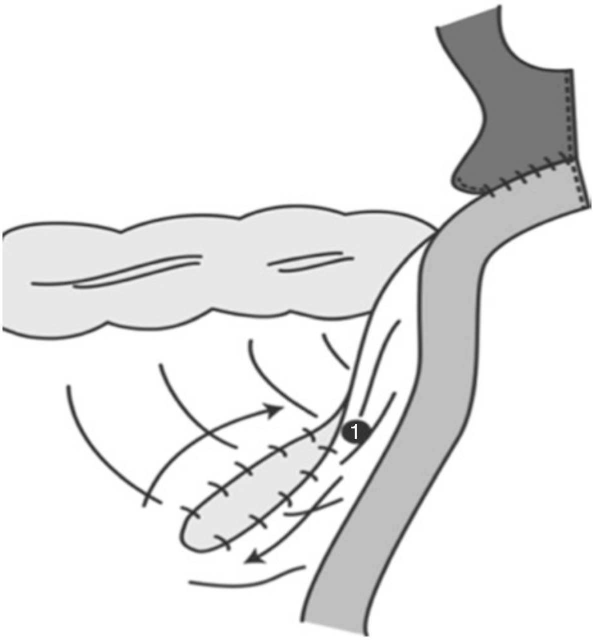


Fig. 49.4 Petersen's defect closure [6]

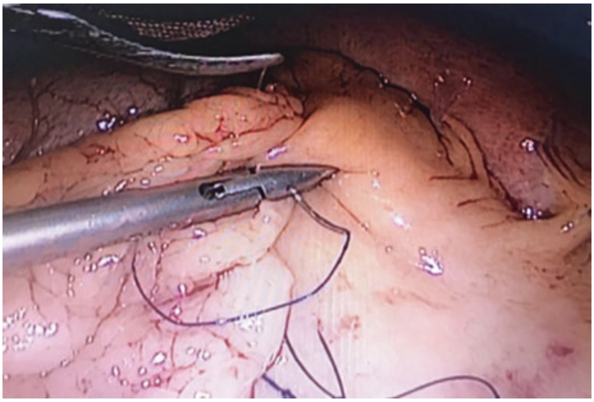


Fig. 49.5 Petersen's defect closure [6]

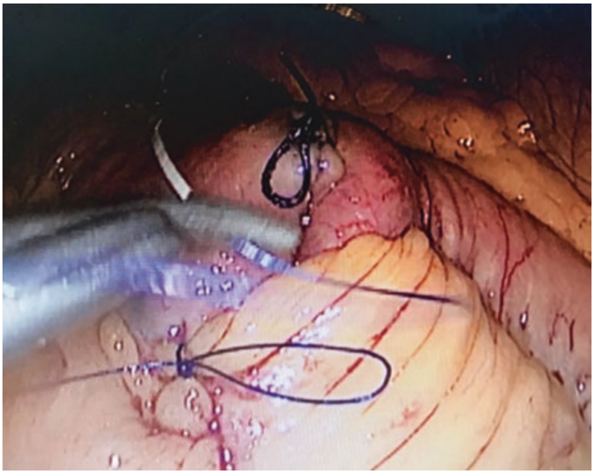


Fig. 49.6 Petersen's defect closure [6]

pain after eating, to dramatic clinical presentation with persistent pain and acute obstructive abdomen [5].

Because of the nonspecific clinical presentation and the absence of reliable diagnostic imaging, it can cause a high morbidity and even mortality [3, 5].

CT scan can show swirling of the bowel mesentery vessels, dilated loops, and clustering of those dilated loops in an atypical location. Yet, CT's sensitivity ranges from 28 to 89% only. Therefore, the clinical suspicion of bowel obstruction must be enough to indicate reoperation, despite CT findings, in order to avoid mesenteric ischemia and bowel perforation [4].

In most cases, bowel obstruction will resolve with nonoperative treatment. However, when it happens in patients undergoing RYGB, because of the high incidence of internal hernia, surgical approach must be necessary [1].

As they know about the possibility of unfavorable outcome associated with internal hernia, surgeons try to find ways to avoid it. In this context, there is a great debate on the question: whether or not to close the mesentery defects.

Several authors have shown that the closure of mesenteric defects [1–3] associated with the pre-colic position of Y on Roux reconstruction reduces the occurrence of internal hernia [1, 3].

Those who criticize this idea argue that the closure of mesenteric defects could lead to complications, such as anastomotic kinking, bleeding, and blood clots on mesentery [2, 4, 6, 7]. Besides, the closure of mesenteric defects does not guarantee that it will remain closed forever, just because new defects may arise with weight loss [6, 7]. In practical terms, the closure of mesenteric defects is technically challenging and could be the most difficult part of the surgery, increasing the duration of the procedure [7].

The closure of mesenteric defects, even with its comproved benefit in internal hernia prevention, still leaves some doubts. There is no determination, yet, on the closure of the jejunojejunostomy defect, only, or associated with the closure of Petersen's defect too [5]. There is also no consensus on the surgical technique and which materials to use.

When searching for data on the occurrence of internal hernia in the duodenal switch technique, information is scarce. This is due to the fact that, despite the improved efficacy in weight loss and remission of comorbidities, duodenal switch is an underutilized technique, representing only 2.2% of the bariatric procedures. In this case, internal hernia occurs in about 4–18% of patients [8].

Internal hernias are a common cause of bowel obstruction as a complication of bariatric surgeries [9]. Probably because it is not yet a largely done procedure all over the world, especially in countries other than the United States, the scientific literature data concerning these events related to the duodenal switch technique is limited.

On the other hand, internal hernias after RYGB have been a subject of great amount of effort and concern by the bariatric surgeons in the past few years. It is already widely known that the defect in the meso-jejunostomy, the transverse mesocolon defect in retro-colic procedures, and the Petersen's space are the main sites related with this type of complication (Fig. 49.7).

Retrocolic, Retrogastric	Antecolic, Antegastric

• 3 defects
• Shorter distance and less tension on gastrojejunostomy
  • Decreased leak rate
  • Decreased stomal stenosis rate
• Risk of mesocolic stenosis or stricture
	• 2 defects
	• Longer distance and more tension on gastrojejunostomy
	  • Increased leak rate
	  • Increased stomal stenosis rate
	• No risk of mesocolic stenosis or stricture

Fig. 49.7 Advantages and disadvantages of Roux limb position [9]

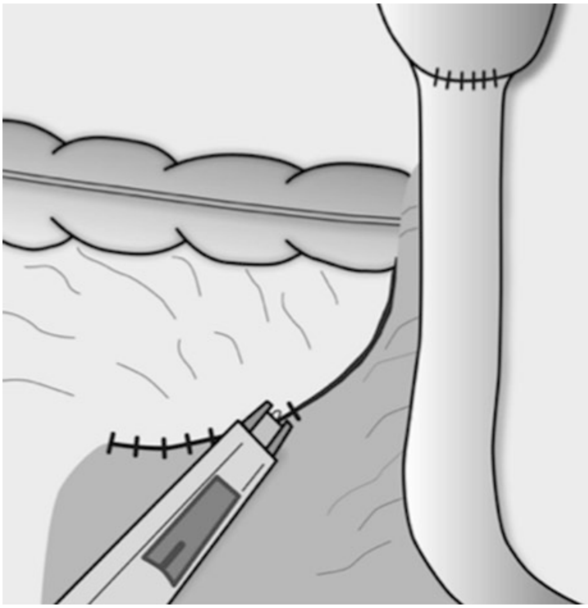


Fig. 49.8 Closure of Petersen's defect [10]

Therefore, different methods have been extensively discussed in the aim of preventing these kinds of unfortunate outcomes. For example, the closure of mesenteric defects is defended by many, but frequently associated with prolonged operative duration, mesenteric hematoma, and kinking of the Roux limb at level of the jejunojejunostomy [10].

In the present scenario, there is consistent evidence in favor of the closure of the mesenteric defects .Beside that, it is notable the description of new approaches of doing it without a high cost in short-term complications. The Endohernia® stapler device has been showing promising results on the efficacy of the closure method, reducing the related operative time and incidence of hematomas and problems with the anastomosis [7, 10, 11] (Figs. 49.8 and 49.9).

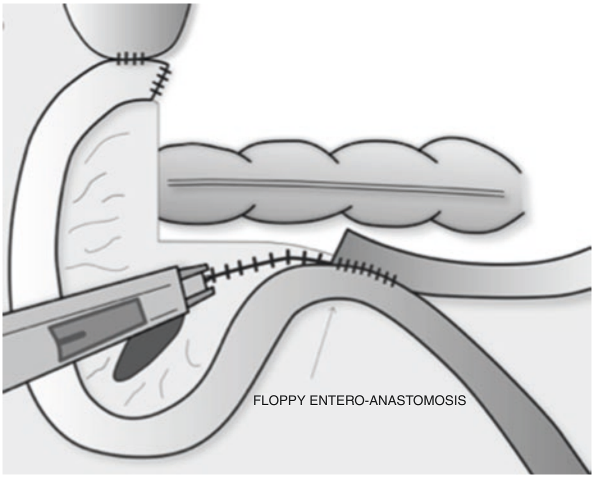


Fig. 49.9 Closure of mesenteric defect [10]

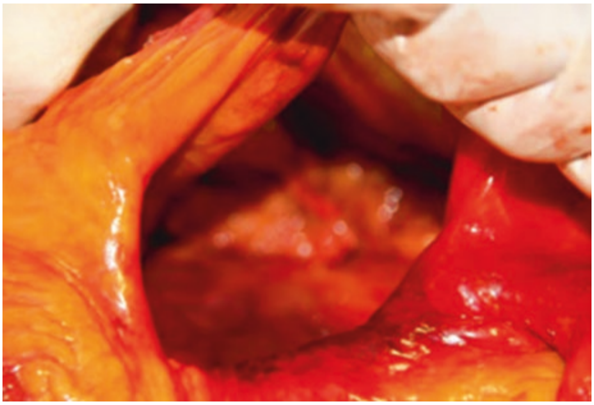


Fig. 49.10 Petersen's defect [12]

Nevertheless, the fixation of the first part of the jejunum to left side of the transverse mesocolon has been pointed as an interesting alternative to closing the Petersen space, as well as contemplating the following technical points: an antecolic positioning of the jejunal loop to make the gastric reservoir anastomosis, a linear reservoir-jejunal anastomosis with a fixation suture, an orientation of the alimentary limb so that the stump faces left and the loop descends on the right, not dividing the omentum, performance of the procedure in the supra-mesocolic space, and not dividing the mesentery [12, 13] (Figs. 49.10, 49.11, 49.12, 49.13, and 49.14).

Fig. 49.11 Hernia orifice through Petersen's defect [12]

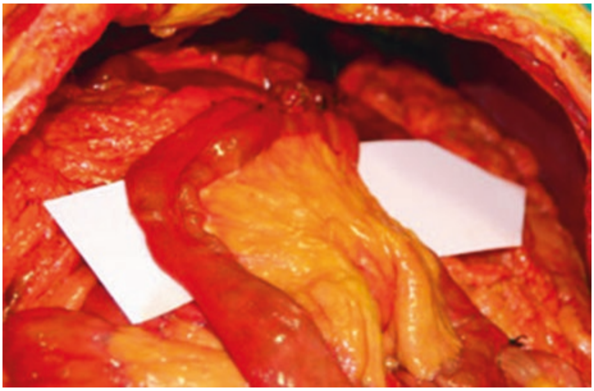


Fig. 49.12 Mesenteric defect [12]

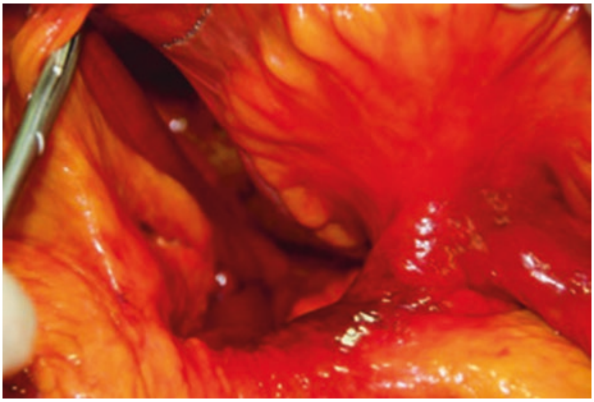
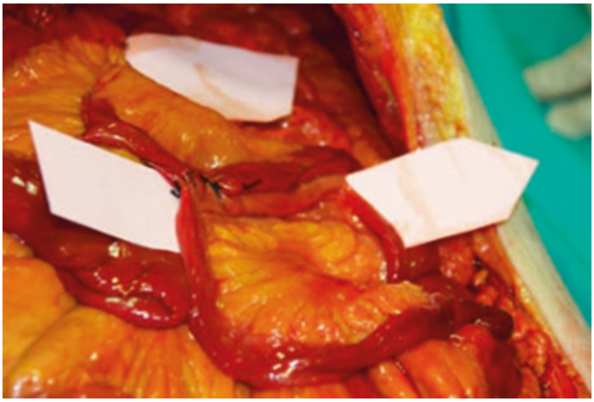


Fig. 49.13 Hernia orifice through mesenteric defect [12]



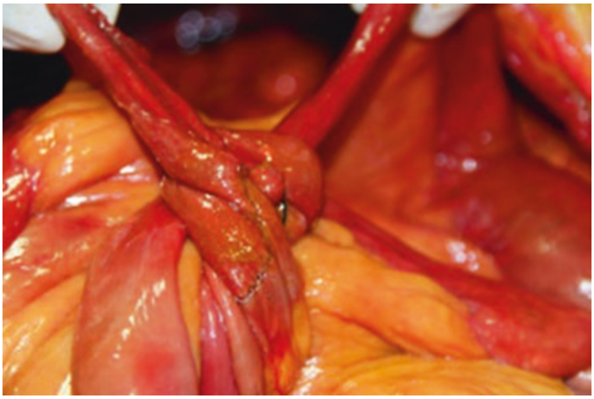


Fig. 49.14 Twisting of the intestinal loop through mesenteric defect [12]

49.2 Discussion

The primary closing of the mesenteric defects in bariatric surgery to prevent internal hernia and the consequent bowel obstruction has been supported by several studies, but the surgical technique of systematic closure is still a topic of discussion [5–7, 14–17].

Most studies regarding the closure of mesenteric defects and its impacts were conducted in laparoscopic RYGB, probably due to this technique being more common than duodenal switch [5–7, 14, 15]. However, there are reports of internal hernia after duodenal switch and evidence supporting the closure of the mesenteric defects in this technique as well [16, 17].

The closure of both Petersen's space and the mesentery at the jejunojejunostomy with running nonabsorbable suture reduces the incidence of internal hernias in laparoscopic Roux-en-Y gastric bypass when compared to the same technique without closure [5–7, 14, 15]. Some studies showed an increase in internal hernias with absorbable sutures [6] (Fig. 49.15).

Due to the risk of internal hernias in the postoperative period, when performing any abdominal surgery in patients with a history of gastric bypass or duodenal switch, it's recommended to review both mesenteric defects [7].

Several complications have been associated with the closure of the mesenteric defects in laparoscopic RYGB such as incomplete closure of the mesenteric defects causing internal hernias, kinking of jejunojejunostomy, adhesions, and consequent small bowel obstruction and hematoma. These complications were reported at an overall low risk of occurring [2, 18].

In regard to internal hernias, their incidence after incomplete closure was significantly lower than after non-closure of the mesenteric defects, suggesting special attention on performing the closure [18]. To help avoid hematoma, studies suggest keeping the sutures superficial when closing mesenteric defects.

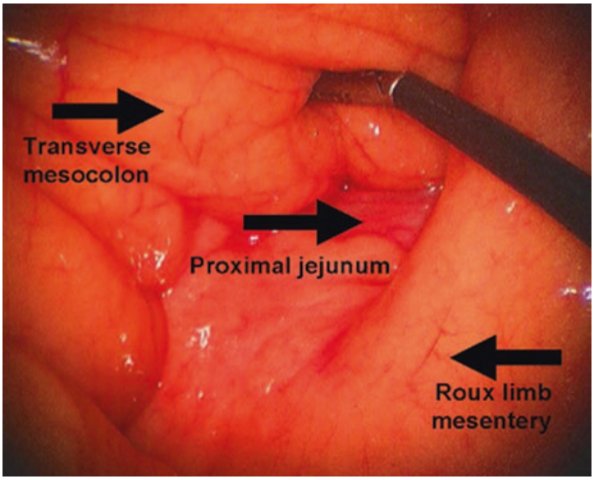


Fig. 49.15 Petersen's defect [14]

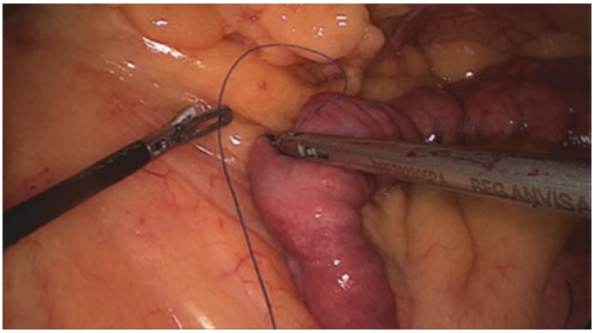


Fig. 49.16 Jejunum fixation to the mesocolon [13]

One study suggested enlarging the jejunojejunal anastomosis with a bidirectional stapling to reduce the risk of kinking of the anastomosis; however, it was related to an increase in digestive bleeding, and further studies are required [4].

Although the closure of mesenteric defects with running nonabsorbable suture is considered the gold standard, there have been other techniques described. The use of nonabsorbable metal clips, for example, has been reported to decrease the mean operation time, but it increases the instrument costs and appears to be slightly less effective than sutures. The stapler technique is another option for closure of the mesenteric defects, which was proven to be effective in comparison with non-closure and safe for routine use [11, 19].

In addition to the primary closing of the mesenteric defects, the routing of the Roux limb via antecolic/antegastric is also an effective measure in preventing internal hernias and bowel obstruction, when compared to the retrocolic/retrogastric position [9].

A Brazilian study suggested a fixation maneuver of the first part of the jejunum to the left side of the transverse mesocolon to prevent its migration and herniation through the Petersen space as an alternative to its primary closure [13] (Figs. 49.16 and 49.17).

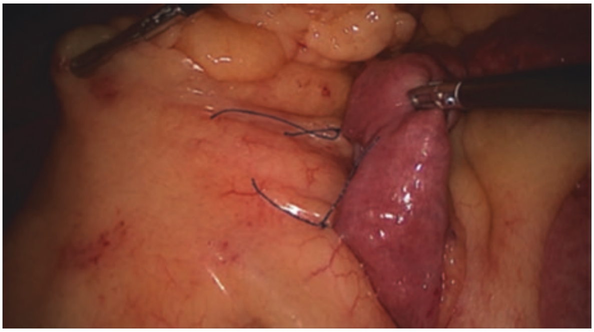


Fig. 49.17 Jejunum fixation to the mesocolon [13]

49.3 Conclusion

The primary closure of the mesenteric defects with running nonabsorbable suture remains as the gold standard method for preventing internal hernias in laparoscopic RYGB and duodenal switch. The closure of the Petersen's space and the mesentery at the jejunojejunostomy should be performed in routine procedures.

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Chapter 50
Management of Portal Vein Thrombosis Following Bariatric Surgery

Grant Jester, Jacob Barish Jacob, and Said Baidas

50.1 Introduction

The number of bariatric surgeries performed yearly has been increasing rapidly with a 10% increase between 2017 and 2018. It is estimated that 252,000 bariatric surgeries were performed in 2018; more than 50% of those surgeries were laparoscopic sleeve surgery [1].

Portal vein thrombosis (PVT) is a rare complication following bariatric surgery occurring at a rate of 0.3–1.0% [2–4]. It is postulated that traumatic injury to blood vessels during bariatric surgery, slow portal circulation due to carbon dioxide pneumoperitoneum, and steep Trendelenburg position contribute to PVT development [3, 4]. Obesity is an independent factor for increased risk of thromboembolism [5].

PVT has been seen in a variety of other conditions including liver cirrhosis; abdominal malignancies such as gastric, pancreatic, and liver cancer; inflammatory bowel diseases; pancreatitis; and abdominal infections such as appendicitis and diverticulitis [6–8]. Oral contraceptive use, pregnancy, abdominal surgery, paroxysmal nocturnal hemoglobinuria (PNH), Janus kinase 2 (JAK2) mutations, and myeloproliferative neoplasms are also linked to PVT [9] (Table 50.1).

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Table 50.1 Common causes of PVT

Acquired disorders	Transient risk factors	Inherited risk factors
Myeloproliferative neoplasms	Intra-abdominal surgery	JAK2 V617 mutation
Cirrhosis	Pregnancy	Factor V Leiden
Solid malignancy	Hormone supplementation	Prothrombin gene G20210A mutation
Antiphospholipid disorder	Intra-abdominal infection	Protein C and S deficiency
Paroxysmal nocturnal hemoglobinuria		Antithrombin deficiency
Autoimmune disease		
Inflammatory bowel disease		

50.2 Presentation

Acute PVT is usually discovered early following bariatric surgery [10]. The most common presenting features are abdominal pain, nausea, vomiting, anorexia, fever, abdominal distension, and occasionally transient ascites and rectal bleeding [6, 11]. PVT if left untreated can lead to further intestinal ischemia with risk of intestinal perforation, peritonitis, and shock [7]. About half of the patients present with unexplained abdominal pain [11].

Chronic PVT following bariatric surgery is usually asymptomatic and is discovered incidentally on imaging. Chronic PVT is rarely associated with bariatric surgery and is generally seen in patients with liver cirrhosis. Chronic PVT may have features of portal hypertension, varices, ascites, and bleeding [12].

50.3 Diagnosis: Imaging and Laboratory Testing

Ultrasound with Doppler is the recommended initial imaging modality used in diagnosis of PVT [6–8]. In the early stages of acute PVT, the thrombus may be hypoechoic and difficult to detect, but later becomes more echogenic and readily apparent [13]. In chronic PVT, cavernous transformation may be seen in addition to a fibrotic or partially occluded segment of the portal vein [7]. Color Doppler provides information on the flow in the PV and can differentiate between partial and complete occlusion. The extent of PVT should be assessed by examining the superior mesenteric vein and intrahepatic branches of the PV using computed tomography (CT) scan or magnetic resonance imaging (MRI); both are more accurate than the ultrasound [14]. CT scan and MRI can also better differentiate actual thrombus from tumor thrombus in malignant states and may be better in identifying ischemic bowel related to PVT [15].

Laboratory testing is neither specific nor helpful in diagnosis of PVT. Liver function tests and bleeding parameters are usually normal unless PVT is associated with liver cirrhosis [7].

50.4 Prophylactic Anticoagulation Following Bariatric Surgery

The 2012 Chest guidelines (ninth edition) for general surgery prophylactic anticoagulation including bariatric surgery advised venous thromboembolism (VTE) pharmacologic prophylaxis with low-molecular-weight heparin (LMWH) or low-dose unfractionated heparin (UFH) in addition to mechanical prophylaxis for patients with moderate and high risk for VTE. For patients with high risk of bleeding, the Chest guidelines recommended only mechanical prophylaxis. For patients in whom both LMWH and unfractionated heparin are contraindicated and who are not at high risk for major bleeding, Chest guidelines suggested low-dose aspirin, fondaparinux, or mechanical prophylaxis. Chest guidelines suggested that inferior vena cava (IVC) filters should not be used for primary VTE prophylaxis in patients undergoing general abdominal-pelvic surgery [16].

The 2019 American Society of Hematology (ASH) guidelines for prevention of venous thromboembolism in surgical hospitalized patients cited the same 2012 Chest guidelines for prophylactic anticoagulation in general and abdominal surgery including bariatric surgery. ASH recommended LMWH and UFH for prophylaxis. ASH recommended extended antithrombotic prophylaxis (more than 3 weeks) over short-term antithrombotic prophylaxis (up to 2 weeks) for major surgery [17].

The Michigan Bariatric Surgery Collaborative study evaluated the effectiveness and safety of three predominant venous thromboembolism prophylaxis strategies among patients undergoing bariatric surgery comparing UFH preoperatively and postoperatively, UFH preoperatively, and LMWH postoperatively and LMWH preoperatively and postoperatively in 24,777 patients undergoing bariatric surgery. The study reported that LMWH is more effective than UFH for the prevention of postoperative VTE among patients undergoing bariatric surgery and does not increase rate of bleeding [18].

Direct oral anticoagulants (DOACs) are well studied in prevention of VTE in orthopedic patients, but no randomized studies have been done to evaluate efficacy or safety in prevention of VTE after bariatric surgery [19]. DOAC trials in VTE prevention following orthopedic hip and knee surgeries included obese patients; the results of these clinical trials may be extrapolated to postoperative VTE prevention in obese patients. Pooled analysis of these studies for obese patients showed DOACs are equally efficacious when compared to LMWH [20]. Comparing dabigatran to enoxaparin in collective analysis of RE-MODEL, RE-NOVATE 1, and RE-NOVATE II trials revealed no statistical difference between the two agents for rates of VTE and risk of bleeding in the BMI > 30 kg/m^2 category [21]. The ADVANCE 2 and

ADVANCE 3 studies which compared apixaban 2.5 mg to Lovenox, a pooled analysis of patients with BMI > 30 kg/m^2, showed no statistical difference in both rate of VTE and risk of bleeding [22]. Lastly for rivaroxaban, a pooled analysis of patients who weighed >90 kg in RECORD 1–4, which compared rivaroxaban 10 mg to Lovenox, revealed a statistically higher rate of bleeding with no difference in the rate of VTE [23].

These studies suggest that DOACs in the usual prophylactic doses can be used for VTE prevention in obese patients. Apixaban is the preferred oral anticoagulant after bariatric surgery due to better absorption in the small intestine. There are still no major society guidelines on using DOACs after bariatric surgery.

50.5 Treatment of Venous Thromboembolism in Obese Patients and After Bariatric Surgery

Obesity can interfere with oral anticoagulants pharmacokinetics (PK) and pharmacodynamics (PD). Obesity may alter parameters such as volume of distribution and drug clearance [24]. Bariatric surgery might affect the pharmacokinetics of the oral anticoagulation agents by bypassing the main site of absorption and by decreasing caloric intake. The clinician must carefully consider these factors when choosing the optimal anticoagulant.

Direct oral anticoagulants are given as fixed dose independent of weight [25]. Warfarin, an oral vitamin K antagonist, is dosed according to international normalized ratio (INR), and low-molecular-weight heparin is dosed mainly according to weight in the presence of normal kidney function [24]. DOACs are the preferred anticoagulant in the unselected patient with VTE due to ease of administration in oral form, fixed dosing, and lack of required monitoring [26]. Direct oral anticoagulants PK/PD is not affected by specific dietary components [20].

The standard **therapeutic** dose of low-molecular-weight heparin enoxaparin in obese patients with normal renal function is 1 mg/kg every 12 h based on actual body weight [27]. In patients with BMI ≥ 40 kg/m^2, a lower dose of 0.75 mg/kg every 12 h is suggested [28]. In obese patients, once daily dosing is not recommended [29]. For VTE **prophylaxis** in patients with BMI 30-39 kg/m^2, the standard dose is 30 mg every 12 h or 40 mg once a day. For high-risk bariatric surgery patients with BMI 40–50 kg/m^2, use adjusted dose of 40 mg every 12 h, and in patients with BMI > 50 kg/m^2, use the adjusted dose of 60 mg every 12 h [30]. It is not recommended to monitor anti-factor Xa in clinically stable patients with weight up to 144 kg, but can be considered in patients with BMI ≥ 40 kg/m^2 [31] (Table 50.2).

The standard **therapeutic** dose of DOACs in patients with normal kidney function is as follows: for dabigatran 150 mg twice daily after completing 5 days of parenteral therapy, for rivaroxaban 15 mg twice daily with food for 21 days followed with 20 mg daily with food, and for apixaban 10 mg twice daily for 7 days followed with 5 mg twice daily. The standard **prophylactic** dose of DOACs in

Table 50.2 Enoxaparin (Lovenox) prophylactic and therapeutic dose with normal renal function

	VTE prophylactic dose	VTE therapeutic dose
BMI 30–39 kg/m^2	40 mg once a day or 30 mg every 12 h	1 mg/kg every 12 h
BMI 40–50 kg/m^2	40 mg every 12 h	0.75 mg/kg every 12 h
BMI >50 kg/m^2	60 mg every 12 h	0.75 mg/kg every 12 h

Table 50.3 DOAC prophylactic and therapeutic dosing

DOAC type	VTE prophylaxis dosing[a]	VTE treatment dosing[a]
Dabigatran	110 mg once after surgery on first day, then 220 mg once daily	150 mg twice daily, after completing 5 days of parenteral therapy
Rivaroxaban	10 mg once daily after hemostasis is established	15 mg twice daily with food for 21 days, followed by 20 mg once daily with food
Apixaban	2.5 mg twice daily after hemostasis is established	10 mg twice daily for 7 days, followed by 5 mg twice daily

[a] Dosing in patients with normal renal function

patients with normal kidney function is as follows: for dabigatran 110 mg once on the first day of surgery and after hemostasis is established 220 mg daily, for rivaroxaban 10 mg daily, and for apixaban 2.5 mg twice daily after hemostasis is established following surgery [32–34] (Table 50.3).

The vitamin k antagonist warfarin is affected by bariatric surgery as patients require decreased dosing of warfarin in the post-surgery period as compared to pre-surgery secondary to decreased absorption and decreased caloric intake [35]. The dosage requirements gradually increase to reach 90% of pre-surgery dose in about 1 year. Monitoring of INR in the postoperative period should be more frequent [35].

The use of DOACs in obese patients becomes increasingly uncertain as patients approach the extremes of obesity with weights >120 kg and BMI > 40 kg/m^2. A review of the available trials on the use of DOACs in treatment of VTE showed that less than 20% of patients included in these trials had a weight of >100 kg [25, 36–44] (Table 50.4).

Extreme obesity (BMI more than 40 kg/m^2) may have variable effects on PK and PD of DOACs and might lead to uncertain correlation with clinical outcome. A study reviewing the pharmacokinetics and pharmacodynamics of rivaroxaban in healthy patients with weights >120 kg revealed no clinically significant differences in both safety and bioavailability [45]. Another phase I study of apixaban in severely obese patients demonstrated a 20% reduction in plasma concentration, but the drug's linear relationship with anti-factor Xa activity held steady [46]. These studies provide some insight into the pharmacokinetics and pharmacodynamics of DOACs in patients with obesity, but experts caution against extrapolating this data for therapeutic purposes in an individual patient [47]. When using DOACs in patients with a BMI > 40 kg/m^2 or weight > 120 kg, some experts recommend monitoring peak and trough levels. However, this is often not logistically feasible and rarely used in clinical

Table 50.4 Percent of obese patients in phase III DOAC studies. Both by weight and BMI

		Weight			BMI		
DOAC type	Included phase III studies	Patients >100 kg	Total patients in study	% patients >100 kg	Patients with BMI >35	Total patient in trial	% patients with BMI >35
Dabigatran[a]	RE-COVER I, RE-COVER II, RE-LY, RE-MEDY, RE-SONATE	4460	24,043	18.5	608	3819	15.9
Rivaroxaban[b]	EINSTEIN DVT, EINSTEIN PE, ENSTIEN EXTENSION, ROCKET-AF	2710	11,883	22.8	972	7131	13.6
Apixaban [25]	AMPLIFY	522	2691	19.4	349	2691	13.0
Edoxaban [44]	HOKUSAI VTE	611	4118	14.8	Did not report		

[a] Only RE-COVER I/II specified by BMI [37–40]

[b] Rocket-AF rivaroxaban study reported on patients with weight above 90 kg, while Einstein studies reported on patients with weight above 100 kg. Rocket-AF was only rivaroxaban study to report BMI [41–43]

practice [20]. The FDA-approved prescribing information for DOACs does not mention dose adjustment for extreme BMI [32]. The international society on thrombosis and hemostasis ISTH 2016 guidelines on use of direct oral anticoagulant in obese patients suggested DOACs not to be used in patients with weight higher than 120 kg or BMI more 40 kg/m^2 due to limitation of available data [20].

Rivaroxaban is absorbed in the stomach and upper part of duodenum, and its absorption depends on presence of food especially the therapeutic doses of 20 and 15 mg, while the prophylactic dose of 10 mg can be given independent of food. Apixaban is absorbed outside the stomach through most of the small intestine [35]. Importantly, the duodenal switch procedure causes significant loss of absorption capacity by reduction of the stomach and bypassing of the proximal small intestine. Roux-en-Y surgery bypasses the duodenum and proximal jejunum [48]. Bypassing the stomach entirely could reduce the max concentration of rivaroxaban by as much 50%; however it is unclear as to the exact effect that partial gastrectomy may have on absorption [49]. Sleeve gastrectomy surgery, which bypasses the stomach, is an example of a situation in which rivaroxaban should ideally be avoided [24]. Ultimately, apixaban due to its intestinal absorption might be the most reliable of the DOACs following bariatric surgery [49] (Fig. 50.1 and Table 50.5).

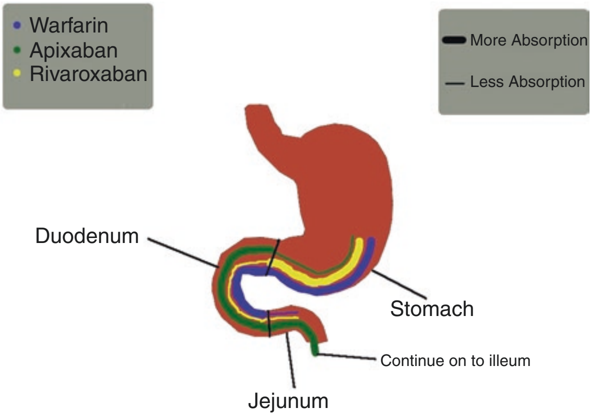

Fig. 50.1 Absorption site of DOACs and warfarin

Table 50.5 Absorption site and impact of food on anticoagulants

Anticoagulant	Location of absorption	Food impact on absorption
Apixaban	Primary: small intestine Secondary: stomach	None
Rivaroxaban	Primary: stomach Secondary: proximal small intestine	Improves absorption; 15 mg and 20 mg doses should be taken with food
Warfarin	Stomach and proximal small intestine	None

50.6 Management of Portal Vein Thrombosis After Bariatric Surgery

The American Chest guidelines recommend anticoagulation of symptomatic patients with PVT and withholding anticoagulation for asymptomatic patients with incidentally discovered PVT [50]. Low-molecular-weight heparin or unfractionated heparin is recommended as the initial therapy [51]. Parenteral agents such as low-molecular-weight heparin or unfractionated heparin are preferable if there are signs of increased risk of bleeding [52].

Anticoagulation treatment for PVT should continue for at least 3 months in patients undergoing bariatric surgery [53]. Longer duration of anticoagulation may be considered if persistent VTE provoking risk factors such as thrombophilia, malignancy, and cirrhosis remain after 3 months, but must be continually balanced against bleeding risk [51].

In rare circumstances, thrombolysis might be considered in treatment of splanchnic vein thrombosis either by catheter directed or systemic therapy. The benefits of this procedure may be heavily outweighed by the increased risk of bleeding [50].

50.7 Conclusion

Acute portal vein thrombosis is a rare event but can lead to severe complications if left untreated. The clinician must have a personalized discussion with each patient regarding the efficacy and risks associated with each anticoagulant treatment. VTE treatment in obese patients undergoing bariatric surgery is challenging given the paucity of data and the associated alterations in pharmacokinetics and pharmacodynamics. Direct oral anticoagulants cannot be routinely recommended for the treatment of portal vein thrombosis following bariatric surgery with current available data [35]. Direct oral anticoagulants are preferred as prophylactic oral anticoagulants in most obese patients with BMI ≤ 40 kg/m^2 because of their convenient fixed dosing. In the future, additional clinical trials focusing on patients at the extremes of weight would be helpful to further delineate the best use of oral anticoagulants.

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Chapter 51
Gallstones and Choledocholithiasis

Marcelo Falcão and Cláudio Vasconcelos

Highlights

- Choledocholithiasis can be present in 10% of people with cholelithiasis and can be a technically challenging problem to treat the population after bariatric surgery.
- Is more likely to find patients with choledocholithiasis who had previously undergone bariatric surgery.
- A reduction in body mass by at least 25% as a predictor for the formation of gallstones after different bariatric procedures.
- ERCP is also graded in patients with biliodigestive derivations as having maximum class 3 difficulty.
- The hybrid approach of laparoscopy-endoscopy for access to the bile duct, whether transgastric or transenteric, is feasible and safe.

51.1 Introduction

51.1.1 Cholelithiasis

Metabolic imbalances related to obesity generate factors for the formation of gallstones, with mainly an increase in the synthesis and secretion of cholesterol. Through its different methods, bariatric surgery leads to a significant and rapid

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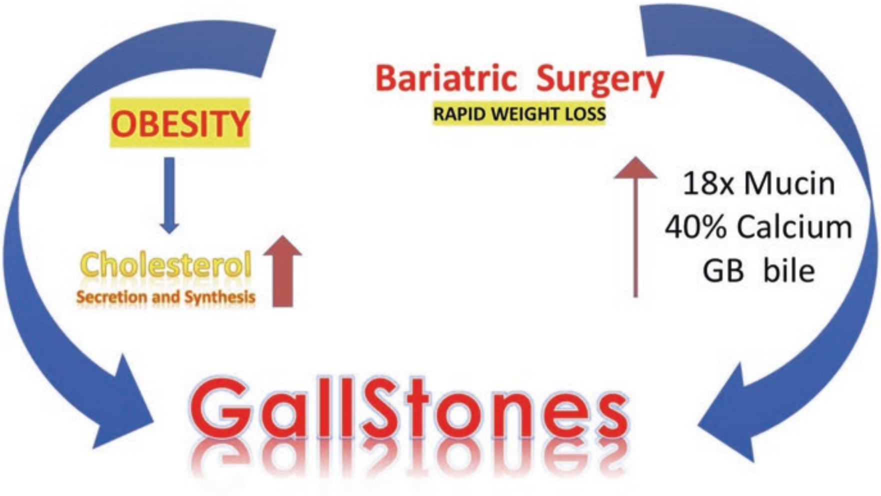

Fig. 51.1 Changes in the composition of bile and increased concentration of mucin (18 times) with an increase in calcium ions (40%). (Source: Own authorship)

decrease in weight. Changes in the composition of bile, which is responsible for the reduction of body mass, lead to a pronounced increase in the concentration of mucin (18 times) with an increase in calcium ions (40%) (Fig. 51.1) [1].

These changes lead to a high propensity to develop gallstones. A prospective study conducted by Schiffman and published in 1991 in *Am. J. of Gastroenterology* [2] showed that in patients undergoing gastric bypass, significant changes in the composition of bile are generated, leading to the appearance of gallstones in 36% of cases in approximately 6 months and evolving as biliary mud in about 13% of cases. In patients who have developed gallstones, almost half (41%) are symptomatic [1–3].

This high frequency led to the search for identifying risk factors for the occurrence of gallstones after bariatric interventions. It has been discovered that traditional risk factors for the appearance of gallstones are not predictive for the formation of gallstones after bariatric surgery. In 2009, Li et al. published in *Surgical Endoscopy* the results of a study that identifies a reduction in body mass by at least 25%, as a predictor for the formation of gallstones after different bariatric procedures [4].

Bariatric surgery has become the most common elective surgery in the United States [5]; in Brazil evaluating 8 years, the number of bariatric surgeries grew 84.73% between 2011 and 2018, according to a survey released by the Brazilian Society of Surgery Bariatric and Metabolic (SBCBM) [6]. In 2018 alone, 63,969 bariatric surgeries were performed, and in the 8 years studied, approximately 424,000 obesity surgeries were performed in the country [6]. With the formation of gallstones at this frequency, we cannot help thinking about their complications, given that the evolution of cholelithiasis and its complications are not different in obese patients compared to the general population.

51.1.2 Choledocolithiasis

Choledocholithiasis can be present in 10% of people with cholelithiasis and can be a technically challenging problem to treat the population after bariatric surgery, due to the altered upper gastrointestinal anatomy. Considering the rapid increase in the number of procedures, he is more likely to find patients with choledocholithiasis, who had previously undergone bariatric surgery, in our health institutions [6].

The experience available to treat these patients is still limited to large centers with adequate expertise and technology. Several approaches have been studied and tried in an attempt to solve this problem; however, the appropriate technique and technology will depend on the type of bariatric surgery performed and its anatomical alteration in the upper digestive tract [6]. It is accepted that the laparoscopic gastric band (LAGB) and the laparoscopic vertical gastrectomy (Sleeve) are surgeries where access to the oral biliary tree is maintained and the endoscopist can use a conventional duodenoscope. The perspective of approaching patients who have already undergone Roux-en-Y gastric bypass (RYGB) or a biliopancreatic such as duodenal switch (DS) [6] is different.

In the scale of difficulty gradation in endoscopic retrograde cholangiopancreatography (ERCP) adopted by ASGE (America Gastrointestinal Endoscopy), which divides the procedures into three degrees, the cholangiogram or pancreatogram in patients with Billroth II is considered grade 2 and any therapeutic intervention in these patients, classified as grade 3 [7]. In the HOUSE classification, ERCP is also graded in patients with biliodigestive derivations as having maximum class 3 difficulty [8].

Solutions for endoscopic treatment of choledochal lithiasis in patients with bariatric surgery (nonabsorbable, restrictive, and mixed) are shown in Table 51.1 [9].

Table 51.1 Endoscopic treatment of choledochal lithiasis in patients with bariatric surgery

• Percutaneous transhepatic anterograde endoscopic access
• Assisted laparoscopic transenteric/gastric endoscopic access
• Laparoscopic exploration of the conventional common bile duct
• Endoscopic access by balloon enteroscopy (double or single)

51.2 ERCP in Patients with Surgically Altered Anatomy

The postoperative anatomy in Roux-en-Y reconstruction is characterized by short (<50 cm) or long (>100 cm) loops, depending on the type of surgery (Fig. 51.2). In patients with Roux-en-Y derivation, several attempts using duodenoscopes, pediatric colonoscopes, and oblique vision endoscopes have been reported with a low success rate of 33–67% [10]. Balloon enteroscopy is more effective in this regard, so several authors [11–16] reported therapeutic success in ERCP with 88% assisted balloon enteroscopy in patients with small bowel loop segments smaller than 150 cm, compared with only 33% for length between 150 and 225 cm and 0% for lengths greater than 225 cm.

It must be taken into account that ERCP assisted by enteroscopy requires specialized accessory catheters due to the length (200 cm) and diameter (2.2–2.8 mm) of the working channel of the commonly used enteroscopy [11]. The arrival on the market of a single-balloon and double-balloon enteroscopy with a 3.2 mm channel facilitates the passage of accessories over 2 mm in diameter, including metallic prostheses, especially in situations in which the endoscope is very angled [17–19]. Due to the technical difficulty of performing broad papillotomy with frontal vision devices, dilation of the papillae with a balloon, after a small papillotomy, is frequently used in these patients. The removal of gallstones is performed with usual accessories (Fig. 51.3).

The risk of complications in ERCP with assisted balloon enteroscopy ranges from 0 to 19.5% of the procedures [20]. In a review of 32 articles, major complications occurred in 32 of 945 (3.4%) procedures, with perforation being the most frequent (13) and sometimes fatal, followed by pancreatitis (11), bleeding (3), and cholangitis (1). There was also a death attributed to cerebral gas embolism [21].

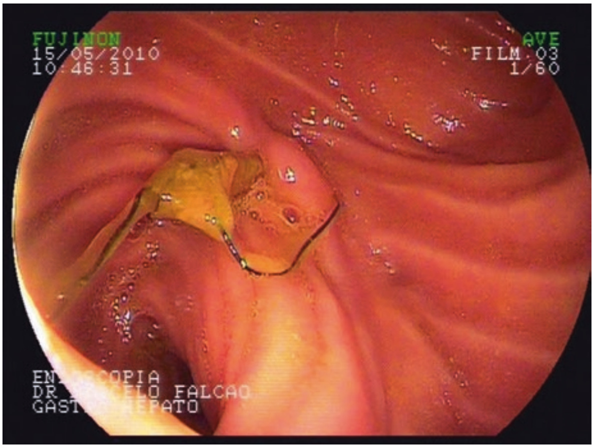

Fig. 51.2 Entero-entero-anastomosis in a patient with Roux-en-Y bypass. (Source: Own authorship)

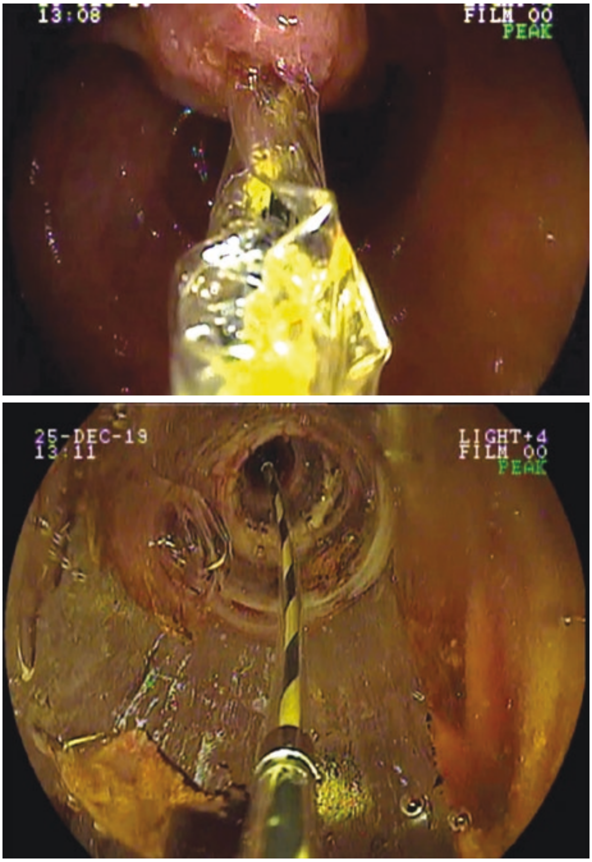

Fig. 51.3 Dilatation of the papilla with a TTS balloon in a gastrectomy patient at BII. (Source: Images provided by Dr. Victor Galvão)

51.3 Transgastric and Transenteric ERCP Assisted by Laparoscopy

The introduction of the duodenoscope directly into the stomach or small intestine loop allows the papilla to be reached. The duodenoscope, in addition to being widely available, makes it possible to perform ERCP using conventional techniques and accessories. Access to the bile duct in duodenal switch (DS)-type biliopancreatic surgery, for LA-ERCP, has the preference of transenteric access, with the introduction of the trocar in the slender biliopancreatic loop, and can use the traditional duodenoscope as well as its accessories; however, the view of work from the papilla to the endoscopist is inverted, making him perform every approach with extreme technical difficulty, requiring from the endoscopist a greater experience in advanced endoscopy, as described by Marchesini JCD et al. in 2017 (Fig. 51.4) [9]. Also, Mutignemi et al. [22] reported this technique successfully in a patient with a normal bile duct diaphragm (3 mm) and is considered high risk and very challenging procedure.

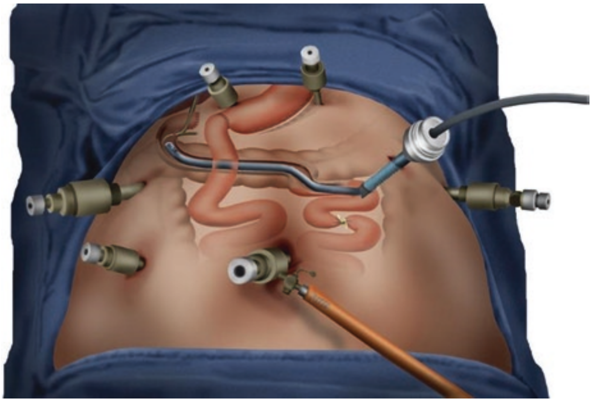

Fig. 51.4 Duodenoscope directly into the stomach or small intestine loop. (Source: Marchesini JCD et al. in 2017)

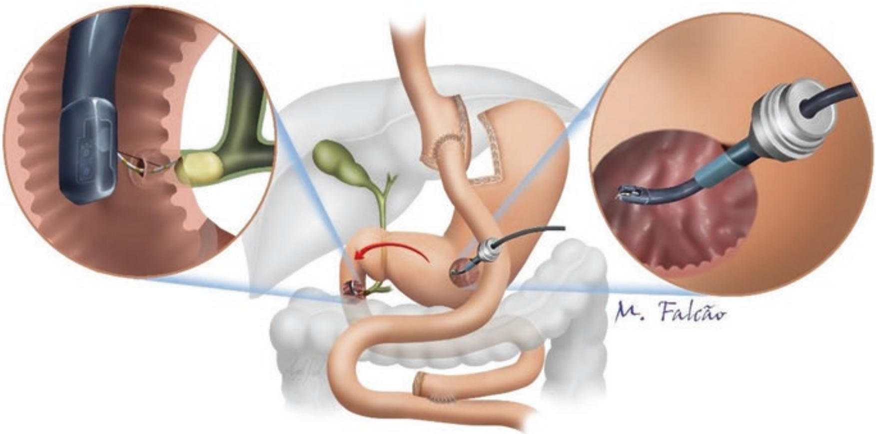

Fig. 51.5 Transgastric ERCP. (Source: Own authorship)

In RYGB, non-surgical access to the excluded stomach to perform ERCP can be done through gastrostomy guided by ultrasound or computed tomography. However, this method has important disadvantages such as the need to mature and dilate the path in a few weeks, limiting its use to elective situations, temporary permanence of the gastrostomy tube after the procedure, risk of serious complications including peritonitis, gastric perforation, tube migration through gastric wall, fistula, hemorrhage, fragmentation of the tube, and leak [23–25].

In this sense, ERCP through transgastric access by laparoscopy in patients with RYGB was first described in 2002 [26]. Since then, it has been used with high success in this situation [27–31] (Fig. 51.5). In a multicenter study that included 388 patients, success in reaching the papilla was achieved in 98% and cannulation of the desired duct in 98%, and the desired intervention was performed in 97% [32].

Two studies directly compared ERCP with balloon-assisted enteroscopy to laparoscopy-assisted ERCP (LA-ERCP). LA-ERCP was superior to ERCP-EBA to papilla identification, cannulation rate, and therapeutic success [33, 34], but there were more complications in the LA-ERCP group in one of the studies: complications occurred in 11 procedures of LA-ERCP (14.5%), in 10 ways related to gastrostomy [34]. Grimes et al. observed a complication rate of 14% (6/42) in the group of patients undergoing transgastric ERCP assisted by laparoscopy. Conversion to open surgery occurred in one case due to the inability to maneuver the duodenoscope through the pylorus [25].

During laparoscopy, the excluded stomach is identified, and a gastrostomy can be performed using a "hook" (Fig. 51.6). The ideal area for gastrotomy is chosen by assessing the mobility of the stomach and the possibility of pulling it toward the abdominal wall. According to Facchiano, gastrotomy should generally be performed in the antrum, 6–8 cm from the pylorus.

After that, two points are passed through the abdominal wall and then on the two opposite sides of the gastrotomy to anchor the stomach. These two points will subsequently be used to lift the stomach and pull it toward the abdominal wall. A 15 mm trocar is inserted through the abdominal wall and introduced into the stomach through the gastrotomy, and the stomach can be fixed to the abdominal wall by pulling the threads on the outside of the abdomen (Fig. 51.7).

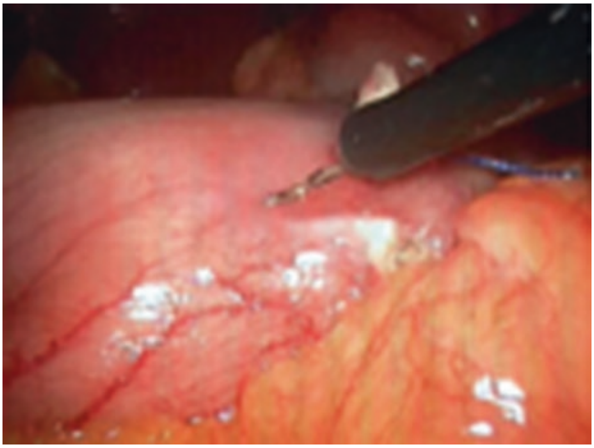

Fig. 51.6 Laparoscopic gastrostomy. (Source: Own authorship)

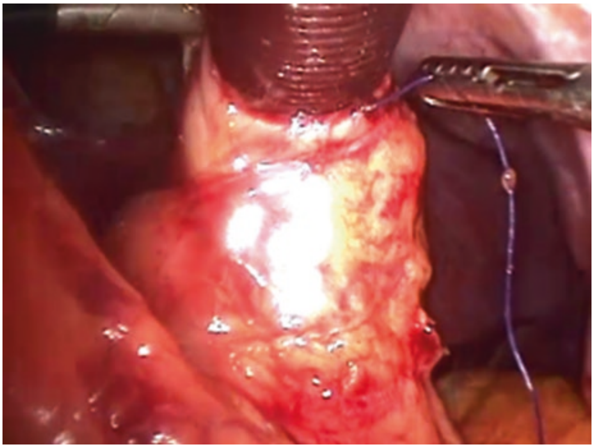

Fig. 51.7 Locator was inserted in the excluded stomach. (Source: Image courtesy of Dr. Victor Galvão)

The wires can then be fixed outside the abdomen using two Kocher, performing a kind of temporary gastrostomy. However, the passage of the 15 mm trocar can be conventional, and after the laparoscopic gastrostomy, the duodenoscope is introduced into the trocar, with the assistance of laparoscopy, immediately following to the gastric cavity, giving greater mobility to the endoscopist, as the stomach is not fixed on the abdominal wall. The lateral view endoscope (duodenoscope) is progressed through the pylorus to the papilla. Generally, no change in the position of the patient or the operating table is necessary. To facilitate the progression of the endoscope, the surgeon can guide the progression of the endoscope by moving the trocar outside the abdominal wall [23].

To avoid gas distension of the slender, an intestinal clamp can be placed in the jejunum shortly after the Treitz angle [35]. Once the biliopancreatic intervention is finished, the endoscope is removed from the stomach, and the stitches used to fix the stomach to the abdominal wall are cut. The gastrotomy is closed using a suture or stapler [23, 35]. In patients in whom the need for repeat ERCP is anticipated, a gastrostomy tube can be left at the trocar site to facilitate access in subsequent procedures.

51.4 Final Considerations

In summary, the hybrid approach of laparoscopy-endoscopy for access to the bile duct, whether transgastric or transenteric, is feasible and safe; however, complicity and training between surgical and endoscopic staff is necessary, in addition to expertise in advanced laparoscopic and endoscopic procedures.

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Chapter 52
Hyperinsulinemic Postprandial Hypoglycemia After Duodenal Switch

Anna Casajoana, Javier Osorio, and Jordi Pujol Gebellí

52.1 Introduction

Duodenal switch in patients with morbid obesity is associated with marked metabolic improvements and glucose control. It is one of the techniques with more weight loss and higher diabetes and dyslipidemia remission rates [1].

As with other bariatric procedures, there are complications in the follow-up. Among these outstands postprandial hypoglycemia as a medical complication. Hypoglycemia can occur in up to 40% of patients after RYGB or sleeve gastrectomy, but it is often paucisymptomatic and therefore probably underdiagnosed [2, 3]. When symptomatic, symptoms of hypoglycemia are fatigue, weakness, confusion, hunger, or/and vagal and sympathetic activation, which presents with perspiration, palpitations, tremor, and irritability [4, 5].

Although infrequent, some patients suffer from severe hypoglycemia with neuroglycopenia that can lead to loss of consciousness and convulsions.

The most common cause of hypoglycemia is the "dumping syndromes," which are secondary to the removal of part of the stomach in the bariatric surgery procedure. This results into a rapid exposure of the small intestine to nutrients. Dumping syndrome has two forms, an early dumping syndrome, in which symptoms develop within the first hour after ingestion, and a late dumping syndrome, in which symptoms develop 1–3 h after. The two forms are associated with different symptomatology. The *early dumping syndrome* is associated with gastrointestinal symptoms

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(including any combination of the following: abdominal pain, bloating, borborygmi, nausea, and diarrhea) and/or vasomotor symptoms (such as flushing, palpitations, perspiration, tachycardia, hypotension, fatigue, desire to lie down, and, rarely, syncope). The underlying mechanisms involve osmotic effects and autonomic neural responses. Hypoglycemia is not frequent in this form. The *late dumping syndrome*, also named postprandial hyperinsulinemic hypoglycemia, primarily manifests with hypoglycemia, which is mainly the result of an incretin-driven hyperinsulinemic response after carbohydrate ingestion [5], although other contributing mechanisms have been described [6].

The literature of hyperinsulinemic hypoglycemia after duodenal switch is scarce. This rare complication after bariatric surgery is sometimes refractory to dietary changes and/or medical treatment and might require revisional surgery. This chapter focuses on diagnosis and treatment of the hyperinsulinemic hypoglycemia after the duodenal switch technique. We report a case of persistent hyperinsulinemic hypoglycemia refractory to medical treatment after duodenal switch that required a conversion to sleeve gastrectomy.

52.2 Etiology

The etiology of this entity is not fully understood, but several mechanisms have been proposed. The basic pathophysiologic mechanism is the rapid exposure of the nutrients to the small intestine after the removal of part (or all) of the stomach. The different techniques, however, present with intrinsic differences. RYGB is associated with the fastest arrival of nutrients to the small intestine (proximal jejunum). This stimulates L-cells to an enhanced incretin response [2, 7]. In duodenal switch, food arrives more slowly, as the residual stomach is larger, and goes directly into de ileum. This fact markedly affects the glucose absorption routes and results in lower peak levels of glucose and insulin and more stable values (less glucose and insulin variability) [2, 7, 8]. For these reasons, symptomatic postprandial hyperinsulinemic hypoglycemia is more often seen in patients who have undergone RYGB than those with a duodenal switch or other restrictive procedures.

52.3 Diagnosis

Hyperinsulinemic hypoglycemia is a diagnostic challenge as there are no consensus criteria. The American Society of Bariatric and Metabolic Surgery (ASBMS) proposed a postprandial hyperinsulinemic hypoglycemia statement: symptoms can be unspecific, but Whipple's triad for hypoglycemia has to be documented: (1) symptomatic hypoglycemia, (2) documented low plasma glucose levels, and (3) resolution of symptoms after glucose administration. However, a detailed history and high level of suspicion are necessary to diagnose postprandial hypoglycemia. A patient journal, with particular attention to dietary history, specific hypoglycemic symptoms, and their temporal relationship, is imperative for diagnosis [3].

52.4 Treatment

There are no consensus guidelines for the treatment for hyperinsulinemic hypoglycemia. Treatment usually involves a combination of dietary modifications and medical or revisional surgery.

1. ***Dietary modifications:*** Patients should be advised to reduce the amount of food ingested at each meal, to postpone fluid intake until at least 30 min after meals, and to eliminate (from the diet) rapidly absorbable carbohydrates (present in all sweet foods and drinks). Instead, patients are advised a diet high in fiber and rich in proteins; consumption of fruits and vegetables is also encouraged. Alcoholic beverages should be avoided as they are rapidly absorbed and increase glucose levels. Patients should also be advised to eat slowly and chew well [9]. A number of studies have evaluated the use of supplements that increase food viscosity, such as guar gum, pectin, and glucomannan, in patients with dumping syndrome [10].
2. ***Medical treatment:*** There are some reports of patients treated x-glucosidase inhibitors (acarbose), somatostatin analogues (octreotide), and potassium channel agonists (diazoxide) and GLP-1 analogs [3, 10].
3. ***Revisional surgery:*** Revisional surgery restoring the gastrointestinal continuity to treat hyperinsulinemic hypoglycemia has been indicated in cases of Roux-en-Y gastric bypass, but not after duodenal switch [11]. There are two main surgical options to restore gastrointestinal continuity after a duodenal switch: (1) side-to-side anastomosis between the alimentary limb and the biliopancreatic limb, as close as possible to the angle of Treitz [12–14], and (2) full anatomic restoration performing a new anastomosis between the duodenal stump and the postpyloric duodenum of the sleeve gastrectomy [15].

52.5 Case Report and Reversal of Duodenal Switch into Normal Anatomy with Sleeve Gastrectomy (Fig. 52.1; See Video 52.1)

We present a 38-year-old male with a body mass index (BMI) of 53 kg/m^2 and both hypertension and sleep apnea who underwent a two-stage duodenal switch. One month after surgery, he presented episodes of postprandial hypoglycemia. After repetitive episodes, blood tests revealed high insulin levels, and a tomography excluded a pancreatic insulinoma. The episodes were refractory to diet modification

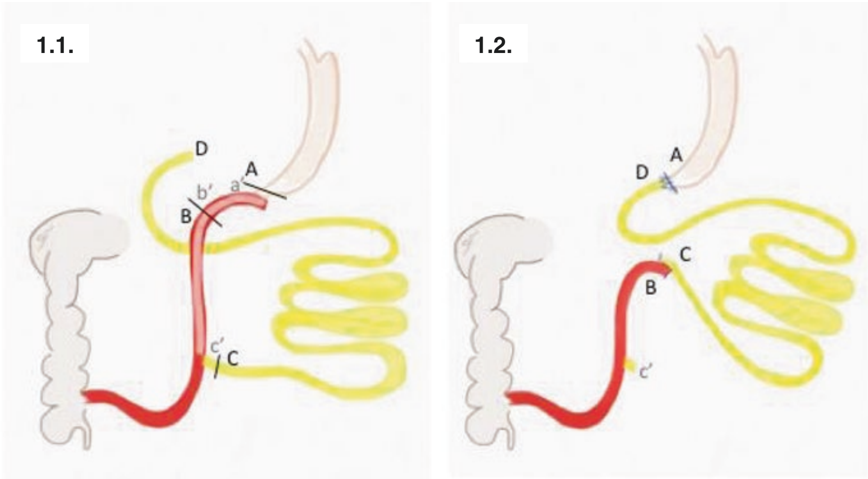

Fig. 52.1 Reversal of duodenal into normal anatomy with sleeve gastrectomy. (1) Duodenal switch anatomy (AB: duodenoiloestomy; D: duodenal stump; Cc' ileoileostomy. (2) Reversal of duoenal into normal anatomy (AD: Duodenoduodenostomy; CB: new ileoileostomy)

and medical treatment. After a consensus meeting between endocrinologists and surgeons, we decided conversional surgery from duodenal switch to sleeve gastrectomy.

We followed these surgical steps: we started with the identification of the duodenoileostomy anastomosis. We next deconstructed the duodenoileostomy and isolated the alimentary limb (Fig. 52.2). We then dissected 2 cm of the duodenal stump (isolated from the previous surgery; Fig. 52.2a–c), and we performed a hand-sewn end-to-end duodenoduodenostomy (Fig. 52.2d). This is the most challenging step in the surgery. A leak test was performed through endoscopy. We next removed the 20 proximal centimeters of the alimentary limb (Fig. 52.3a, b). In the next step, we followed the alimentary limb to the jejunojejunostomy, and we divided the biliopancreatic limb near the jejunojejunostomy (Fig. 52.3c). We then performed the new side-to-side jejunojejunostomy proximally to alimentary limb and distally to biliopancreatic limb (Fig. 52.3d, e). Finally, we closed the mesenteric defect. Our patient had no intra- or postoperative complications, and the patient was discharged after 4 days. One year later, the patient had a BMI of 24 kg/m^2 and did not present episodes of symptomatic hypoglycemia.

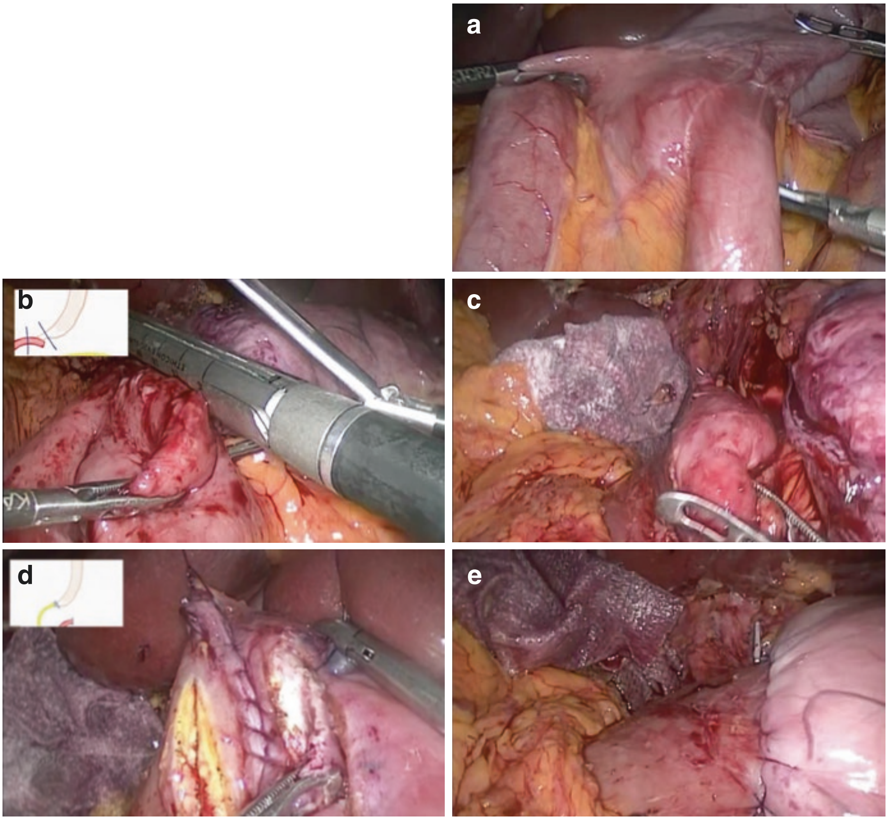

Fig. 52.2 Deconstruction of the previous duodenoileostomy and perform the new duodenoduodenostomy. (**a**) Identify the duodenoileostomy. (**b**) Duodenoileostomy transection. (**c**) Dissection the duodenal stump. (**d**, **e**) Hand-sewn end-to-end duodenoduodenostomy

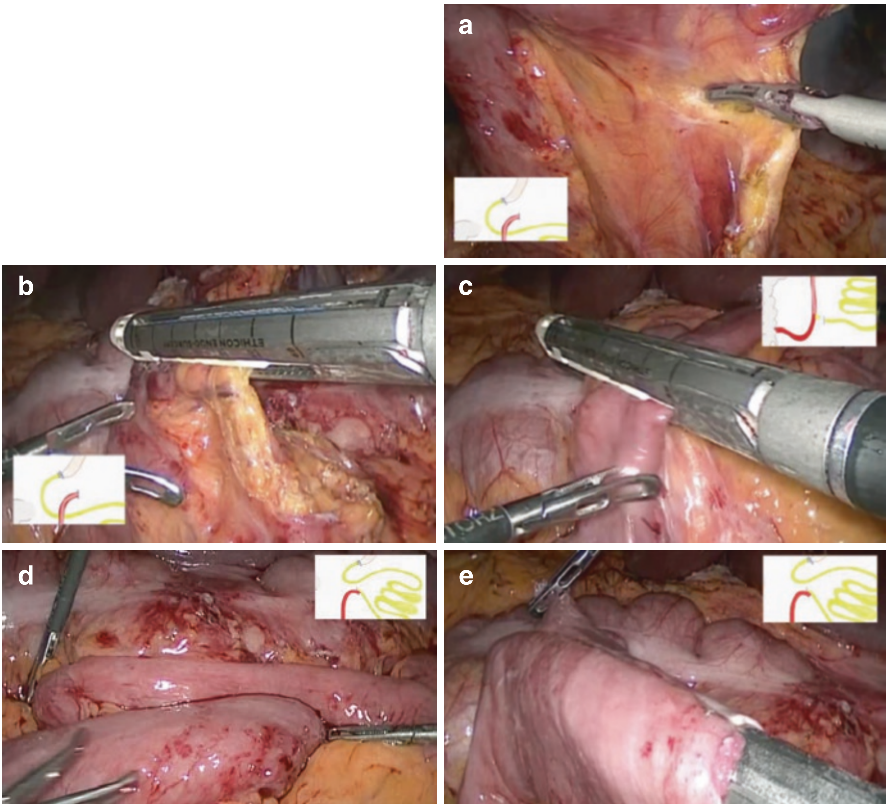

Fig. 52.3 Restoring de alimentary limb. (**a**) Remove the 20 proximal centimeters of the alimentary limb. (**b**) Divide the alimentary limb. (**c**) Divide the biliopancreatic limb. (**d**, **e**) Perform the new side-to-side jejunojejunostomy

52.6 Conclusions

Patients with duodenal switch procedures can develop hyperinsulinemic hypoglycemia as other bariatric procedures. When diet modifications and medical treatment are not effective, we recommend a revisional surgery of duodenal switch to restore the gastrointestinal continuity.

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Chapter 53
Diarrhea After Duodenal Switch: Medical and Surgical Management

Barbara J. Allen and Patrick W. Domkowski

Bariatric surgery has emerged as the primary treatment for chronic morbid obesity disease in the United States and the world. The data supporting the health improvement and reduction in BMI are indisputable. However as more and more people undergo bariatric surgery, the prevalence of certain sequelae following surgery is also becoming more evident. One of these problems that can have a direct impact on the quality of life is diarrhea. The reasons for it after bariatric surgery are numerous and sometimes challenging to treat.

Chronic diarrhea, although infrequent, can become a debilitating problem for patients after bariatric surgery and in particular the duodenal switch.

Bariatric surgery does alter bowel function. The effects are in part determined by the type of bariatric surgery performed. The effects of altered bowel function may also be acute, meaning within the first month of surgery or more chronic in nature, affecting function years later. Diarrhea is one specification manifestation of altered bowel function. Moreover, it has a spectrum of presentation with respect to stool consistency and frequency.

The World Health Organization defines diarrhea as three or more (frequency) loose bowel movement a day. Diarrhea is usually defined as three basic categories: watery, fatty (malabsorptive), and inflammatory. For our purposes we will focus on fatty or malabsorptive diarrhea. Diarrhea can also present as a spectrum to several inconvenient loose bowel movements a day to the other extreme of more than 20 watery bowel movements daily with no ability to leave your house.

Despite the significant effectiveness of the duodenal switch (DS) in ameliorating morbid obesity disease and many of its comorbid conditions, it is yet to be widely adopted by bariatric surgeons or embraced by patients seeking bariatric surgery. The

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DS is performed in less than 1% of all bariatric surgeries worldwide. When evaluating the risk benefit analysis for the DS, many providers and/or patients may be dissuaded against the procedure due to concerns for diarrhea. This chapter will review the pathophysiology of the DS and its impact on diarrhea. It will also review medical and surgical management of diarrhea postoperatively.

53.1 Diarrhea

Alterations in bowel function can be expected after DS surgery due to the anatomical changes. The average number of bowel movements per day following the DS is 2–3 [1]. Diarrhea is generally accepted to be the passage of three or more loose or liquid stools per day or more frequent passage than is normal for the individual.

Diarrhea is generally considered to be one of the commonly accepted operative risks associated with DS surgery as there is a sixfold increase in diarrhea postoperatively [2]. DS patients report higher incidence of bowel movements, flatus, and urgency [2]. Patients with severe diarrhea may also experience dehydration, nutritional deficiencies, physical discomfort, and changes in quality of life.

Diarrhea can be acute lasting 1 or 2 days, persistent lasting longer than 2 weeks but less than 4 weeks, or chronic lasting more than 4 weeks. Diarrhea can be categorized as watery, fatty (malabsorptive), or inflammatory. This chapter will focus more on malabsorptive causes of diarrhea. However, when completing your history and physical exam, it is important to consider other sources that may be causing or exacerbating postsurgical diarrhea.

53.2 Pathophysiology of Duodenal Switch and Diarrhea

The basic anatomical changes associated with the duodenal switch are the restriction caused by the sleeve gastrectomy portion of the surgery and alterations in metabolism caused by the biliopancreatic diversion. The sleeve gastrectomy restricts calorie intake and food choices. Because it is pylorus sparing, it is not associated with “dumping syndrome.” There is a decrease in acidity of gastric contents, but the sleeve anatomy generally does not have much impact on bowel function. However, by diverting food from the proximal to the distal gut, there is an impact on intestinal hormone secretion, decreased fat absorption, and creation of short gut syndrome. It is generally accepted that the common channel length of 100 cm produces the same weight loss with lesser diarrhea and decreased protein deficiency compared to a 50 cm common channel [3]. Although it is individually variable, over time the body will naturally improve absorption of fat until it reaches a new equilibrium [3]. Therefore, consideration of surgical intervention for diarrhea is not generally recommended until after the first year [4].

In normal anatomy, the presence of fat in the duodenum causes the release of the gut hormone, cholecystokinin (CCK), which slows gastric motility and emptying, stimulates pancreatic enzymes release, and causes contraction of the gallbladder with subsequent release of lecithin and bile salts [3]. Lipid digestion and absorption is affected by the diversion of the biliopancreatic limb. Shortening of the common channel can lead to incomplete absorption of dietary fat. Excessive levels of bile acids in the lower gastrointestinal tract may cause diarrhea via one or more mechanisms: altering water and sodium transport; increasing lower gastrointestinal motility; damaging the mucosa; inducing mucus secretion; or stimulating defecation [5]. Fatty acids that are not broken down are passed directly into the colon. Undigested fat leads to lose and frequent bowel movements that may be often hard to control and associated with cramping, foul-smelling diarrhea, and lots of gas.

The diversion of the biliopancreatic limb also affects digestion of starches and complex carbohydrates. Decreased exposure to amylase in the GI tract decreases the time that carbohydrates can be broken down into simple sugars for absorption. In normal anatomy, starch exposed to pancreatic and digestive enzymes is nearly completely hydrolyzed before it has passed beyond the duodenum and the upper jejunum [3]. Many patients report onset of lactose intolerance following bariatric surgery. Incomplete carbohydrate absorption can lead to an increased osmotic load of sugar, with an augmented intraluminal volume (water) and a consequent acceleration of intestinal passage. Gas production and diarrhea occur in connection with the bacterial flora in the colon, the unabsorbed sugar presenting as a substrate for increased bacterial fermentation [6]. Ingestion of sugar alcohols which are not well absorbed in the GI tract can also lead to fermentation and subsequent GI upset with bloating, gas, and diarrhea. The most common forms are sorbitol, mannitol, xylitol, and maltitol. The microvilli of the small intestine further digest starch and other dietary carbohydrates. Over time, the GI tract can compensate with thicker and more efficient villi to counteract the malabsorption and decrease GI symptoms. Another factor contributing to diarrhea is the presence of relatively undigested food passing rapidly through the gastrointestinal tract creating irritation in the ileum [4].

There is reason to believe that bariatric surgery including the DS alters the neuronal and hormonal signaling pathways that regulate pancreatic secretions. The symptoms of pancreatic exocrine insufficiency (PEI) steatorrhea, weight loss, maldigestion, and malabsorption are expressed in both patient populations. Although clinical studies are lacking, it is appropriate to consider pancreatic enzyme replacement therapy in the management of post DS diarrhea [7].

53.2.1 Evaluation of Diarrhea

53.2.1.1 History

Evaluation relies heavily on the patient history. Have the patient describe the onset of symptoms, frequency, and consistency of the stool as well as other associated symptoms like urgency, fever, bloating, abdominal pain, blood, or mucus in the stool. Patients with diarrhea often report fatigue, dizziness, nausea, unplanned weight loss, low urine output, or concentrated urine. Include dietary history and look for potential triggers like sugar alcohols, fatty foods, caffeine, and alcohol. Ask about recent travel and employment (daycare worker, food handler). Review medication list for drugs commonly associated with diarrhea. Do not forget to assess the impact symptoms have on the patient's quality of life. Having three bowel movements a day has a different impact on an office worker versus an over the road truck driver. Some patients report meal skipping behaviors because eating triggers diarrhea.

53.2.2 Physical Exam

The primary focus of the physical exam is to assess for evidence of dehydration, malabsorption, or its sequela. Alterations in general appearance (lethargy), skin turgor, mucous membranes, and vital signs (include orthostatic vitals) are signs of dehydration related to diarrhea. Evidence of muscle wasting, hair loss, ascites, ecchymoses (vitamin K deficiency), temporal wasting, angular cheilitis, glossitis, and peripheral edema is indicative of malabsorption. A general abdominal exam is warranted especially if there are complaints of abdominal pain to rule out an acute abdominal process. If the patient is experiencing neuromuscular signs of muscle weakness or convulsions, severe electrolyte abnormalities are to be suspected.

53.2.3 Testing

It is reasonable to suspect malabsorption in patients with diarrhea following the DS. The most frequent causes are protein, fat, and carbohydrate malabsorption. However, chronic or persistent diarrhea following the DS could be related to deficiency in zinc or selenium ([8, 9], p. 197). While there is no specific serologic test for malabsorption, laboratory tests are helpful to identify specific deficiencies or complications from malabsorption as well as other potential causes of diarrhea. Based on patient history and physical exam, laboratory testing may include CBC, CMP, prealbumin, vitamin B12, folate, 25-hydroxyvitamin D, lipid panel, prealbumin, prothrombin time, carotene, methylmalonic acid, zinc, and selenium. Refer to Table 53.1 for serologic lab testing.

Stool specimens may be helpful to evaluate diarrhea related to surgical malabsorption and to rule out other causes (Table 53.2). Stool tests can be utilized to document fat malabsorption, which is the most sensitive indicator among the macronutrients to identify global malabsorption. Fecal fat can be performed by

Table 53.1 Serologic lab testing

Test	Evaluate for	Findings
CBC	Anemia due to iron deficiency or vitamin B12 or folate deficiency	Microcytic anemia—iron deficiency Macrocytic anemia—vit B12 or folate malabsorption Dehydration—hematocrit elevated
Serum iron, total iron binding capacity	Iron deficiency	Decreased
Vitamin B12, folate	Vitamin deficiency	Decreased
CMP	Protein deficiency, electrolyte imbalances, and organ function	Protein malabsorption—decreased protein, albumin, calcium Dehydration—elevated BUN/Cr, potassium, sodium Diarrhea—decreased potassium, sodium, magnesium, CO_2
Magnesium	Malabsorption	Decreased
Prealbumin	Malnutrition	Decreased
Lipid panel	Malabsorption	Decreased—cholesterol, triglycerides
Carotene	Fat malabsorption	Decreased
25-Hydroxyvitamin D	Fat malabsorption vitamin D	Decreased
Prothrombin time	Fat malabsorption vitamin K	Increased
Methylmalonic acid	Early indicator of vit. B12 deficiency	Increased
Zinc	Malabsorption	Decreased
Selenium	Malabsorption	Decreased

completing a qualitative assessment on a single specimen or a quantitative analysis that requires 72-h fecal fat collection. Instruct patients to consume a normal amount (80–100 g/day) of fat before and during the collection. A fecal fat excretion of >7 g/day indicates fat malabsorption or pancreatic exocrine insufficiency (PEI).

The hydrogen breath test can be used to detect carbohydrate malabsorption as well as small intestine bacterial overgrowth. Glucose hydrogen breath test is more acceptable for diagnosis of small intestinal bacterial overgrowth (SIBO), whereas lactose and fructose hydrogen breath tests are used for detection of lactose and fructose maldigestion, respectively [9].

Sometimes Zollinger Ellison's syndrome (ZES) presents with diarrhea and no other symptoms. If this is suspected at a gastrin level 10 times, the normal findings are suggestive of ZES and require further workup.

It is important to remember that patients with a DS have normal gastric emptying. This was studied. They found that over 80% of patients had normal gastric emptying.

Table 53.2 Stool specimen testing

Test fecal	Evaluate for	Findings
Culture	If bacterial infection is suspected	Bacteria • *Campylobacter* species • *Salmonella* species • *Shigella* species
Clostridium difficile toxin	*Clostridium difficile* especially for patients with diarrhea after hospitalization or following antibiotic therapy	Positive
Ova and parasites	Ova and parasites suggested for those with a history of travel or camping	Positive
Fecal occult blood	Suspected malignancy	Positive
Stool for white	Inflammatory intestinal disease	Positive
Fecal calprotectin	Inflammation	Elevated in inflammatory bowel disease, bacterial infections, some parasitic infections, and colorectal cancer Decreased in irritable bowel syndrome and viral infections
Fecal fat—qualitative	Fat malabsorption	Positive
Fecal fat—quantitative (72-h collection)	Fat malabsorption or PEI	Greater than 7 g/day
Elastase	PEI	Decreased

53.3 General Management of Diarrhea

The goals of management include treating the underlying disease, optimizing the control of diarrhea, identifying and treating nutritional deficiencies, monitoring for recurrence, and optimizing quality of life.

53.3.1 Medical Management of Diarrhea Related to Nutrient Malabsorption

- Have patients complete a food diary and symptom tracker to identify trigger foods.
- Serum laboratory testing to evaluate for dehydration and determine degree of malabsorption as well as vitamin and mineral deficiencies. Serum laboratory testing will also be completed to monitor patient progress (Table 53.1).

- Consider testing to confirm the source of malabsorption (fecal fat, hydrogen breath test, lactose tolerance test) (Table 53.2).
- Nutritional consult for dietary education based on above findings.
- Nutritional support to ensure appropriate protein (80–120 g/day) and caloric intake:
  - Oral nutrition is preferred with food and/or protein shakes.
  - In severe cases, parenteral or enteral supplementation may be warranted. Use caution when initiating high concentrations of dextrose to prevent refeeding syndrome.
  - If prolonged parenteral or enteral supplementation is required, surgical intervention is considered.
- Ensure adequate hydration:
  - Water, sugar-free sports drinks, non-caffeinated beverages.
  - IV hydration is especially helpful when diarrhea is severe or is associated with nausea and vomiting. Infuse normal saline and consider infusing a banana bag (multivitamin, thiamine, folic acid) if indicated. Do not infuse dextrose until a thiamine deficiency is ruled out.
- Replacement of vitamin and mineral deficiencies.
- Exocrine pancreatic insufficiency:
  - Pancrelipase microencapsulated, delayed release (e.g., creon). Initially 30,000 USP units lipase with meals and half of that amount with snacks; adjust gradually to patient needs. Recommended for patients with intact upper GI tract and intact gastric secretions.
  - Pancrelipase, non-microencapsulated (e.g., Viokace). Initially 30,000 USP units lipase with meals and half of that amount with snacks; adjust gradually to patient needs. Inactivated by stomach acid. Use in patients lacking acid-peptic gastric environment or administered with acid-suppressing drugs ([10], p. 11).
- Bile acid malabsorption is usually determined through empirical treatment and resolution of symptoms rather than through testing:
  - Cholestyramine 4 g once daily initially; increase gradually (weekly) to four divided doses; maximum, 36 g/day ([10], p. 11).
  - Please note there is a potential for reduced absorption of other drugs and supplements, and therefore cholestyramine should be administered either 1 h before or 4–6 h after other medications.
  - Unfortunately, use of cholestyramine for chronic diarrhea due to bile acid malabsorption is currently an off-label use and is not always covered by insurance.
- Antidiarrheals can be used to slow transit time and assist with symptom management:

- – Begin with loperamide and advance to diphenoxylate and atropine if needed.
- – A dose of loperamide at bedtime can decrease the number of early morning bowel movements. It may also delay the onset in those who have been previously awakened early in the morning by urgent bowel movements [4].
- – Caution patients that cases of torsades de pointes, cardiac arrest, and death have been reported with the use of a higher than recommended dosage of loperamide.

- Small intestinal bacterial overgrowth:
  - – The use of antibiotics to treat the symptomatic patient with SIB0 is the cornerstone of therapy ([11], p. 172).

    Ciprofloxacin and metronidazole are commonly used.
    Amoxicillin–clavulanic acid, doxycycline, and trimethoprim–sulfamethoxazole may also be considered.
    Rifaximin use is limited by its high cost.

  - – Nutritional support and correction of nutritional deficiencies is an important step in managing SIBO since it is not only associated with malabsorption but can cause malabsorption and vitamin deficiencies ([11], p. 170).
  - – Although a diet low in fermentable oligo-, di-, and monosaccharides and polyols (FODMAP) has been shown to improve bloating and gas in patients with irritable bowel syndrome, there is no strong evidence to support its recommendation in patients with SIBO.
  - – It is common practice to consider probiotics in the treatment of SIBO. Although a small study on Roux-en-Y gastric bypass surgery patients supported the use of probiotics to improve bacterial overgrowth [12], the use of probiotics in the duodenal switch patient is largely empiric.

53.3.2 Patient Education

Having 2–3 bowel movements a day is considered normal.

Complete a food diary and symptom tracker to help identify dietary causes of diarrhea. There are even downloadable apps that can help track dietary intake and bowel patterns. Use of dietary tracking apps to monitor intake of macronutrients (carbohydrates, fats, fiber, proteins, and water) provides data that can help with symptom management and self-care.

Restrict fat to less than 50 g/day.

Whenever possible, eliminate or avoid trigger foods. Ingest triggers foods with or after other foods to increase tolerance.

Read labels to avoid sugar alcohols (sorbitol, mannitol, xylitol, and maltitol).

If lactose intolerant, consider lactose-free milk or addition of lactase. Lactase should be taken with your first bite of food or drink.

Use quality protein supplements as needed to meet a protein goal of 80–120 g daily. Whey *isolate* protein supplements have little to no lactose. Don't drink protein shakes too fast.

Avoid more than one serving a day of caffeine containing beverages.

Avoid full strength sugar sweetened beverages. If consumed dilute with water in a 1:1 ratio.

Compliance with nutritional supplements and lab monitoring is critical to preventing/managing nutritional deficiencies and therefore diarrhea.

Stay hydrated. The general recommendation of maintaining hydration with 64 ounces of fluid daily may not be adequate in the presence of high-water loss with diarrhea. If additional fluids are needed, consider supporting electrolytes with a sugar-free sports drink.

53.3.2.1 Surgical Treatment of Diarrhea

The biliopancreatic diversion (BPD) with the duodenal switch (DS) as described by Hess and Hess in 1998 remains one of the most effective bariatric surgeries for short- and long-term reduction in body mass index as well as amelioration of type II diabetes, one of the diseases most commonly associated with obesity disease [13]. However due to its technical difficulties and purported post-surgical nutritional deficiencies, it has yet to be widely adapted into mainstream bariatric surgeries. Among these side effects are possible protein malnutrition and diarrhea. As reported in the original paper by Hess and Hess in 1998, the length of the common channel was between 50 and 100 cm. This is why it is critical for the DS patient to consume 90–100 g of protein daily.

If diarrhea persists even after both dietary modifications and prescription medications have been exhausted, then surgical revision may be an option. There are several case reports in the literature of patients that have had successful elimination of their diarrhea through revisionary surgery.

However, it is important to note that the perception that the duodenal switch may cause more frequent bowl habits compared to other bariatric surgeries is not true. A study by Wasserberg and colleagues compared the bowel habits of gastric bypass patients to duodenal switch patients. Although the duodenal switch is associated with more bowel episodes than the bypass, the difference was not statistically significant [14]. Fysekidis and colleagues reported that the average number of bowel movements per day for 43 pre-op patients was 1.9 [15]. Postoperatively the frequency of bowel habits was measured at different time intervals and compared with preoperative values. Six months after surgery, the average number was 2.7. Twelve months following surgery that was 2.6 and 36 months was 2.8. None of these measured time points were significantly different to the preoperative number.

In another study, Sovik and colleagues did a comparative study on the duodenal switch and the gastric bypass effects on bowel habits [16]. They had followed up at 1 and 2 years after surgery, and participants were surveyed. They reported an increase in both the amount of bowel habits and anal leakage following the switch compared to the gastric bypass.

The concept of revising a bariatric surgery due to refractory diarrhea is not unique to the duodenal switch. Revisional surgeries have also been in gastric bypass patients. In 2012, Appresai and Murr reported the lengthening of the common channel in a gastric bypass patient suffering with chronic diarrhea and decreased quality of life [17]. The patient had an original distal gastric bypass with a 150 cm reported common channel. At the time of the revisionary surgery, 50 additional centimeters was switched from the biliopancreatic limb to the alimentary limb. This ameliorated the diarrhea and returned the patients serum albumin to above 3 g/dL. Therefore, the length of the common channel and thus the absorptive intestinal surface area appears to be the chief determinant in frequency of diarrhea.

This has been reported with "very very long" limb bypasses where the common channel is shorter [18]. Nelson and colleagues reported this name for their surgery. The Roux limb was made between 300 and 500 cm with a 100 cm common channel that the incidence of diarrhea significantly and negatively impacting the quality of life was 4%. All of these patients required surgical revision to increase the length of the common channel 100–200 cm. This surgical maneuver increases the absorptive capacity of the small intestine, thereby increasing serum albumin and water absorption, thus leading to less diarrhea. Physiologically, this increases the surface area of absorption and thereby effectively eliminates the diarrhea in these refractory cases. The fact that there are only case reports in the surgical literature speaks to their rarity.

Conceptually the surgery involves lengthening the common channel. However, it is by definition considered revisional bariatric surgery and therefore must be undertaken with an even greater level of hyper vigilance. Most importantly, the intestinal limbs must be correctly identified before anything transacted and re-anastomosed. In the BPD-DS, this would include identifying the alimentary limb, the biliopancreatic limb, and the common intestinal channel. Typically, the common intestinal channel in the DS is between 50 and 100 cm in length. Increasing it to 150–200 cm will generally increase absorption of nutrients enough to eliminate the diarrhea.

A variation of the traditional duodenal switch is the single anastomosis duodenoileal bypass with sleeve gastrectomy (SADI-S) [19]. This is a potentially a promising alternative to the traditional duodenal switch with purported less gastrointestinal sequel. Nonetheless, a concern of this variation is the chronic diarrhea and potential hypoproteinemia. A single site experience reported a 6-year experience with the SADI-S. Horsey and colleagues reported a significantly reduced number of average bowel movements from 9 to 2.6 with common channel lengthening with the SADI-S. Since this is a loop switch, the duodenal ileostomy has to be redone.

As reflected in the published literature, the vast majority of patients with diarrhea can be managed medically through a combination or dietary modifications and medications. In those refractory cases, surgery can be performed to decrease malabsorption by returning more small bowel intestinal length to the food stream.

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Chapter 54
Endoscopic Treatment of Complications

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Highlights

- Among surgeries with a mixed functioning component, the duodenal switch (DS) is important because it can provide considerable weight loss.
- The DS procedure is associated with greater short- and long-term morbidity than any contemporary bariatric procedure.
- More than a third of DS patients require readmission for a related procedure. Complication is 50% more than that associated with the Roux-en-Y laparoscopic gastric bypass (RYGB) gold standard.
- Nutritional abnormalities due to malabsorption after DS are 2.5 times more likely to occur compared to after a laparoscopic RYGB.
- Liver abnormalities after DS are 7 times more likely to develop than after laparoscopic RYGB.
- Complications related to stenosis and fistulas can be managed endoscopically.

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54.1 Introduction

Obesity stands out as an important predictor of several public health problems, which can cause serious comorbidities [1]. Currently, about 30% of the world's population is overweight or obese. In 2020, over 60% of the world population reached overweight or obesity, with a prevalence in 2030 of 11% [1]. It is estimated that by 2025 Brazil will find itself in fifth place in the world ranking, with 18.0 million people [2].

In this scenario, bariatric and metabolic surgery can contribute to reducing the impacts of obesity and its comorbidities [3, 4]. Among the procedures, four are currently recognized in the United States by national health agencies, insurance companies, and medical societies. These procedures include the adjustable gastric band, the Roux-en-Y gastric bypass (RYGB), the duodenal switch (DS) with biliopancreatic bypass, and, the most recent procedure, vertical gastrectomy. All procedures are generally performed by laparoscopy or robotically [4, 5].

In this context, Marceau and colleagues [6] published the first DS report in 1993. Rabkin and colleagues [7] and later Ren and colleagues in 2000 described the laparoscopic approach [8]. The first long-term report with a large series of 701 patients operated on at the University of Southern California was published in 2003 [9]. It is universally accepted that DS is the most effective procedure to achieve weight loss and has the best results among all four operations, with sustained results in the long term of more than 70% (EBWL) [10, 11]. This is also the most effective procedure for resolving the main comorbidities, such as type 2 diabetes mellitus, sleep apnea, hypertension, and dyslipidemia [10–12].

Despite this, the DS did not gain popularity. The reasons include the massive malabsorption component, which has major metabolic side effects, including protein malnutrition, nutrient and vitamin deficiencies, and the relative technical complexity of the procedure [13, 14]. Also, multiple anastomoses, including the complex duodenoileal anastomosis and the long-staple lines of the associated vertical gastrectomy, have not facilitated its laparoscopic adoption [15].

Also, the DS procedure is associated with greater short- and long-term morbidity than any contemporary bariatric procedure. More than a third of DS patients require readmission due to a procedure-related complication that is 50% more than that associated with the Roux-en-Y laparoscopic gastric bypass (RYGB) gold standard [16]. Nutritional abnormalities due to malabsorption after DS are 2.5 times more likely to occur compared to after a laparoscopic RYGB. Liver abnormalities after DS are 7 times more likely to develop than after laparoscopic RYGB [16].

In this context, in an attempt to reduce DS complications, a variant of biliopancreatic deviation with a duodenal switch (BPD-DS), called a single anastomosis duodenal switch (SADS), has been popularized worldwide, but the number of published reports has small compared to other bariatric surgical procedures [16]. SADS procedure is a type of duodenal switch that involves a loop anastomosis instead of the traditional Roux-en-Y reconstruction. This modification simplifies the procedure, decreases the complication rate, and combines the physiological factors [16].

Recently, surgery to preserve the intestinal pylorus of the stomach (SIPS) was introduced as a simpler and potentially safer variation of the DS. It is a single proximal duodenal-ileal end-to-side anastomosis with vertical gastrectomy [14–16]. Although safe and effective, DS surgery can course with serious complications such as fistulas [5, 17].

54.2 Major Approaches on the Duodenal Switch

54.2.1 General Information: Duodenal Switch

The biliopancreatic deviation was first described by Scorpinaro in 1979. This procedure combined a horizontal gastric resection with the closure of a duodenal stump, gastroileal anastomosis, and an ileoileal anastomosis, to create a common 50 cm canal and a 250 cm alimentary canal [18]. Patients undergoing this procedure suffered from biliary gastritis, which is why it was changed to the DeMeester duodenal exchange procedure in 1987 [18]. The DS evolved into a modern biliopancreatic bypass with a duodenal switch procedure that includes a vertical gastrectomy, the transection of the duodenum distal to the pylorus, and the creation of a 200–250 cm long food tube [19, 20].

The surgical technique of DS is a variation of intestinal bipartition (BDP) designed to combat bile reflux [21, 22]. It was established when Hess and colleagues associated a vertical gastrectomy with pyloric preservation to intestinal deviation [23]. Currently, it corresponds to less than 5% of the procedures performed in Brazil, and weight loss can exceed 70% of the total body weight [21]. Biliopancreatic diversion with a duodenal switch can be performed using an open or laparoscopic approach.

54.2.2 Major Complications

Biliopancreatic deviation with DS complications can be divided into early and late complications. Common early complications are anastomotic leak and hemorrhage. The main complications are listed below [24, 25].

54.2.2.1 Leak

The incidence of gastric or duodenal leakage after biliopancreatic diversion with a duodenal switch is 1.14% vs. 1.12% for Roux-en-Y gastric bypass [24]. The location of the leak appears to be more common in the duodenoduodenal anastomosis [25]. The risk of leakage of the longitudinal gastric staple line is minimal compared to the leakage rate of the gastric staple line in the gastric bypass procedure. These patients may be asymptomatic, but they often have tachycardia, which is usually the first sign. They may also have tachypnea and be feverish. The diagnostic test of choice for an anastomotic leak should be a computed tomography scan with oral and IV contrast, high sensitivity, and specificity. If the leak is acute (<5 days), they may return to the operating room for exploration with repair and placement of a distal feeding tube [26]. When there is adequate drainage of the abdominal cavity, endoscopic treatment may be indicated.

Computed tomography is the best imaging method for the diagnosis of fistula and helps to guide the management of the need or not for abdominal drainage, although it is questioned for the diagnosis of fistula in patients with a BMI greater than 50 due to the size of the waist, abdominal [27]. Also, in patients in whom the cavity drain remains in place, methylene blue administered orally can be very helpful in confirming the fistula [28].

The use of endoscopic treatment represents a surgical treatment option. From the use of the self-expanding prosthesis, the endoscopic treatment appeared, initially, for malignant fistulas and spontaneous perforation of the esophagus (Böerhaave syndrome), and, later, it was proposed for postoperative fistulas [28–30]. Besides, dilation and septotomy allow earlier resolution of chronic fistulas [31].

54.2.2.2 Endoscopic Treatment

Conventional surgical treatment of fistulas brings high morbidity and mortality, due to the high complexity of the proposed procedures, such as total gastrectomy and fistulojejunostomy. Thus, the endoscopic approach has been gaining popularity and encompasses internal drainage methods: septotomy, balloon dilation, double pigtail stents (DPS), and vacuum endoscopic therapy. Some methods of intraluminal leak block are also proposed, such as placement of an endoscopic prosthesis, endoscopic suture, and clips apposition, with variable results. The choice of treatment is related to the chronicity of the fistula. More acute conditions, with intense leakage of gastric content, require immediate blockage of the fistula to control intracavitary contamination. Chronic cases, with intense fibrosis, require some sessions of septotomy and dilation, to reverse the stenosis and allow internal drainage of the abscess [31].

54.2.2.3 Blocking Methods: Self-Expanding Metal Prosthesis

One of the most common endoscopic strategies is external drainage (surgical or percutaneous) associated with the placement of a self-expanding metallic prosthesis, self-expandable metallic stents (SEMS). The prosthesis aims to occlude the fistulous orifice and promote a deviation of the flow of the intraluminal content, in addition to correcting any stenoses linked to the perpetuation of the fistula.

The technique is based on the intragastric placement of an esophageal or bariatric prosthesis with the aid of a guidewire, under the endoscopic vision and radioscopic control. This strategy has good results for cases of acute and early fistula, together with control of leakage of secretion into the abdominal cavity and reduction of sepsis. However, in late and chronic cases, success rates are lower, due to the extensively fibrotic tissue and chronic stenosis. Also, some complications can happen, such as migration, stenosis, ulceration, and intolerance [32].

Thus, this treatment must be performed in centers with an advanced bariatric endoscopy service with experienced professionals. The prosthesis must be removed early to avoid complications, usually between 2 and 4 weeks.

54.2.3 Internal Drainage Methods

54.2.3.1 Septotomy with Dilation

Late and chronic cases are commonly associated with distal stenosis and the presence of a fibrous septum between the perigastric abscess and the intraluminal cavity. The septotomy consists of the section of the septum with electrocoagulation or argon plasma, followed by dilation with a 30 mm achalasia balloon with the aid of Savary's metallic guidewire, under direct endoscopic view. The communication between the abscess and the intragastric cavity and the reduction of intraluminal pressure allows internal drainage of the abscess, leading to the closure of the fistula [32].

54.2.3.2 Internal Drainage with Pigtail Drain

Internal drainage with a double pigtail stent (DPS) is a relatively recent technique for the treatment of fistulas. The technique is based on the insertion of a DPS through the fistulous orifice, so that one end is coupled in the cavity to be drained and the other in the gastric lumen, to avoid migration and allow drainage to the gastrointestinal lumen. The device creates an internal drainage system, and the foreign body reaction stimulates the tissue to re-epithelialize, being very useful for abscesses with a long fistulous path. In a period between 4 and 6 weeks, the device is changed, and, depending on the length of the fistula, different gauges of the same type of drain can be used. In some cases, a nasojejunal tube for enteral nutrition is inserted. The technique has been showing results comparable to treatment with SEMS with a lower rate of complications and early removal due to intolerance [32].

54.2.3.3 Vacuum Endoscopic Therapy

The good results of the treatment of fistulas of the gastrointestinal tract, especially for cases of esophageal fistula, with endoscopic vacuum therapy (EVT), motivated its application for the treatment of fistula after bariatric surgery. The traditional technique is based on the insertion of a polyurethane sponge in the abscess cavity, which covers and reduces the fistula orifice, followed by the application of a negative pressure that promotes an active internal drainage system, removing the secretion from the wound and reducing the interstitial edema. Also, the sponge induces a foreign body reaction, and the negative pressure stimulates the microcirculation, leading to a greater supply of growth factors and accelerating the formation of granulation tissue. The works reported in the literature demonstrate a high success rate [33].

Despite the enthusiasm, some disadvantages are observed when the technique is compared to other methods, such as the high amount of necessary endoscopic procedures, 11.3 per patient with sessions being performed every 3–5 days, to change the sponge, which can adhere to the granulation tissue and cause injury if the removal is delayed as well as making it difficult to remove, with the risk of fragmentation of the device and the need for a surgical approach. Besides, the polyurethane sponge system is related to difficulty in crossing the cricopharyngeal space due to the friction that is promoted.

54.2.3.4 Hemorrhage

Hemorrhage is most commonly seen with laparoscopic gastric bypass in open procedures [34]. Postoperative hemorrhage is treated at the surgeon's discretion, depending on the patient's clinical condition [35]. In cases of bleeding in the stapling line or an ileum duodenal anastomosis, endoscopic treatment is possible with the placement of clips, sclerotherapy, use of thermospray, or ablation with argon plasma.

54.3 Final Considerations

Biliopancreatic diversion with a duodenal switch is a common weight loss procedure that is gaining popularity. The procedure is still not as common as vertical gastrectomy and Roux-en-Y gastric bypass. Long-term studies have shown similar results in patients with Roux-en-Y gastric bypass, vertical gastrectomy, and biliopancreatic bypass with duodenal switch. The main differences demonstrated are that super obese patients with a BMI >50 kg/m^2 can lose more weight and maintain weight loss better than other bariatric procedures. Biliopancreatic bypass with duodenal switch has also been shown to have a better effect on diabetes and on reducing hyperlipidemia than other procedures [34]. The caveat is that this procedure requires an adequate follow-up program, as there is a greater risk of nutritional deficiencies compared to other bariatric procedures [35].

The appearance of postoperative fistula represents a great challenge, being difficult to diagnose, and its treatment is complex and multidisciplinary [36]. Therapeutic options range from conservative clinical treatment to laparotomy with primary closure of the fistula and, in cases of abdominal contamination, which are mostly radiological or laparoscopic drainage [37]. Endoscopic treatments are performed in cases where there is stability and can be performed at all stages in cases of fistulas.

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Chapter 55
Global Analysis of Our Experience with Hypoabsorptive Technique: >500 Cases DS vs. SADI-S

Jordi Pujol Gebellí, Claudio Lazzara, and Javier Osorio

55.1 Introduction

Obesity is a worldwide epidemic, with rates that have tripled from the 1970s [1]. The duodenal switch (DS) procedure has proven to be the most effective bariatric intervention for the treatment of morbid obesity and related metabolic diseases [2–6]. However, it accounts for a small percentage of current bariatric procedures, mainly because of complex technique, long surgical time, and risk of postoperative complications and mid-/long-term diarrhea and malnutrition [7, 8]. In order to simplify the procedure, Sánchez-Pernaute and Torres introduced in 2007 the DS with one anastomosis, named single-anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) [9]. Technically, DS and SADI-S have the same sleeve gastrectomy, having DS a Roux-en-Y and SADI-S a one loop Billroth II-like gastrointestinal tract reconstruction; by avoiding the distal ileoileal anastomosis with a large total alimentary limb, SADI-S was expected to decrease operating time and postoperative risks of leak, obstruction, internal hernia, and malnutrition while maintaining the principles and efficacy of DS [10]. Both surgical procedures might be primary or two-stage procedures for super-obesity patients or revisional techniques for insufficient weight loss or weight regain after sleeve gastrectomy (SG). Although there is little information on SADI-S safety and efficacy, the simplicity of the procedure, in comparison with DS, has caused an increasing interest among bariatric surgeons. The aim of this chapter is to present and share the outcomes of DS and SADI-S in terms of weight loss, postoperative complications, comorbidities

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remission, and nutritional deficiencies in our high-volume center with more than 10 years of experience in DS and SADI-S.

We reviewed the charts of a surgical cohort of patients submitted to DS or SADI-S from May 2006 to December 2018 in our single high-volume center. Patients were considered for bariatric surgery according to current guidelines following the NIH criteria [11]. According to our hospital bariatric surgery algorithm, we performed both techniques in subjects with BMI >45 kg/m^2 with no symptomatic gastroesophageal reflux. We included subjects with primary and two-stage procedures. Since initial experience with SADI-S in 2014, there were no different indication criteria established between DS and SADI-S in our hospital during this period. All patients were informed about the various surgical procedures for weight loss at an educational seminar. Then, they had an individual visit with the surgeon, with whom risks and potential benefits were discussed before they signed specific informed consent.

55.1.1 How We Do It

Prior to surgery, all patients were visited by each member of the multidisciplinary team (endocrinologist, nutritionist, psychologist, pneumologist, surgeon, and anesthesiologist). Education seminars were done including dietary, psychological, and physical counseling support. Two weeks before surgery, the subjects followed a high-protein liquid diet for extra weight loss. Patients who gained >10% weight in this whole preoperative process were excluded for surgery in a multidisciplinary committee.

Both procedures were performed in the same position. Surgeon was placed between the patient's legs except for the measuring of the small intestine, when he changed to the patient's left side. Six trocars were placed in the supraumbilical abdomen (two trocars of 12 mm in the mid-clavicular line, 2 of 10 mm in the midline for the camera and subxiphoid line for the liver retractor, and 2 of 5 mm, one in the anterior-axillary line for the first assistant and the other one in the left lower quadrant for bowel measurement). First step, we dissected the duodenal bulb until the gastroduodenal artery, with a systematic ligation of the right gastroepiploic vessels, as well as the right gastric artery, in order to reduce tension in the duodeno-ileal suture. Second, a sleeve gastrectomy over a 42 Fr Bougie with Seamguard® was performed. Then, we transected the duodenum with a blue linear stapler using Seamguard®. After that, in case of SADI-S, we measured the 300 cm of the small bowel proximal to the ileocecal valve, and we performed and tested a two-layer hand-sewn end-to-side duodeno-ileal anastomosis with a common limb length of 300 cm. In the initial experience with DS, this anastomosis was mechanical linear side-to-side with GIA®; since 2009, we have changed to end-to-side two-layer hand-sewn anastomosis with absorbable suture. In DS, we then performed an enteroenteric side-to-side anastomosis with a white linear mechanical stapler leaving a common limb length of 100 cm and an alimentary limb of 200 cm. In both procedures, the total alimentary limb length was 300 cm. We systematically closed the mesenteric and Petersen defect with a nonabsorbable running suture. Since 2015, hiatal hernia has been systematically looked for and repaired intraoperatively. Finally, we placed a drain in the duodenal stump and in the angle of His [12].

During hospitalization, patient education was reinforced by a nutritionist. After hospital discharge, patients were followed at the outpatient hospital by responsible surgeons, endocrinologists, and nutritionists for at least 6 years. Endocrinologist follow-up included at least two blood tests during the first year and then yearly, or more often if needed, in order to detect possible nutritional, vitamin, and micronutrient deficiencies. Whole nutritional supplementation included a multivitamin treatment with extra doses of vitamin D, calcium, and proteins.

55.1.2 Our Register

Data were prospectively entered in our bariatric unit's database including sex; age; maximum weight and BMI; obesity-related metabolic comorbidities; type of surgery (surgical approach, 1 or 2 stage and associated procedures); 30-day complications (type and Clavien-Dindo severity score); 30- and 90-day mortality; weight evolution after surgery at 6 months, 1 year, and then yearly; as well as comorbidity resolution; need of extra supplementation to treat nutritional, ionic, or vitamin deficiencies; and need for revisional surgeries. Primary outcome was weight loss expressed as a percentage of total weight loss (%TWL) or as percentage of excess weight lost (%EWL) at 2 years (Table 55.2). Percentage of EWL was calculated taking as reference an ideal BMI of 25 kg/m^2. Secondary outcomes were 30-day complications (type and Clavien-Dindo severity score); 30- and 90-day mortality; remission rates for type 2 diabetes, hypertension, dyslipidemia, and obstructive sleep apnea (OSA); and need of extra supplementation aside from the routinely given to treat nutritional deficiencies. Resolution/remission of comorbidity was defined as the indication of complete withdrawal of all specific treatment by the patient's treating doctor.

55.1.3 Statistical Analysis

Continuous variables were expressed as mean ± standard deviation or median (interquartile range) as appropriate. Differences between both techniques were evaluated using a parametric test (χ^2 for categorical variables and *t* test for continuous variables). No hypothesis testing was done, and therefore, no sample size was calculated, as recommended in http://nature.com/articles/d41586-019-00857-9 for cohort comparative studies. All statistics were analyzed with the IBM-SPSS Statistics Version 20 computer software. A p value <0.05 was considered statistically significant.

55.1.4 Our Experience

We present our results of 581 cases that underwent high absorption techniques (DS and SADI-S). Of those, 323 underwent DS (55.6%) between May 2006 and December 2020 and 258 underwent SADI-S (44.4%) between May 2014 and December 2020.

Table 55.1 shows the preoperative and 2 years postoperative demographic data of the patients. Gender, BMI, and rate of comorbidities were comparable between groups except for sleep apnea that was higher in the DS group ($p = <0.01$). SADI-S patients were slightly older with a lower rate of OSA. All the procedures were done laparoscopically except 11 patients in the DS group and 4 in the SADI-S group due to adherences because of previous abdominal surgery. One-stage procedure as a

Table 55.1 Demographics characteristics of patients included in the analysis

	Preoperative			Postoperative 2 years			Change	
	DS *n* = 323	SADIS *n* = 258	*p*	DS *n* = 202	SADIS *n* = 79	*p*	DS/SADIS	*p*
Gender			n.s.					
Male *n* (%)	86 (26.5)	63 (24.4)						
Female *n* (%)	237 (73.1)	195 (75. 6)						
Age, year mean (SD)	48.8 (± 9.9)	50.4 (± 9.3)	n.s.					
Weight, kg (SD)	136.2 (± 24.2)	134.7 (± 22.3)	n.s.	80.42 ± 13	85.44 ± 16.5	**0.008**	− 5.02 [− 8.7 to − 1.3]	
BMI (SD)	51.16 (± 6.4)	50.5 (± 6.2)	n.s.	30.51 ± 4	31.99 ± 5.1	**0.011**	− 1.48 [− 2.6 to − 0.3]	
Any comorbidity			n.s.					
Diabetes *n* (%)	121 (37.7)	85 (33.5)	n.s.	19 (15.2)	12 (14.3)	n.s.		
Hypertension *n* (%)	181 (57.6)	141 (55.5)	n.s.	70 (37.6)	48 (34)	n.s.		
Sleep apnea *n* (%)	183 (57)	101 (39.8)	**<0.001**	31 (17)	14 (14.3)	n.s.		
Dyslipidemia *n* (%)	108 (33.6)	70 (27.6)	n.s.	21 (19.5)	17 (24)	n.s.		
GERD *n* (%)	4 (3.2)	9 (8.5)	n.s.					
Laparoscopy *n* (%)	312 (96.3)	256 (99.2)	**0.022**					
1st stage procedure *n* (%)	263 (83)	212 (82)	n.s.					

Data are expressed as number of patients (%) or median
DS duodenal switch, *SADI-S* single-anastomosis duodeno-ileal with sleeve, *BMI* body mass index, *EWL* excessive weight loss, *SD* standard deviation, *GERD* gastroesophageal reflux disease

primary surgery was done in most of the patients in both groups (83.4% vs. 82%, p = n.s.). Prior to surgery, prevalence of diabetes, arterial hypertension, dyslipidemia, and OSA was 37.7% vs. 33.5%, 57.6% vs. 55.5%, 33.6% vs. 27.6%, and 57% vs. 39.8% in DS and SADI-S group, respectively.

Follow-up was 59.1 ± 38.4 months for DS and 32 ± 19 months for SADI-S. Table 55.1 shows anthropometric changes at 2 years. In the overall analysis, both SADI-S and DS showed comparable BMI changes (Fig. 55.1a) and %EWL (Fig. 55.1b) at 6 months and 1 year; instead DS achieved a higher control of BMI (30.5 ± 4 vs. 31.9 ± 5.1, p = 0.01) and a higher %EWL (78.5 ± 15.4% vs. 73.8 ± 18.4%, p = 0.03) than SADI-S at 2 years (Tables 55.1 and 55.2).

Table 55.1 shows the comorbidities prior and 2 years after surgery. Rate of comorbidities at 2 years for DS and SADI-S was 15.2% and 14.3% for diabetes, 37.6% and 34% for hypertension, 20% and 24% for dyslipidemia, and 17% and 14.3% for sleep apnea, with no differences between both techniques.

Table 55.3 summarizes surgery short-/long-term complications with Clavien-Dindo score. In the whole cohort, 468 subjects presented a Clavien-Dindo 0

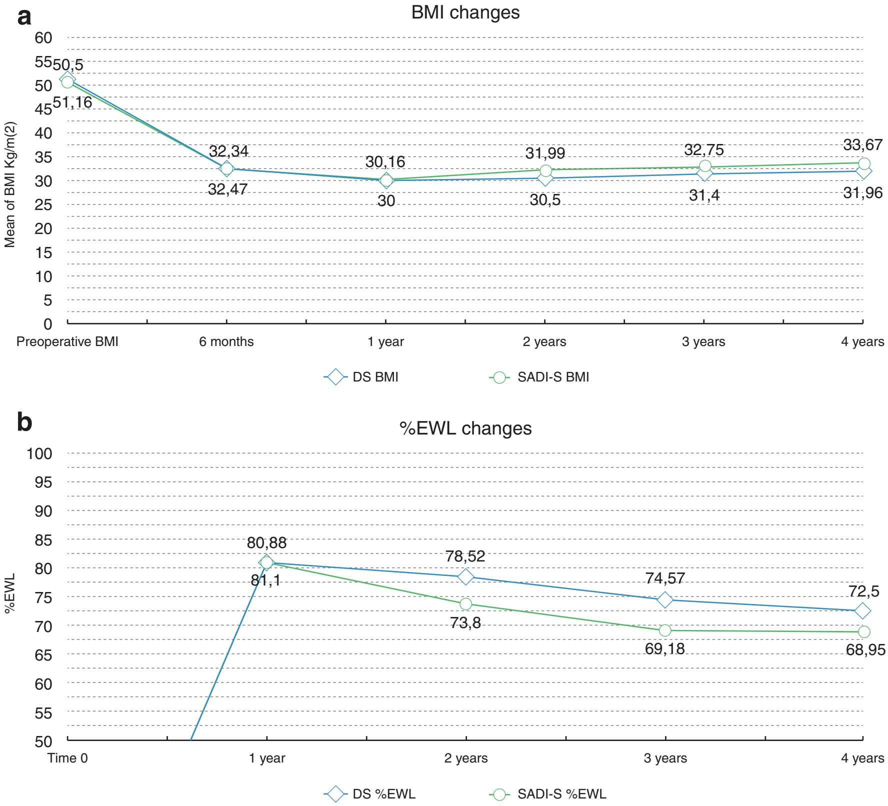

Fig. 55.1 Changes after hypoabsorptive techniques (DS and SADI-S). (**a**) BMI changes. (**b**) %EWL changes

Table 55.2 Postoperative EWL% and IMC outcomes of patients included in the analysis

	DS			SADI-S			*p* value	
Follow-up	*n*	EWL% (±SD)	BMI (±SD)	*n*	EWL% (±SD)	BMI (±SD)	EWL%	BMI
1 year	264	80.88 ± 14.4	30.00 ± 3.90	206	81.10 ± 14.98	30.16 ± 4.31	0.874	0.671
2 years	202	78.52 ± 15.4	30.50 ± 4.02	79	73.80 ± 18.42	31.99 ± 5.13	**0.030**	**0.011**

Data are expressed as number of patients (%) or median
DS duodenal switch, *SADI-S* single-anastomosis duodeno-ileal with sleeve, *BMI* body mass index, *EWL* excessive weight loss, *SD* standard deviation

Table 55.3 Short- and long-term complications after hypoabsorptive bariatric surgery

	DS *n* = 323	SADI-S *n* = 258	*p* value
Readmission < 30 days	4 (3.8%)	5 (5.2%)	0.643
Exitus <30 days	1 (0.3%)	1 (0.4%)	0.880
Exitus <90 days	1 (0.3%)	0 (0%)	0.368
Complications			
Short-term	59 (18.2%)	36 (14%)	0.168
Long-term	44 (13.6%)	21 (8.1%)	**0.038**
Clavien-Dindo			0.053
0	251 (77.5%)	217 (84.1%)	
I	9 (2.8%)	7 (2.7%)	
II	22 (6.8%)	5 (1.9%)	
IIIa	3 (0.9%)	5 (1.9%)	
IIIb	23 (7.1%)	15 (5.8%)	
IV	0	0	
V	2 (0.6%)	1 (0.4%)	
Missing	13 (4.0%)	8 (3.1%)	
CD ≥ IIIA	26 (8.0%)	20 (7.8%)	0.904

(80.5%). Most of the complications were Clavien-Dindo I and II, with a Clavien-Dindo ≥ IIIa in 7.9% of patients. At short-term, DS and SADI-S showed similar complications (18.2% vs. 14%, p = n.s.) and Clavien-Dindo scores. There were six duodeno-ileal anastomotic leaks (1.4%), three of which occurred in the initial DS cases (between 2006 and 2008), when this anastomosis was done mechanically. One case of 30-day mortality occurred in the SADI-S group (0.4%), due to postoperative hemoperitoneum. Another case of 30-day mortality and a case of 30–90-days mortality occurred in the DS group (0.6%), both related to a duodeno-ileal anastomotic leak. At long-term, we found more complications after DS than after SADI-S (13.6% vs. 8.1%, $p = 0.03$). There were 12 cases of internal hernia (2.1%); 2 cases in the SADI-S group, both cases with a Petersen hernia at 12 days and 4 months after surgery; and 10 cases in the DS group, 3 with a Petersen defect and 7 with a mesenteric defect, ranging from 4 to 73 months after surgery. We found a

Table 55.4 Nutritional supplementation between DS and SADI-S

	DS $n = 323$	SADI-S $n = 258$	p value
Nutritional supplementation			
Vitamin A	117	35	**0.001**
Vitamin B	23	6	**0.05**
Vitamin K	4	0	n.s.
Vitamin E	9	0	**0.05**
Vitamin D	179	94	**0.001**
Calcium	116	32	**0.001**
Iron	133	49	**0.001**
Copper	19	4	**0.05**
Zinc	3	24	**0.001**
Folic acid	12	51	**0.001**

higher rate of patients with symptomatic GERD in the SADI-S group: 5.6% vs. 3.6%, ($p = 0.031$). In three SADI-S cases, GERD was documented as bile reflux. Ten patients (five in each group) were submitted to revisional surgery during follow-up: All five SADI-S revisional surgeries consisted in conversion to DS, three of them due to bile reflux and the other two because of insufficient weight loss. As for the five DS revisional surgeries, there was one patient with acid reflux converted to Roux-en-Y gastric bypass; two patients reverted to sleeve gastrectomy, one for hypoalbuminemia and the other one to treat hyperinsulinemic hypoglycemia; one chronic gastric fistula treated with esophagectomy and coloplasty reconstruction; and one enterocutaneous chronic fistula needing limited intestinal resection and anastomosis. Global vitamin and micronutrient deficiencies in the DS group were superior compared to SADI-S (Table 55.4).

55.2 Discussion

In this observational cohort evaluation, we found a higher, significant, and maintained weight loss at 2 years after DS compared with SADIS-S, associated with remarkable diabetes, hypertension, dyslipidemia, and OSA remission rates, comparable between both techniques. Although short-term complications were similar in both groups, long-term complications and vitamin and micronutrient deficiencies were superior in DS than in SADI-S.

In patients submitted to DS in this cohort, the %TWL of 40% at 2 years is comparable to the 45.8% of the study by Surve et al. [13], and the %EWL of 78.5% at 2 years is similar to the 83% reported by Biertho et al. [14]. In SADI-S, the %TWL at 2 years was 37.3%, comparable to the previously reported ranging from 34.2 to 45.8% [15–18] and %EWL of 73.8% at 2 years, comparable to the 80.5% reported in Shoar's et al. systematic review [17]. According to our results, DS is superior to SADI-S in %EWL and BMI, but not in the %TWL at 2 years in the global series.

Although a lack of difference in weight loss was observed in two previous retrospective studies comparing SADI-S with DS at 2 years, by Cottam et al. (n = 122) [19] and Moon et al. (n = 185) [15], a third comparative study by Surve et al. (n = 182) shows a significant greater %EWL of DS compared to SADI-S (94.9% vs. 87.1%) at 2 years [13]. As for metabolic comorbidities control, in our series, DS and SADI-S showed similar results, with a rate of comorbidities at 2 years of 15.2% and 14.3% for diabetes, 37.6% and 34% for hypertension, 20% and 24% for dyslipidemia, and 17% and 14.3% for sleep apnea, respectively. These results are comparable to those that showed similar DS and SADI-S observational studies and better than the results obtained after SG and Roux-en-Y gastric bypass [2–5, 7].

Overall short-term complications in our analysis are comparable to published data by groups with experience in laparoscopic DS: severe complications (Clavien-Dindo score >2) occurred in 7.9% of the patients; reoperation was required in 6.6%, and 90-day mortality was 1%. A leak in the duodeno-ileal anastomosis occurred in 1.4% of the cases, 0.7% in the duodenal stump, and 0.5% at the gastric suture line [15–18, 20, 21]. Biertho et al. noted that their risk of duodeno-ileal leak decreased from 2.6 to 0.4% when they passed from circular mechanical to hand-sewn anastomosis [14]. Similarly, we found that 3 out of the 6 duodeno-ileal anastomotic leaks of our series occurred in the initial 30 cases, when anastomosis was done linear mechanical (10%), and that the risk was reduced to 0.7% when we adopted hand-sewn double-layer technique. None of the DS patients experienced a leakage in the ileoileal anastomosis; this seems to be a rare event, with none reported in most series and 1 in the series of 1000 cases by Biertho et al. [15, 22, 23]. Therefore, the extra ileoileal anastomosis is not likely to increase the short-term (30-day) complication rate, even though it supposes a higher risk of internal hernia in the long term. In fact, in our experience, there are only slight differences between short-term outcomes of both groups. Even for these small differences, surgical experience and learning curve must be taken into account, as DS cases were operated on earlier in time. Contrarily to the similar short-term morbidity, long-term complication rates are significantly higher for DS than for SADI-S, primarily due to mesenteric internal hernias. This correlates with previous studies' data and cannot be explained by the learning curve but is attributable to the type of surgery [18]. Even though in all the cases in this study both the mesenteric and Petersen defect were closed by a running nonabsorbable suture, we found ten cases of internal hernia in the DS group (3.1%) and two cases in the SADI-S group (0.8%). Literature with long-term data report rates of internal hernia as high as 8% after a DS [24], while after SADI-S, in which mesentery is not divided, this complication has only been reported once before [25]. Interestingly, GERD is the only long-term complication that is more frequent in the SADI-S group, even though follow-up was shorter for these patients. In three of these SADI-S cases, GERD was probed to be due to bile reflux and needed surgical conversion to DS. If we consider clinically relevant bile reflux can occur after a surgical operation that preserves the pylorus as SADI-S does, it seems logical to maintain our concerns about a surgical technique without pyloric barrier or Roux reconstruction, as mini-gastric bypass. Even though published revision rates for bile reflux of mini-gastric bypass range between 0.5 and 1.5% [26, 27] and are therefore comparable to ours, we must note that not all patients with this pathology are symptomatic and, also, that indication for revisional surgery is subjective and depending on surgeon's criterion and that bile gastritis and esophagitis are to be considered as pre-malignant conditions [28, 29]. We found a higher percentage of patients in the DS group with fat-soluble vitamins A, D, and E deficiencies. This finding is in concordance with other studies [13, 30] and is attributable to the shorter common channel of the Roux configuration of DS: its purpose is to reduce fat absorption, but it also reduces the absorption of fat-soluble vitamins and essential fatty acids. A similar rationale can be applied to the difference in micronutrient deficiencies, such as calcium, iron, copper, zinc, and folic acid. Two cases in the DS group (0.7%) and none in the SADI-S group underwent reversals due to hypoglycemia or diarrhea and protein malnutrition. While need of reversal due to severe hypoalbuminemia and intractable diarrhea was reported in 9 cases of a cohort of 1243 primary DS patients (1.5%) [20], in SADI-S' patients, most of these complications have been described when a 200 or 250 cm afferent limb was performed [9, 31]. All SADI-S cases in this cohort were performed with a 300 cm of alimentary/efferent limb, a technical modification that some authors have considered relevant enough as to change the operation's name to SIPS (stomach-intestinal pylorus sparing surgery) [13, 32].

Even though patients of this cohort followed strict analytic controls by the endocrinologists for at least 5 years, biochemical parameters were not included in the database. Instead, we recorded the need of extra vitamin and micronutrient supplementation, as a simplified reflection of the effort done by patients and clinicians to artificially maintain these parameters into the normality ranges.

55.3 Conclusions

This single-institution experience analysis presented in this chapter shows better weight control with higher %EWL for DS compared to SADI-S at 2 years follow-up. Conversely, it reports comparable obesity-related comorbidities resolution rates for DS and SADI-S and more long-term complications and need for extra supplementation to compensate for vitamin and micronutrient deficiencies in DS patients.

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Chapter 56
Body Contouring After Duodenal Switch

Omar E. Beidas

56.1 Introduction

With obesity becoming ever-more prevalent throughout the world, the epidemic continues to worsen. According to the World Health Organization, the obesity rate has almost tripled since 1975 [1]. In 2016, 39% of adults worldwide, or 1.9 billion people, were overweight [1]. In 2019, an estimated 256,000 bariatric surgeries were reported by the American Board for Metabolic and Bariatric Surgery (ABMBS), with approximately 2000 being duodenal switches [2]. These patients deserve mention due to the higher risk of wound complications when undergoing plastic surgery [3]. Careful evaluation of each patient's deformity and priorities is crucial to obtain a satisfactory result that meets the patient's goals.

56.2 Preoperative Evaluation and Planning

Body contouring involves dissection in skin and subcutaneous tissue and is therefore considered low risk by the American College of Cardiology and American Heart Association (ACC/AHA) [4]. For patients with a history of bariatric surgery, their primary care physician should optimize any comorbidities. The patient's general practitioner will have greater knowledge of the patient's history and medical conditions. Referrals to specialists can be made as appropriate for pre- and postoperative management of specific conditions.

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Patients who seek consultation for plastic surgery may have ceased to follow up with their bariatric surgeon, more so the farther out the patient is from weight loss surgery [5]. Therefore, it is imperative that plastic surgeons urge patients to continue to follow up with healthcare providers. If there are any issues or questions surrounding a patient's bariatric surgery—such as dumping syndrome, inability to maintain adequate intake, or weight regain—the patient should be referred back to their bariatric surgery team. It is also important that patients attend support groups, especially if they require further weight loss prior to undergoing body contouring. Patients who attend support groups have a 10% greater decrease in BMI compared to patients that do not [6].

A few salient points deserve mention for patients being referred for plastic surgery. First, patients must be educated that these are not weight reduction procedures; ideal candidates require removal of skin with minimal underlying adiposity. A patient may have some areas that are amenable to surgery, while other areas may require further adipose reduction prior to body contouring. Liposuction can be used to remove fat from stubborn, hard-to-lose regions, but is not a substitute for weight loss. Second, no amount of exercise will remove the excess skin left after massive weight loss, and therefore surgery is the only avenue for treatment. The most important point that patients must understand is the trade-off of skin for scar. Noninvasive modalities will not adequately address the skin laxity in the vast majority of patients.

56.2.1 Weight History

Patients can experience a greater than 70% excess weight loss (EWL) after biliopancreatic diversion with duodenal switch (BDP-DS) [7, 8]. This typically happens rapidly over the first year, then slowly thereafter. It is critical to carefully evaluate patients after massive weight loss (MWL), defined as a loss of greater than 50% of excess body weight that is over ideal body weight (IBW). These patients are at risk of wound healing complications at a rate almost three times higher than non-MWL patients [3]. The risk is greatest in patients who have lost more than 100 pounds [3], as is commonly seen after BDP-DS.

Plastic surgery is ideally suited for patients who maintain a weight within 5 kg (approximately 10 pounds) for at least 3 months [9], as these patients experience less complications than their counterparts who have large swings in weight or use a crash diet in the months preceding surgery [10]. Patients who are not yet at an adequate weight or their goal weight should be re-evaluated periodically.

56.2.2 Body Mass Index (BMI)

Patients must understand the need for maximum weight loss to improve results and decrease complications. Generally, elective plastic surgery is not recommended for patients with a BMI greater than 35 kg/m^2, with stricter cutoffs imposed based on surgeon preference. Patients with a BMI greater than 25 kg/m^2 have an almost-three-time risk of wound healing complications [11]. The higher the BMI, the greater the risk of postoperative complications.

There are, however, instances where surgery may be considered in patients who are not optimized from a BMI standpoint. Evaluations must therefore be on a case-by-case basis and strict BMI requirements avoided as they do not consider region-specific problems. It is appropriate to offer procedures to patients with a significant quality of life restriction secondary to excess tissue. The most common reason is limitation of mobility due to a panniculus that hangs at least to the knees or recurrent infections due to a lymphedematous panniculus, as shown in Fig. 56.1. In these cases, apronectomy provides relief while mitigating risk. Despite a wound complication rate of 42% and re-operative rate of 11.5% in patients with panniculectomy specimens over 10 kg [12], most willfully accept the high complication profile due to the significant improvement in quality of life [13].

56.2.3 Nutritional Assessment

Patients who have undergone BDP-DS typically lose the most weight of all bariatric surgery patients, but also have the highest risk of nutritional, vitamin, and mineral deficiencies. Iron is the most common deficiency, which can be more pronounced in women of child-bearing age [14, 15]. Preoperative hemoglobin levels should be

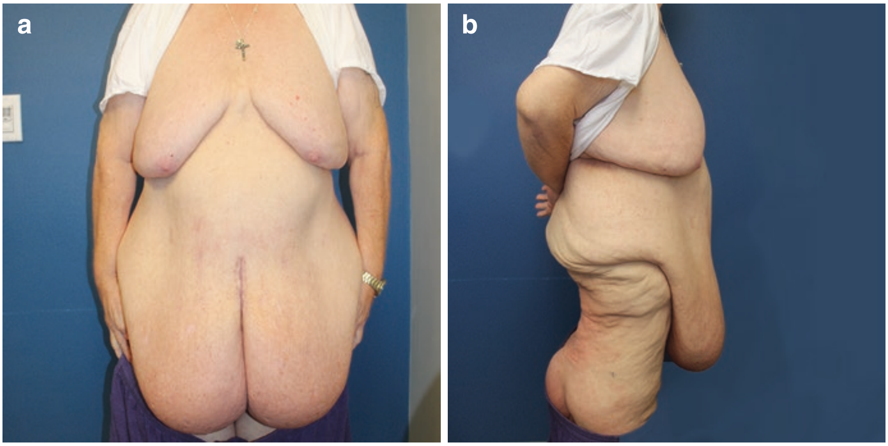

Fig. 56.1 57-year-old male who had DS-BPD and lost over 200 pounds, with a BMI 43.5 and significant hanging lymphadematous panniculus causing recurrent cellulitis of the lower abdominal tissue. He additionally had lymphedema of the lower extremities for which he was referred to lymphedema therapy to assist with decongestion. Due to his body habitus and complex nature of these surgeries in the obese patient, body parts were operated on individually to minimize operative time and complications. First, he underwent panniculectomy and was allowed to recover but continue lower extremity edema treatment. He then had thighplasty after maximizing decongestive therapy of the lower extremities approximately 6 months after the initial surgery

measured and corrected accordingly. Surgery can be considered for patients with a slightly low hemoglobin level; however, this must be weighed with the risk of postoperative blood transfusion. If a patient is undergoing several procedures at once, hemoglobin levels should be normal or near normal. Certainly, surgeon experience and expected blood loss are major factors in the decision to operate on a patient with a low hemoglobin level.

Protein deficiency, defined as serum albumin <3.5 mg/dL, is the most common macronutrient deficiency associated with malabsorptive surgical procedures [16]. Protein deficiency is critical to avoid in the plastic surgery patient as it can cause delayed wound healing. Hence, it is important to verify that patients follow their dietary intake recommendations, in the case of BPD-DS, 90–120 g/day [17]. Surgery and its associated stress can increase energy expenditure by up to 25% [18], and protein intake should increase accordingly to 100–125 g/day in the perioperative period.

Other common deficiencies for which testing can be considered include vitamins A, B, D, E, and K and zinc. The American Society for Metabolic and Bariatric Surgery (ASMBS) periodically publishes updated guidelines [19], and these are a good source for the plastic and reconstructive surgery team. Patients should follow up with a bariatric team at least yearly for long-term monitoring.

56.2.4 Medical, Surgical, and Social History

Fortunately, many medical comorbidities seen in the obese population, such as hypertension, hyperlipidemia, diabetes, and sleep apnea, are ameliorated or resolved after BPD-DS. Instead, patients after weight loss commonly present with depression, arthritis, and anxiety [20]. Clearance should be obtained from a patient's primary care provider, and specialist referrals made should there be any specific issues requiring perioperative management. Any personal or family history of abnormal bleeding or clotting should be investigated. It is not uncommon for patients to have histories or conditions requiring cardiac, hematologic, pulmonary, rheumatologic, or other specialist input. It is also important to note if a patient is using weight loss medications, as some of these need to be stopped in the perioperative period. The most frequently prescribed medications are phentermine, topiramate, metformin, naltrexone, bupropion, and zonisamide [21].

In most cases, surgical history does not yield information that would change the plastic surgery procedure performed. Previous intra-abdominal and pelvic surgery is important to note as hernias may be occult and scar tissue may make dissection more difficult. Typically, Pfannenstiel scars are removed in abdominal body contouring procedures. If undergoing breast surgery, women above age 35 should be screened with a preoperative mammogram within 1 year of surgery. Breast screening should be considered for younger women with a significant family history.

Patients with previous lymph node dissection or with evidence of pre-existing lymphedema being evaluated for body contouring of the affected extremity should be approached with caution.

Use of nicotine products—including nicotine replacement products such as patches, gum, and electronic devices—is a contraindication to body contouring, as it increases the risk of complications [22, 23]. Nicotine users have an approximate fourfold increase in risk of overall complications, tissue necrosis, and need for re-operation [24]. Optimal timing of nicotine cessation is a minimum of 4 weeks pre-operatively and another 4 weeks postoperatively. Due to unreliable self-reporting of nicotine cessation by patients, preoperative cotinine testing is recommended [25].

56.2.5 Insurance Coverage

Some insurance and healthcare providers deem body contouring to be cosmetic in nature and, therefore, not associated as part of a larger plan for the treatment of obesity. Therefore, financial factors can be a major deterrent for patients wanting surgery. While plans differ in coverage criteria (Table 56.1), most require skin infections refractory to medical treatment and an impedance on activities of daily living.

56.2.6 Venous Thromboembolism (VTE)

One of the most devastating complications after body contouring surgeries is venous thromboembolism (VTE). Post-MWL patients have a 3% risk of VTE, while patients with a BMI over 35 kg/m^2 have an approximate 9% risk [26]. The 2005 Caprini risk assessment model should be used as it is validated for plastic and reconstructive surgery [27]. Most post-bariatric surgery patients are at least at moderate risk for VTE, and appropriate precautions should be taken. Compression stockings or intermittent pneumatic compression (IPC) devices should be used throughout a patient's hospital stay. In addition, patients should ambulate the day of surgery or at the latest the following morning, as this is the most effective prophylaxis against VTE.

Table 56.1 Most major insurance carriers have requirements for panniculectomy coverage and use some variation of the criteria

Criteria for insurance coverage: panniculectomy
• 18 months elapsed since bariatric surgery and stable weight for 6 months • Chronic skin ulceration refractory to 3 months treatment with prescription medication • Excess skin hangs to the level of the pubic symphysis and interferes with activities of daily living (ability to sit, walk, bend down)

Some plans have exclusions for panniculectomy and most have exclusions for other body contouring procedures

56.3 Surgical Procedures

In a study evaluating post-bariatric surgery patients, 11% had previously undergone body contouring, 62% desired body contouring, and 27% had no desire to undergo body contouring [28]. Patients seek plastic surgery due to overhanging skin in the abdomen (73%), inner thigh (50%), upper arms (46%), and breast/chest (43%) [28]. The most common reason for not undergoing plastic surgery was perceived lack of insurance coverage for these procedures.

56.3.1 Staging

Body contouring includes procedures on the face, chest/breast, trunk, and upper and lower extremities, as listed in Table 56.2. Patients may present desiring correction of several regions due to functional or aesthetic concerns. Body contouring ranges from one operation or can require a series of staged procedures. Some may want to minimize surgeries, while others prefer to split procedures for financial or personal reasons. Procedures may also have to be divided due to medical comorbidities. For those who want many body parts addressed, staging allows all skin tightening to be performed over a few surgical sessions. A common method to stage surgeries involves separating surgeries between the upper body, arms, chest/breasts, and upper back, and lower body—abdomen, buttocks, and legs. Figure 56.2 shows a patient who underwent a three-stage body contouring process involving arm, trunk, and thigh skin excision. Revisions are not uncommon to address skin relaxation or areas of adverse scarring.

Table 56.2 Body contouring procedures exist for all body parts, and this table illustrates treatment options for each region

Anatomic site	Procedure(s)/technique(s)
Face	• Facelift
Neck	• Necklift • Neck Z-plasty
Arms	• Brachioplasty
Chest (male)	• Correction pseudo-gynecomastia
Breast (female)	• Mastopexy • Reduction • Augmentation
Abdomen	• Panniculectomy • Abdominoplasty • Reverse abdominoplasty • Fleur-de-lys (FDL)
Back	• Upper back lift
Buttocks	• Buttock lift ± autoaugmentation • Belt lipectomy • Flankplasty
Thighs	• Thighplasty

Skin deformities vary from individual to individual, and surgeries are tailored accordingly

Fig. 56.2 46-year-old female who underwent DS-BPD and lost 200 pounds over 2 years. Starting BMI at initiation of body contouring was 33.9. Over the course of 13 months, she underwent three-stage body contouring with stage 1 lower body lift, brachioplasty, and breast fat transfer; stage 2 breast mastopexy (lift) with fat transfer and thighplasty (lift); and stage 3 upper back lift and revisions of abdominal and breast scars. Surgeries were spaced approximately 6 months apart

56.3.2 Upper Body

56.3.2.1 Arm

Brachioplasty, or am lift, is performed to remove excess skin of the arm. Most patients after weight loss surgery require a scar along the long axis of the arm to perform adequate tissue removal, sometimes even requiring an extension onto the forearm. The incision is usually carried down vertically onto the lateral chest to recreate the axillary dome and remove the additional excess skin in this area, treating the so-called "bat wing" deformity. Figure 56.3 shows an example of a patient who underwent extended brachioplasty.

56.3.2.2 Back

In some patients, the laxity of the chest is not only anterior, but continues onto the back. A solution to the extra skin of the upper back is an upper back lift, which requires extension of the horizontal anterior chest incision posteriorly, typically meeting in the central back. This is referred to as a bra-line lift in females, as the scar is hidden in a bra strap. Occasionally, the horizontal chest scar will meet the vertical scar of the brachioplasty at a "T" point.

56.3.2.3 Chest (Male)

In the male patient, chest contouring procedures involve removal of excess subcutaneous tissue and skin of the chest. This can be performed via amputation of the chest tissue using an inframammary fold incision and free nipple graft or resection of the tissue and repositioning the nipple on a dermoglandular pedicle (Fig. 56.4).

56.3.2.4 Breast (Female)

For female patients, breast reshaping requires not only the knowledge of general plastic surgery techniques, but the ability to perform procedures designed for the anatomy of the weight loss patient. A specialized technique used in weight loss patients who have deflated breasts is shown in Fig. 56.5. Female patients will typically request a breast lift (mastopexy), reduction, augmentation, or combination of these procedures. For most weight loss patients, a Wise pattern skin resection—or anchor scar—is necessary to remove excess skin and reposition the breast on the chest wall.

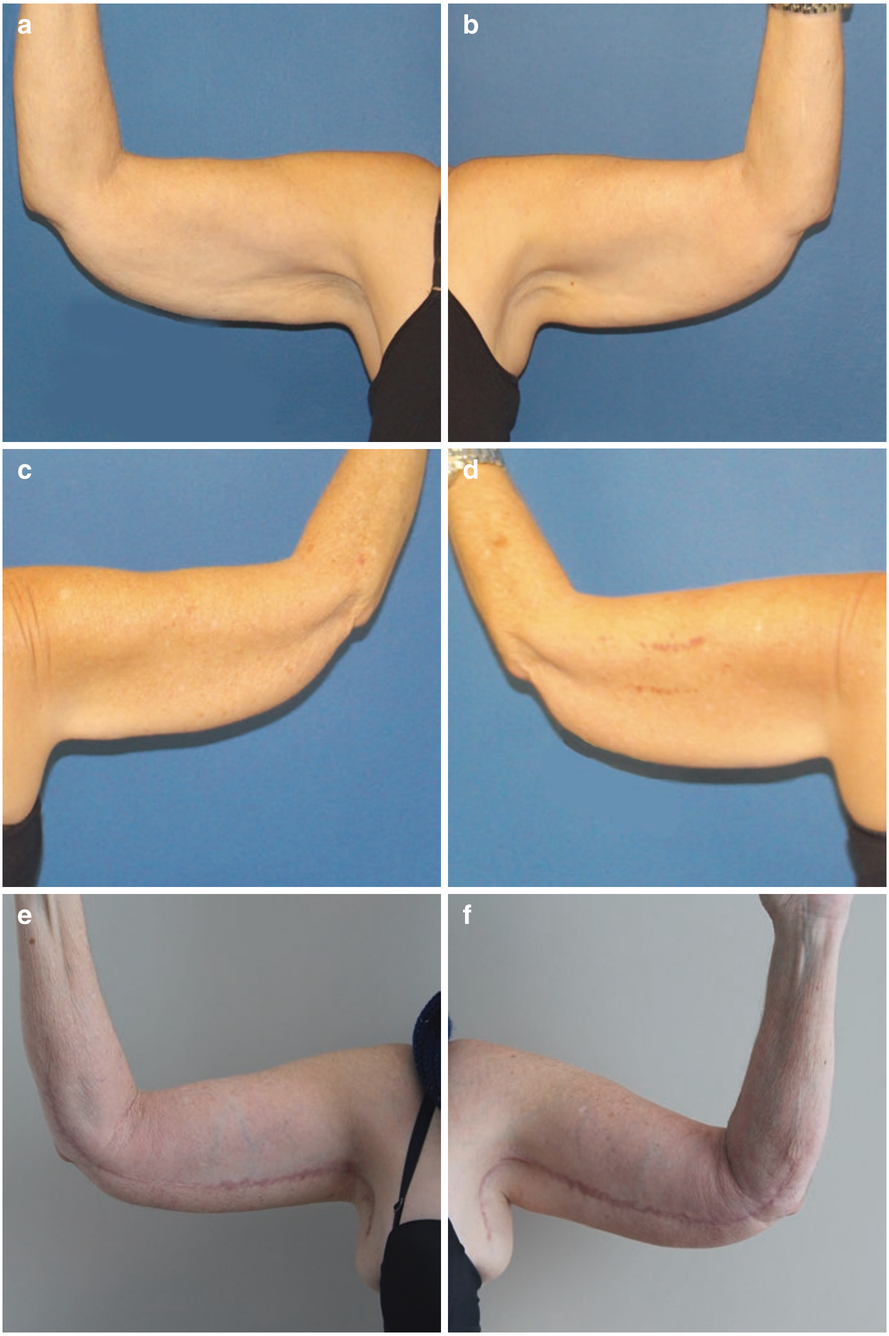

Fig. 56.3 66-year old female with history of Roux-en-Y gastric bypass who lost 150 pounds and presented with a BMI of 25.6 and residual arm laxity. Due to the excess skin in the forearm, an extended brachioplasty was performed, with extension of the scar onto the proximal forearm

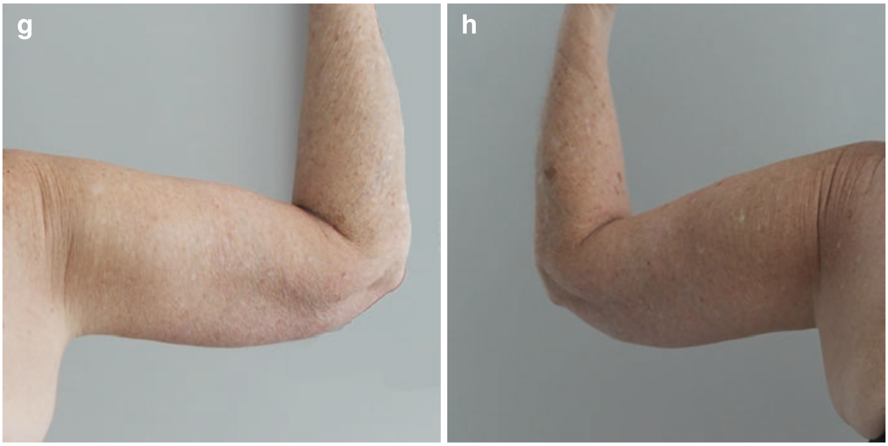

Fig. 56.3 (continued)

Fig. 56.4 51-year-old male who lost 450 pounds, starting at 686 and presenting for plastic surgery at 225 pounds, after DS-BPD. Due to his history of VTE, his procedures were divided into several operations to minimize anesthesia time and allow early ambulation. He underwent a three-stage process involving first stage lower body lift; second stage brachioplasty and chest contouring; and third stage thighplasty. He plans to undergo upper back lift in the future

Fig. 56.5 41-year-old female who underwent DS-BPD and lost 170 pounds over 18 months, stabilizing at a BMI of 27.1. She underwent breast mastopexy with fat transfer followed 5 months later by lower body lift and additional fat transfer to the breasts. Her breasts were reshaped using a special technique called a dermal suspension parenchymal reshaping mastopexy to augment her breasts using her own tissue, without the use of implants. She plans to undergo upper back lift with reverse abdominoplasty in the future

56.3.3 Lower Body

56.3.3.1 Abdomen/Buttocks

The majority of patients who present for body contouring desire removal of the excess skin of the lower abdomen, possibly because many insurance plans provide coverage for panniculectomy. For the lower body, both anterior and posterior skin deformities must be considered, and most patients require an extended or circumferential approach to address the skin laxity. Many patients benefit from rectus sheath plication to correct laxity of the abdominal wall created from weight gain and subsequent loss. Various versions of the buttock lift exist, and the procedure recommended must be tailored to the patient's goals and anatomy.

56.3.3.2 Thigh

Thigh contouring can be performed in several ways; however the most common are the proximal inner and the medial vertical techniques. The proximal inner thigh lift puts the scar in the groin crease and extends anteriorly and posteriorly. Its main drawback is that it only addresses skin laxity in the proximal third of the thigh; however the scar is nicely hidden in the groin crease. The vertical medial thigh lift requires a lengthy scar along the inner thigh. Other options include a lateral thigh lift; however this is much less commonly performed.

56.4 Complications

Complications after body contouring procedures are usually minor and treated on an outpatient basis. The most common postoperative problems are delayed wound healing or wound dehiscence, which reinforces the importance of preoperative optimization. Other complications include seroma and hematoma, which can be treated with needle aspiration or chemical sclerosis. Operative intervention is rarely necessary, but indications include expanding hematoma, large wound dehiscence, or chronic seroma cavity. Local cellulitis or skin infections are treated with a short course of antibiotics and close monitoring. Finally, adverse scarring is possible such as widening or hypertrophic scarring or the development of chronic draining wounds or sinus tracts. These are easily treated with steroid injections or excision.

Serious complications tend to be rare and include nerve injuries, lymphedema, VTE, and death. Nerve injuries can be secondary to patient positioning during prolonged cases or transection during surgery. To decrease the risk of iatrogenic injury to neurovascular or lymphatic structures, especially in extremity procedures, liposuction of the surgical site followed by a skin-only resection can be performed [29]. Postoperative lymphedema is seen in 8% of thighplasty patients [30, 31].

56.5 Outcomes

56.5.1 Quality of Life

Several studies have consistently shown that body contouring improves quality of life (QOL), self-esteem, body image, social life, and physical, work, and sexual function [32–35]. Higher amounts of weight loss correlate with greater amounts of excess skin and worse scores on 7 out of 13 BODY-Q scales [35]. Of patients who have undergone body contouring, 95% had a BMI less than 35 kg/m^2. Patients with class III obesity (BMI ≥ 40 kg/m^2) see less of a QOL improvement—compared to patients BMI < 40 kg/m^2—in three specific domains: satisfaction with body, body image, and social function [36].

Bariatric patients who underwent plastic surgery tended to lose more weight and maintain weight loss for longer than their counterparts who did not undergo body contouring [36, 37]. Patients who underwent plastic surgery in three or more anatomic areas were more likely to maintain long-term weight loss, compared with patients who underwent surgery on less than three body parts [38]. Some of the changes in satisfaction with body image can be specific to the region treated, and treatment of one area can lead to subsequent dissatisfaction with separate, untreated areas [39].

56.6 Conclusion

Post-duodenal switch patients are the most complex bariatric surgery patients to treat from a plastic surgery perspective. They typically lose the most weight, and therefore the residual skin deformities are among the most severe on the spectrum. Nutritional deficiencies are common, and patients must be appropriately managed. These patients must be warned that revisions are possible due to the significant degree of skin laxity. Body contouring is a vital component of these patients' weight loss journeys and referral to a plastic surgeon is key to their maintained success.

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Chapter 57
Bariatric Surgery Population in the ICU

Tracy R. Bilski, Lucille Woodley, William S. Havron III, and Anthony Gielow

The World Health Organization (WHO) has stated that overweight and obesity are conditions where increased risk to health can occur from excess or abnormal fat accumulation. Obesity in the general population has become an increasing problem having tripled since 1975 (WHO.int). In the intensive care unit currently, approximately 20–30% of patients are obese, and of these, 7% meet criteria for Class II and III obesity [1]. The growth of the obese population and the number requiring intensive care in addition to the increase in bariatric (and metabolic) procedures and operations suggest that the obese surgical patient population will constitute an increasing number of ICU patients in the future [2]. Despite the debate over mortality risk in the critically ill obese patient, the increase in morbidity and resource utilization exists [1]. This patient population presents unique issues, diagnoses, and required care alterations when it comes to their intensive/critical care [1]. This chapter will aim to provide an overview of system-based issues and treatment plans unique to the obese and bariatric surgical population.

57.1 Obesity Definitions

The WHO provides a classification system for obesity by body mass index (BMI)—see Table 57.1.

Some other differential classification systems utilize location of obesity (central vs generalized vs compound) and others qualifying factors such as visceral obesity or sarcopenic obesity. We will use the WHO classification for purposes of this chapter.

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Table 57.1 WHO classification of overweight and obesity by BMI

Body mass index (kg/BSA)	Classification
25.0–29.9	Overweight
30.0–34.9	Class I obesity
35.0–39.9	Class II obesity
40.0–49.9	Class III obesity

57.2 ICU Admission Criteria

Obese patients deemed to have no significant major medical comorbidities are managed postoperatively in the post-anesthesia recovery unit followed by step down unit or floor admission. However, 2.8–4.9% of bariatric surgical patients will require postoperative ICU admission. The following criteria have been proposed for ICU admission for bariatric surgical patients and can be applied to the general obese surgical population [3, 4]:

- BMI ≥50 kg/m^2
- Severe obstructive sleep apnea (OSA) or obesity hypoventilation syndrome (OHS) and/or noninvasive mechanical ventilation requirements
- Need for respiratory or cardiac monitoring
- Difficult glycemic control
- Intraoperative surgical or anesthetic complications (bleeding, cardiovascular or respiratory event, accidental lesions)

57.3 The Respiratory System

The anatomic, physiologic changes and challenges of the respiratory system in the obese patient are possibly the most familiar to providers in the surgical and critical care setting. These important changes include soft tissue mass increase on the oro-/nasopharynx and upper airway, higher Mallampati score, alteration of compliance, lung expansion, work of breathing, and oxygen consumption [5]. Preexisting OSA and OHS result in a baseline high $PaCO_2$ which can lead to chronic metabolic alkalosis—all of which affects the obese patient's ability to exchange gas appropriately.

Airway management can therefore be challenging as, in general, obese patients have relatively short, wide necks with redundant oropharyngeal tissue which can make preoxygenation and intubation difficult. Rapid arterial desaturation is common after anesthesia induction or rapid sequence induction [2]. A difficult airway cart with adjuncts such as video laryngoscopy, laryngeal mask airways, bronchoscope for awake fiber-optic intubation, bougie, and other equipment can prove to be invaluable in these situations and should be available when intubation is needed. Proper positioning of the patient is also a key feature of successful intubation in the obese. Upper body positioning using ramps or blankets such that a straight line exists from the sternum to the tragus of the ear improves visibility and chances of successful intubation. Utilizing the reverse Trendelenburg or beach-chair position may also be useful [5].

As mentioned, there are two respiratory entities common to the overweight and obese population—OSA and OHS. OSA is defined as “a disorder that is characterized by obstructive apneas, hypopneas, and/or respiratory effort-related arousals caused by repetitive collapse of the upper airway during sleep” [6]. Many of these patients will be diagnosed prior to an admission to the ICU and will be using home noninvasive ventilation (NIV). While in inpatient status, it is important that patients be maintained on their home CPAP settings to prevent desaturation events. OHS on the other hand is defined as “the presence of *awake* alveolar hypoventilation in an obese individual which cannot be attributed to other conditions associated with alveolar hypoventilation” [7]. Complications related to OSA and OHS include pulmonary hypertension (PH) which is experienced by nearly 66% of those with OSH. Right heart failure can ensue which can have significant implications for the critically ill surgical patient. It is important to recognize, diagnose (if needed), and appropriately treat/take into account these two syndromes when admitting obese patients to the ICU.

Compliance of the lungs and chest wall are reduced by the accumulation of fat tissue. Further complicating this situation is the accumulation of fat tissue in the abdominal wall and intraperitoneal cavity which creates an elevation of the diaphragm resulting in decreased lung expansion. Add to this a positional change from sitting to supine, and the diaphragm can shift approximately 4 cm cranially. This whole scenario worsens with increasing BMI [5]. Unfortunately, this reduction in compliance and expansion leads to an increased work of breathing. Unique to the surgical population are the needed body positions of strict supine and Trendelenburg which can exacerbate the above and lead to profound atelectasis as the ventilator must work to overcome the forces imposed on proper gas exchange. This atelectasis is not only present during the surgical procedure but remains and can worsen in the 24 h post-anesthesia and post extubation.

Mechanical ventilation (MV) strategies must incorporate the above alterations. There is no evidence to suggest that either volume or pressure control ventilation modes are superior; however, to minimize atelectasis during MV, adequate positive end-expiratory pressure (PEEP) is essential and can be assessed using pressure-volume loops or oxygenation titration. This may need to be in conjunction with positional changes. Additionally, obese patients are ventilated using higher tidal volumes (TV) based on ideal body weight (IBW) (6–11 mL/kg) as compared to normal weight subjects (6–8 mL/kg) [3] which can lead to ventilator-induced lung injury. For this reason, driving pressure (DP) has been suggested to minimize atelectasis and lung injury. DP is the difference between inspiratory plateau pressure and end-expiratory pressure and should be kept <15 cm H_2O [1]. Should ARDS occur, prone positioning is an option for treatment but can be taxing on staff and resources.

Ventilator liberation strategies are also multifactorial. Minimizing residual respiratory depressants in the circulation is important, and positioning the patient in the upright, reverse Trendelenburg or sitting position improves mechanics and chances of liberation [2]. The high incidence of OSA and OHS add to the complexity of the problem, and patients may benefit from immediate use of noninvasive ventilation (NIV) after extubation. There is a suggestion that post extubation preventive NIV ± high flow nasal cannula oxygen may have a benefit in preventing reintubation [8].

57.4 The Cardiovascular System

The pathophysiology of obesity-related cardiovascular disease is significant, and the coronary artery disease risk from obesity itself is independent of co-existing hypertension and diabetes mellitus. Some concerning background features include sedentary lifestyle which may not allow for eliciting angina or symptoms of congestive heart failure, chronically inaccurate noninvasive blood pressure monitoring from cuff size discrepancy, and undiagnosed OSA or OHS as outpatients [1, 2]. Obesity-related pathology includes an increase in preload and afterload. Approximately 3 mL blood volume is needed per 100 g adipose tissue, and therefore as BMI increases, so does blood volume and preload. There is an increase in stroke volume and cardiac output accordingly as well as myocardial work. The afterload is thought to increase via elevated circulating catecholamines, mineralocorticoids, renin, and aldosterone. Part of this is a result of the visceral and ectopic fat endocrine effects. Add to this the afterload-increasing hypertension, the dyslipidemia often present and ischemic cardiomyopathy and over time this leads to ventricular hypertrophy, diastolic dysfunction, and eventual ventricular dilation (the cardiomyopathy of obesity) [3, 4].

Atrial fibrillation is a frequent complication of this cardiomyopathy; however beta blockade—the typical modality for coronary artery disease and atrial fibrillation—must be used with caution due to the potential for reduced cardiac contractility.

Pulmonary hypertension (PH) should be suspected in obese patients as it is reported that 5% of these patients, otherwise healthy, have PH of a moderate to severe degree. The incidence goes higher with increasing morbidity over time. Bariatric surgery is reported to affect favorable changes in pulmonary artery pressure and is one of the benefits of such surgery. The WHO has classified PH into five categories, and obesity is linked to three of these related to the structural and hemodynamic changes as well as the inflammatory changes as discussed above. The inclusive groups include group 1 PH or pulmonary arterial hypertension, group 2 PH or PH due to left heart disease, and group 3 PH which is due to lung disease or chronic hypoxia (much of which is related to OSA and OHS) [9]. PH will contribute to the difficulty in ventilator and hemodynamic management in the ICU.

Hemodynamic monitoring is therefore essential in the intensive care management of obese patients. Catheter placement in obese patients can be challenging given the alteration in anatomy and may require the use of adjuncts such as Doppler or ultrasound for guidance. As standard cuff measurements may be difficult for blood pressure monitoring, arterial catheters are helpful in blood pressure management. Volume resuscitation can be challenging as obese cardiomyopathy is intolerant of volume overload. Advanced monitoring of cardiac output, cardiac index, systemic vascular resistance, stroke volume variance, and others via an arterial pressure waveform analysis device can be extremely helpful in goal-directed resuscitation, but one must assure calibration and waveform reliability as these are often an issue in the obese patient. For patients on the ventilator, caution must be used to adjust for PEEP and pressure settings which may affect calculations.

One must also account for the increased blood volume when volume resuscitating. There is no current guidance from the Surviving Sepsis Campaign when specifically obese septic patients are encountered, but data shows that obese patients receive less fluid on a weight basis than normal weight counterparts. Several studies in shock and trauma showed that these patients required longer time and increased hemodynamic support to reach stability. A retrospective analysis of a large cohort of shock patients suggested that adjusted body weight was a better guide to initial fluid resuscitation than ideal or total body weight [10, 11].

57.5 The Renal System

It is increasingly recognized that obese patients are more likely to suffer from acute kidney injury (AKI). This is multifactorial and includes the increased incidence of hypertension and diabetes mellitus in this population. The incidence of AKI in critically ill obese is now thought to increase with increasing BMI. A recent study's secondary analysis in 2016 looked at 15,470 critically ill patients in a single-center cohort and found that AKI incidence rates increased as follows: 18.6% in normal weight, 20.6% in overweight, 22.5% in Class I obesity, 24.3% in Class II obesity, and 24.0% in Class III obesity [12, 13]. Moreover, in patients undergoing orthopedic, cardiac, bariatric, or trauma surgery, a higher incidence of AKI in obesity has been described [12]. Obesity is thought to be an independent risk factor for developing AKI in the setting of trauma, ARDS, critical illness in general, and some other pathologies.

The proposed mechanism is not fully understood; however it seems to be a complex interplay of different existing conditions. Among these include obesity-related factors such as glomerulonephropathy, low-grade inflammation, endothelial dysfunction, activated renin–angiotensin system, increased sympathetic activity, metabolic syndrome, hypertension, and coronary artery disease [12]. From a survival standpoint, the study by Danziger in 2016 found that in-hospital and 1-year mortality rates associated with an episode of AKI (both medical and surgical ICU patients) were similar across all BMI categories [13].

Prevention of AKI in obese surgical patients will require strict attention to mitigating known risk factors such as nephrotoxic drugs, accurate optimization of hemodynamics and volume status, and frequent re-assessment of interventions performed to assure desired affect or outcome. A multidisciplinary approach to resuscitation, pharmacology, and appropriate weight calculations should be undertaken in the ICU [12].

57.6 Pharmacology in the ICU

The discussion of ICU pharmacology in the obese patient starts with an understanding of body composition. In the normal weight individual, approximately 80% of weight is considered lean weight, and 20% is adipose weight. In the obese patient, it is 60% lean weight and 40% adipose and can be skewed even further in higher BMI obesity. This alteration of weight affects the volume of distribution of drugs. Hydrophilic drugs in general have a higher plasma concentration and smaller volume of distribution whereas lipophilic drugs more readily distribute into adipose tissue with a resultant lower plasma concentration [16]. In general, hydrophilic drug distribution volume correlates with lean body weight, and for lipophilic drugs, the volume of distribution more likely correlates to total body weight. For the highly lipophilic drugs, a loading dose may be needed. Many drugs regardless of their composition should utilize therapeutic drug monitoring for accuracy.

Unfortunately, despite the above knowledge, many drugs used in the intensive care unit do not have product labeling related to dosing obese patients [17]. In 2020, Erstad and Barletta performed a detailed literature search and provided a comprehensive summary of dosing strategies for commonly used ICU pharmaceuticals. A summary of commonly used drugs in critical care and dosing recommendations is summarized in Table 57.2. For analgesics, they recommend that opioids be dosed incrementally using ideal or adjusted body weight. For non-opioid analgesics, the use of standard dosing as with normal weight individuals is used. Commonly used antipsychotics such as haloperidol or quetiapine should use non-weight-based, standard doses.

Sedatives used in the ICU are more complicated, and dosing is based on the different drug classes used. Propofol is dosed using ideal or adjusted body weight, and dexmedetomidine dosing should use adjusted body weight. Etomidate dosing suggestions use actual (total) body weight for BMI <40 kg/m^2 and either actual body weight or adjusted body weight if BMI is ≥ 40 kg/m^2. Midazolam (a benzodiazepines) is highly lipophilic and has a large volume of distribution, and the use of ideal body weight or adjusted body weight is suggested to minimize the accumulation and hemodynamic effect concerns. Ketamine should consistently use weight-based dosing utilizing ideal body weight or adjusted body weight especially in patients with BMI ≥ 40 kg/m^2 or more severe forms of obesity [17].

Table 57.2 Commonly used drugs in critical care and dosing adjustment recommendations [16, 18]

Drug/category	Class	Dosing adjustment recommendation
Propofol	Sedative	IBW or ABW
Etomidate	Sedative	TBW for BMI <40 kg/m^2 and ABW for BMI ≥40 kg/m^2
Dexmedetomidine	Sedative	IBW or ABW
Midazolam	Sedative-benzodiazepine	IBW or ABW for initial and continuous dosing
Ketamine	Sedative/analgesic-dissociative	IBW or ABW
Fentanyl	Analgesic-opioid	IBW or ABW
Ibuprofen	Analgesic/anti-inflammatory	Standard dosing[a]
Toradol	Analgesic/anti-inflammatory	Standard dosing[a]
Acetaminophen	Analgesic	Standard dosing[a]
Haloperidol	Anti-psychotic	Standard dosing[a]
Quetiapine	Anti-psychotic	Standard dosing[a]
Vancomycin	Antibiotic-glycopeptide	TBW but consider a maximum loading dose of 2.5–3 g; adjust by TDM
Gentamicin, tobramycin, amikacin	Antibiotic-aminoglycosides	Use ABW with correction factor of 0.4 for initial dose and adjust by TDM
Levofloxacin	Antibiotic-fluoroquinolones	Standard dosing[a]
Carbapenems	Antibiotic	No adjustment, consider prolonged infusion of meropenem
Cefepime	Antibiotic-cephalosporin	TBW, consider prolonged infusion
Zosyn	Antibiotic-β-lactam penicillin	TBW, consider prolonged infusion

IBW ideal body weight, *ABW* adjusted body weight, *TBW* total body weight, *TDM* therapeutic dose monitoring
[a]Standard dosing refers to non-weight-based recommended dosing

57.7 Assessing Caloric Needs in the Critically Ill Obese Patient

Published weight-based formulas are less accurate in the overweight and obese ICU population to predict target energy requirements [19]. In their 2006 article, Zauner et al. describe that since energy expenditure is not constant when adjusted for weight, the usual equations used for calculating energy requirements do not work well in the obese patient [20]. For this reason, if possible, indirect calorimetry (IC) is the most accurate way to calculate energy expenditure in the critically ill, obese patient. In fact, most current societal recommendations state the same. When IC is not available, the American Society for Parenteral and Enteral Nutrition, ASPEN, recommends weight-based equations using 11–14 kcal/kg *actual body weight* for BMI 30–50 and 22–25 kcal/kg *ideal body weight* for BMI >50 [19]. They state that a high-protein hypocaloric diet should be used to "preserve lean body mass, mobilize adipose stores, and minimize the metabolic complications of overfeeding." Similarly, The European Society or ESPEN recommends that an isocaloric high protein diet (1.3 g/kg adjusted body weight/day) will provide for adequate nutrition.

As critical illness provides specific challenges, ASPEN further recommends that when a critically ill obese patient is admitted to the ICU, biomarkers of metabolic syndrome (which include glucose, triglyceride, and cholesterol concentrations), evaluation of comorbidities, and level of inflammation (including measuring C-reactive protein, erythrocyte sedimentation rate, and evidence of systemic inflammatory response syndrome) should be checked to assess nutritional needs of this population [19].

57.8 Nutrition in the Post-bariatric Surgery Patient

It is well documented and studied that patients who have undergone most types of bariatric surgery have significant alterations to their intestinal anatomy and physiology and, as such, develop micronutrient deficiencies due to malabsorption, decreased intrinsic factor, and dumping syndrome. To prevent symptoms or physiologic issues related to these deficiencies, these patients are maintained on vitamin supplementation for life. When a patient is admitted to the ICU, it is critical that these nutrient deficiencies be identified, and supplementation must commence urgently. Patients who have undergone a sleeve gastrectomy are prone to folate and B12 deficiencies primarily due to a lack of intrinsic factor. Patients who have undergone a mixed restrictive/malabsorptive procedure such as Roux-en-Y or duodenal switch are prone to deficiencies in iron, B12, and thiamine. Although uncommon, some patients will experience other trace mineral deficiencies such as copper or zinc. Clinical evaluation and replacement as indicated is critical [21].

In addition to micronutrients, there is also a documented incidence of hypoalbuminemia, which represents a protein deficiency that can have significant morbidity at baseline and especially in a critical care setting. Patients who underwent restrictive procedures had the least likelihood and having protein deficiency, while patients who underwent a malabsorptive procedure had the higher likelihood. A small study showed that in addition to continuous tube feeding, frequent supplementation of pancreatic enzymes was effective at increasing albumin in hypoalbumenic patients [22].

57.9 Deep Venous Thrombosis Prophylaxis

Several studies have shown that obese patients are at a higher risk for deep venous thrombosis (DVT). In a 2003 study Frederiksen et al. confirmed a negative correlation between anti-Xa levels and body weight. This highlighted that one-dose-fits-all does not apply to DVT prophylaxis dosing [23]. Shaikh et al. wrote a systematic review of studies aimed at identifying the dosing regimen that allowed obese patients to reach their target anti-Xa level. They found that weight-based dosing regimens such as 0.5 mg/kg BID were more effective at having patients reach their target anti-Xa levels. Interestingly, although this study did show that weight-based lovenox regimens were the most successful at having patients reach their anti-Xa level goals, it did not show a reduction in DVT or PE [24].

In a 2020 study, Almarshed et al. was in line with several other studies that are showing that extended duration of lovenox of 10–14 days was effective at decreasing the number of symptomatic DVT in the post-bariatric surgical population and there were no bleeding events at 3 months. Ideally when more evidence exists, a best practice guideline for DVT prophylaxis in this population can be developed [25].

57.10 The Obesity Paradox in Critical Care

It would be assumed that given the degree of comorbidities and challenges that are inherent to the obese patient population, there would be a higher morbidity and mortality among critically ill obese patients. On the contrary, current literature suggests that obese ICU patients may in fact have an improved ICU outcomes and a survival benefit, a term coined "the obesity paradox."

Hutagalung and others in 2011 found a decreased risk of 60 days in-hospital mortality among surgical ICU patients who were overweight or obese. This is similar to other reported ICU data where a "U-shaped" curve exists for survival of critical illness with the higher mortality in the underweight and Class II and III obesity [14]. More recently in 2020 and specifically in trauma patients, Dvorak et al. found the same "U-shaped" curve with overweight and Class I obesity having a seeming protective effect with regard to mortality; however there was an increased length of hospital and ICU stay for each BMI category above normal weight [15]. Additional evidence was found in the surgical ICU patient with peritonitis where the mortality was lowest in the BMI group over 30. All this suggests a potential protective effect of being overweight or in Class I obesity vs other weight categories although definitive causation has not been shown.

57.11 Nursing Care of the Obese ICU Patient

As much of the care for the obese ICU patient is provided by nursing and ancillary staff, it would be faulty not to discuss concerns that have arisen with regard to issues in this arena. A recent study out of Austria in 2020 [26] related the potential and probable inability to provide the same care to the obese patient as would be delivered to the non-obese patient. Nursing stated they lacked the resources related to the physical care of these patients such as extra trained personnel to help with routine positioning and turning, providing hygiene and device application. They pointed to a lack of clinical guidelines, practice standards, and extra resources needed to provide care. Identified were an inadequate supply of gowns to fit these patients, beds to accommodate them, and extra help with transportation to needed areas of the hospital. They related feeling like they were on the "edge of safe nursing care" much of the time and related feelings of having to provide "different" nursing care. Additionally, many were concerned of how to deal with emotions of repulsion, disgust, anger, frustration, blame, and fear. These concerns are well founded and should perhaps be an area of future research and call to action [26].

In conclusion, approximately 20–30% of current ICU patients are overweight or obese. While much is known about the altered anatomy and physiology of the obese population, ICU care in many ways requires meticulous attention to detail, and there is much lacking with regard to treatment guidelines, pharmaceutical dosing, ventilator management, and nursing protocols.

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Chapter 58
Bariatric Emergencies for the General Surgeon

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As the number of individuals that suffer from obesity increases, so does the number of weight loss surgeries. With the increased frequency and advancement of these surgical procedures, the associated complications have become more defined. For a multitude of reasons, these patients will often present acutely to facilities other than their bariatric centers. This is more likely as time passes from the index operation [1]. In these situations, the on-call or acute care surgeons are often called to intervene. For the purposes of this discussion, the focus will be on the late complications associated with bariatric procedures. Early postoperative complications should be referred to the operating surgeon or a bariatric center whenever possible. At times, severity of illness may preclude safe transfer, and thus those emergent issues may demand immediate surgical intervention. Coupling the lifetime risk of complications with increasing prevalence of the procedures yields a greater number of potential patients presenting acutely to non-bariatric surgeons.

When the general surgeon is called to address this patient population, it is essential to fully evaluate the patient, and care must take not to immediately assume the issues at hand are bariatric in nature. It is important to realize that the common issues requiring surgical intervention are all still possible. Proper work-up and evaluation, as in any patient population, are essential. If the acute presentation warrants surgical intervention, it is beneficial to identify the patients post bariatric surgical anatomy. The patient may not know the anatomic details of their surgical procedure. The various therapeutic options are going to be potentially limited or significantly

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altered based on these anatomic changes. Additionally, depending on the surgical procedure, the potential for metabolic and electrolyte derangements is possible.

Given how rapidly the field of bariatric surgery is expanding, general surgeons must be acutely aware that the bariatric surgeon's armamentarium may include therapeutic options that the general surgeon does not possess. The advanced endoscopic procedures such as stenting and endoscopic suturing may not be available to all acute care surgeons. As this field has continued progress, the operative techniques have become more subspecialized. For this reason, when the clinical setting allows, patients should be transferred to a bariatric center for definitive management. Oftentimes this is not possible; thus the general surgeon needs to be prepared to address these common postoperative complications.

Patient evaluation and management should be addressed with a systematic approach. Degree of resuscitation will be dependent on the patient's hemodynamic status. Routine labs and imaging should be obtained. The patient should be made nil per oris (NPO) and started on intravenous fluids in addition to proton pump inhibitors. The patient should not have a nasogastric tube placed at this time.

Dr. Khan et al. have identified several independent predictors associated with bariatric surgery complications resulting in significantly increased mortality. These include age >45 years, male gender, a body mass index (BMI) of 50 kg/m or higher, open bariatric procedures, diabetes, functional status of total dependency before surgery, prior coronary intervention, dyspnea at preoperative evaluation, more than 10% unintentional weight loss in 6 months, and bleeding disorder [2, 3]. These authors go on to identify the most common complications as bleeding, leak, pulmonary embolism, internal hernia, bowel obstruction, perforation (marginal ulcer), slipped band, and strictures [2, 3]. These common complications will be addressed individually below.

58.1 Implantable Devices

The use of implantable devices to achieve weight loss through gastric volume restriction has gone through significant changes. While the gastric band procedure was initially very popular, it has been nearly abandoned. Advancements in this realm have led to new innovations like the intragastric balloon. While gastric banding is no longer utilized as a weight loss procedure, there are still a significant number of patients with these devices in place. The prevalent complications that led to this procedure being abandon include band slippage, pouch enlargement, band erosion, and port site complications [4].

These patients can present with various symptoms including abdominal pain, nausea, emesis, and obstructive symptoms [5]. When these patients are seen, the initial treatment is the complete deflation of the band by accessing the subcutaneous port. This is done similarly to accessing a Port-A-Cath. Localization of the port and access may be difficult due to body habitus, and in these situations ultrasound guidance can be useful. After complete deflation of the gastric band, the patient should be reevaluated for symptomatic improvement. If symptoms are not resolved, nasogastric tube placement to drain the stomach may provide relief. This can be done with radiographic guidance if nasogastric tube placement is found to be difficult. Initial treatment is continued with intravenous fluid resuscitation, antiemetics, and proton pump inhibitors [6].

Once initial interventions have been completed, it is essential to evaluate for other associated complications such as band erosion, port site complications, or gastric necrosis. Typically, most of the symptoms will be resolved with balloon deflation, and the patient can be referred to a bariatric surgeon for definitive management even in the case of band erosion and port site complications [4, 7]. If the patient is critically ill or presents with an indication for emergent operative intervention, then this should be addressed by the surgeon evaluating the patient [4]. In the stable patient in which erosion of the gastric band is concerned, the bariatric surgeon will perform an esophagogastroduodenoscopy, and if they visualize erosion of the band, they can intervene at that time. The endoscopic technique for removal is indicated when 50% or more of the band, together with its lock, has migrated into the gastric lumen [8, 9].

Many of these complications can be addressed minimally invasively if the patient's condition allows; however if acute operative intervention is required, the surgeon should proceed with the approach they are most comfortable with. After gaining access to the abdomen, the gastric band can be located by following the connecting tube from the subcutaneous port back to the band. The gastric band should be freed of surrounding adhesions and connecting tissues. The surgeon should be aware of the possible fixation of the band with two to four gastro-gastric sutures. The band should be cut to remove the obstruction of the gastric outlet and explanted. In case of gastric necrosis, appropriate resection should be performed after the band removal [10]. Reconstruction should be reserved for a later date as these patients are usually in extremis with severe metabolic derangements precluding safe reconstruction on initial exploration. After approximately 3–4 months, a reconstruction can be attempted with either a gastrogastrostomy or a conversion to a Roux-en-Y gastric bypass [11].

An intragastric balloon is another alternative, minimally invasive treatment for morbid obesity [12]. Complications associated with these devices include gastric or esophageal perforation and bowel obstruction. When a patient with an intragastric balloon presents with abdominal pain, perforation should be ruled out with a computed tomography scan. Patients with intragastric balloons are to remain on proton pump inhibitors throughout the duration of the balloon placement. Esophageal perforations were only seen during the placement and extractions of intragastric balloons. Unfortunately many patients who have had gastric perforations from intragastric balloons have had relative contraindications such as large hiatus hernia, inflammatory bowel disease, increased risk of upper gastrointestinal bleeding, pregnancy, uncontrolled psychiatric disease, drug and/or alcohol abuse, and previous bariatric or gastric surgery [13]. The absolute contraindication for intragastric balloons is reserved strictly for patients with a history of partial gastrectomy [14]. This gives credence to why individual doctors or even institutions without experience, accreditation, or the ability to resolve obesity-related or bariatric surgery-related complications must not undertake such procedures such as intragastric balloon placements or extractions [12, 15]. There is an amount of noncompliance of the patients in getting the balloon removed as well, with a median of 10 months (range 9–48 months) post-insertion to extraction with the recommendation of only 6 months [16–19]. Extending the length of balloon implantation beyond that recommended could lead to increased risk of deflation due to changes in the mechanical properties of the material and subsequent migration of the balloon causing a bowel obstruction [12]. Patient with intestinal obstructions secondary to migration of an intragastric balloon should be managed surgically with evaluating the bowel and removal of the obstructing foreign body. A longitudinal enterotomy proximal to the obstruction can then be performed to remove the migrated balloon.

58.2 Gastrointestinal Bleed

Bariatric patients who have undergone surgical intervention and subsequently develop a gastrointestinal bleed will present with hematemesis with or without melena. Early bleeding is defined as within 30 days of operation and is more common than late bleeding [7]. The majority of these patients can be managed as any patient with gastrointestinal bleeding. At presentation these patients should have appropriate intravenous access established and resuscitation initiated immediately with crystalloid and blood products as needed. Then they should undergo an esophagogastroduodenoscopy with possible intervention if indicated using injection therapy (typically epinephrine), thermal coagulation, hemostatic clips, fibrin sealant (or glue), argon plasma coagulation, or combination therapy. These patients should be started on proton pump inhibitors on admission.

A common source of upper gastrointestinal bleeding in this patient population is a marginal ulcer. A marginal ulcer is a mucosal erosion at the gastrojejunal anastomosis, typically on the jejunal side. The risk factors associated with marginal ulcer formation include smoking, nonsteroidal anti-inflammatory drug use, *Helicobacter pylori* infection, and foreign body (nonabsorbable sutures or staples) [1]. Patients who have a large pouch containing more parietal cells will create an acidic environment leading to ulcer formation. These ulcers would be visualized with an esophagogastroduodenoscopy and can be managed medically with proton pump inhibitors, by removing risk factors and treating *H. pylori* when present.

58.2.1 Leak

Anastomotic leaks occur early and are likely to be identified and immediately addressed in the postoperative state by the bariatric center. Early staple line complications are rare but are feared complications [10]. The leak rate from the gastric staple line ranges from 1.4 to 20% and 0–6.1% for a gastric bypass [11, 20]. Patients can be evaluated with an upper gastrointestinal oral contrast study whether with computed tomography or fluoroscopy. If the patient is found to have a leak, the patient's status needs to be considered. If the patient is stable and there is significant concern for a leak, then the patient should be transferred to a bariatric center. However, if the patient with severe, persistent symptoms concerning for a leak is hemodynamically unstable, they will need to undergo emergent surgical intervention. The patient should be taken to the operating room for an exploratory laparotomy and washout of the abdominal cavity with multiple drain placements [5]. If the area of leak is small, it can be managed with a graham patch. However, if there is a significant area of disruption, the anastomosis may need revision. Three main objectives are pursued: sepsis control, prevention of abdominal recontamination, and nutritional (parenteral and enteral) support [5]. Most importantly definitive reconstruction should be referred to a bariatric center [10]. Bariatric surgeon's treatment is based on percutaneous drainage plus parenteral/enteral nutrition and antibiotics [5]. An endoscopic prosthesis can be positioned in selected cases and/or endoscopic fibrin glue applied [20].

58.2.2 Perforation

Perforations often occur remotely from the initial operation and are more likely than early leaks to be seen by general surgeons. Patients with perforations after a history of bariatric surgery will present similarly to the non-bariatric population. Initial evaluation, management, and resuscitation are likewise similar. Risk factors for perforation include smoking, nonsteroidal anti-inflammatory drug use, and an anastomosis with nonabsorbable suture material [21]. Once again the surgeon should approach the case based on their comfort, be that either laparoscopically or open. Initial source control is paramount. The priorities are to reduce contamination and control the perforation. A patch repair using omentum, the falciform, or intestine (Thal) of the defect is acceptable with or without primary closure of the perforation and placement of drains. In this setting major revision operations should be avoided, if possible [22].

If a perforated marginal ulcer is identified, a laparoscopic or open omental patch repair is a safe and effective treatment for this condition [23–30]. However, if the underlying cause is anatomical (large pouch, foreign body, or fistula), then a revision may be the best approach for treatment [1]. Anastomotic revision may be better suited for elective cases of refractory ulcer disease or for perforations that are not amenable to omental patch because of location or extent [23].

58.2.3 Small Bowel Obstructions

In patients who have a past surgical history of bariatric procedures, obstructive complications are the most common and are due to internal hernias and adhesive disease [1]. Any form of intra-abdominal surgery puts a patient at risk for developing intra-abdominal adhesions and the possibility of a bowel obstruction. The incidence of small bowel obstruction after open bariatric surgery has been reported to be in the range of 1–5%, whereas laparoscopic gastric bypass only reported an incidence of 2.7–3.6% [31–33].

In post bariatric patients, obstruction can involve primarily three locations: alimentary limb, biliopancreatic limb, and common channel. Symptoms can suggest the site of obstruction: heartburn and vomiting are associated with common channel or alimentary limb's obstruction. Bilious vomiting usually originates from common channel obstruction, while distension of the gastric remnant or biliopancreatic limb suggests common channel and biliopancreatic limb obstruction [5]. Computed tomography scan is a standard diagnostic tool and can demonstrate the dilatation of the Roux limb, the gastric remnant, or the biliopancreatic limb. However, even computed tomography scan can fail to identify an internal hernia. This has led to an increasing acceptance for immediate exploration of bariatric patients with subtle symptoms of a small bowel obstruction [10, 34, 35].

There are four locations in which a post bariatric surgical patient can experience an internal hernia depending on the original surgical intervention. The four locations are the transmesocolic hernia, Petersen's hernia, mesojejunal hernia, and jejunojejunal hernia. The jejunojejunal defect and Peterson's defect are the most common locations for internal hernias [7, 36]. A transverse mesocolon defect occurs when one has a retrocolic bypasses in case of transmesocolic Roux-en-Y limb. A mesojejunal defect is created from the entero-enterostomy space, resulting from the union of mesentery at the jejunojejunal anastomosis. A Peterson's defect is created between the Roux limb's mesentery and transverse mesocolon. Jejunojejunal defects are formed in the space between the two jejunal loops. Even when closed at the index operation, as high as 83% of patients spontaneously open their jejunojejunostomy mesenteric defect after weight loss [37]. Regardless of the cause of the small bowel obstruction, operative intervention remains the definitive treatment and should not be delayed in the post bariatric surgical patient due to concerns of possible volvulus and gastrointestinal necrosis.

Operative intervention can be minimally invasive or open depending on the operating surgeon's comfort and abilities. As in any laparoscopic exploration for a small bowel obstruction, a retrograde examination of the bowel starting from the ileocecal valve is easier and less risky when anatomy has been altered such as the case with bariatric surgery [38–41]. If an internal hernia is found, this is followed by gentle reduction and closure of the mesenteric defect.

58.2.4 Stenosis and Volvulus

Roux-en-Y gastric bypass stenosis is common and easy to diagnose. The loss of luminal caliber from the stenosis will result in sensations of stuck food and the need to regurgitate. The incidence of stenosis after Roux-en-Y gastric bypass is 1–31% and more common in those anastomoses done with an end-to-end anastomotic stapler compared to hand-sewn or linear stapler anastomosis [42–44]. Stenosis like symptoms can also develop as a result of an acute kink or volvulus after a sleeve gastrectomy. This is seen in up to 0.7–9% of patients undergoing sleeve gastrectomy [45]. The kink or volvulus can typically be seen on endoscopy or an upper gastrointestinal oral contrast study whether with computed tomography or fluoroscopy. This will require conversion of the sleeve to a Roux-en-Y gastric bypass or serial balloon dilation both of which should be deferred to a bariatric surgeon [46].

58.3 Conclusions

The incidence of bariatric surgical procedures is increasing, and general surgeons in areas when bariatric surgery is not readily available may be required to address complications related to these procedures. It is important to address these patients as any general surgical urgent pathological condition. Evaluation and appropriate resuscitation followed by operative intervention if unstable otherwise transfer to a bariatric center for definitive care.

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Chapter 59
Robotic Bariatric Surgeon Training

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59.1 Introduction

Surgery, like other specialties, has been profoundly modified by technological advances. In 1999, Intuitive Surgical Inc. (Sunnyvale, CA, USA) introduced the *da Vinci* surgical system, which has been adopted worldwide. The number of robotic bariatric surgeries is increasing rapidly—in the United States, more than 7% of bariatric procedures are performed using a robotic approach. Operative time remains significantly longer in robotics compared to laparoscopic ones, but there is a trend toward improvement in key quality and patient outcome metrics as usage increases [1].

The rapid advancement of robotic surgery led to the need of a standardized method of training surgeons in robotic surgery. Acquiring these skills in a simulation lab, rather than in the operating room, has significant advantages for surgeons in training, hospitals, and patients [2–4].

59.2 Simulation Training

The acquisition of surgical skills through simulation plays a central role in the curricula of medical education institutions. Robotic surgery is a perfect model for simulation-based training: easy setup, performance tracking, distance learning, standardized methods, and lower costs.

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Training to perform robotic surgery involves a simulator with stations for handling objects, movement control, energy use, sutures, and other skills. Some of the available models are the dV-trainer and Flex VR from Mimic Technologies (Seattle, WA, USA), RobotiX from Simbionix (Israel), and Skills Simulator da Vinci®-dVSS from Intuitive Surgical (Sunnyvale, CA, USA). They are complete standalone simulation solutions mimicking the da Vinci system hardware. The Fundamental Robotic Surgery Skills (FRSS) curriculum has proven its effectiveness in acquiring basic robotic skills and has been widely adopted [2, 4].

Robotic simulators present validation of competences as an educational tool and an assessment device. They provide excellent interface, content, construction, and validity evidence, delivering a comprehensive robotic surgery training tool [5–7]. The surgeon receives a performance assessment immediately after the exercise, providing guidance on what needs to be improved, or if it was performed correctly. The surgeon can, in this way, familiarize himself with the equipment and, after exhaustive training, perform the initial procedures with more skill and precision, decreasing the learning curve (as already shown in controlled studies) and possibly the risks of accidents and complications [8].

The DVSS and dV-Trainer share the same scoring method. MScore® is the software used, grouping exercise metrics into categories to measure proficiency level [9, 10]. After performing the exercises, the simulator provides scores based on the user's performance, which will be linked to various aspects involved in the execution, such as the activity execution time, economy of movement, arms collision, and maximum use of the workspace, among others, more specific to each proposed exercise, such as the use of energy unnecessarily in dissection exercises [1] (Table 59.1).

Table 59.1 Examples of metrics used in the skills simulator

Metric	Definition
Motion economy	Distance travelled by instruments
Master workspace range	Size of the area controlled by the surgeon's hand
Time to complete	Time to complete the task
Blood loss volume	Amount of blood lost
Dropped needles	Number of times object is dropped
Excess needle passages	Number of extra needle "bites" taken
Excessive force	When the force on an instrument is too large (shown when the instrument turns red)
Incorrect targets	Number of times target was missed
Instrument collisions	Number of times instruments collided (with another instrument or with the endoscope)
Instruments out of view	When instruments are taken outside of the visible field
Needle out of view	When needle is taken outside of the visible field
Scope collisions	When instruments collide with the target
Suture breaks	When the suture is broken due to excessive force

Simulators allow administrators to track learning performance and progress over time, customize user accounts, create and share custom simulation curricula, manage courses, and export data for in-depth analysis. In addition, the score history can show the most important areas for improvement [9].

59.3 Learning Curve and Training Curricula in Bariatric Robotic Surgery

Despite the increased dexterity and accuracy of robotic surgery, like any new surgical technology, it is still associated with a learning curve that may lead to negative patient outcomes. The use of surgical simulators is a low-risk environment, which has been shown to shorten these learning curves [3, 11].

There are no protocols for specific training of robotic bariatric surgeons that are different from other specialties. There is already a tendency for specialties to have their own benchmark score in the simulator to determine competences, thus creating minimum benchmarks for each proposed activity in the robotic virtual reality environment. These benchmark scores are obtained through the performance of specialists in robotic surgery. Thus, the reference scores derived from specialists in that type of procedure provide minimum scores for surgeons in training and allow the training to be based on a competency curriculum [5, 12].

After qualifying in the simulators, the surgeon in training must start practicing real surgeries under the mentoring of an experienced robotic surgeon. There is no consensus on the number of surgeries that should be performed under supervision. In laparoscopic surgery, IFSO recommends that the professional has a minimum experience of 100 weight loss surgeries to obtain credentials to perform bariatric procedures. IFSO considers bariatric surgery to be an advanced laparoscopic procedure that requires comparable skills, such as laparoscopic hiatal hernia repair, laparoscopic gastrointestinal resection, and laparoscopic splenectomy. It is advised that the surgeon has experience in non-bariatric procedures before starting laparoscopic bariatric operations [13].

59.4 Stages of Training in the da Vinci® System

Intuitive has developed a training protocol specially designed to develop the skills needed by the surgeon in a complete and consolidated way. The surgeon first needs to become familiar with the system through simulators, videos, and live case observations and progressively advances the skills. After this phase, surgical practices should be planned according to their specialty, with an experienced proctor in that specialty [9, 14].

1. Online training through the da Vinci community—videos explaining technical aspects of the device
2. Practical training—practical lessons on a simulator and the actual robotic platform, with a company representative

3. Online certification—online test evaluating completion of steps 1 and 2
4. Laboratory certification—a practical test performed by an intuitive specialized evaluator, assessing simulator practice and in vivo procedures
5. Post-certification—surgical procedures done under the supervision of a proctor (highly specialized surgeon)

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Part III
Metabolic and Diabetes Type 2 Surgery

Chapter 60
Mechanisms of Control of Diabetes 2 with Duodenal Switch

Julie Holihan and Erik Wilson

60.1 Introduction

Type 2 diabetes mellitus (DM2) is an extremely common disease, with approximately 5% of the world population affected by it [1]. DM2 results from insulin resistance and deficiencies in insulin secretion. Impaired insulin resistance is partially caused by glucotoxicity, lipotoxicity, and systemic inflammation and is exhibited by the skeletal muscle, liver, and adipose tissue, among other tissues [2]. This leads to a compensatory increase in insulin secretion from the pancreas. Once the pancreatic beta-cells are unable to maintain this increased insulin production, the body remains in a hyperglycemic state, and the patient becomes diabetic.

60.2 Risk Factors

There are a number of risk factors associated with the development of DM2. While incompletely understood, the development of DM2 seems to involve a complex interaction between genetic susceptibility, lifestyle, and environmental factors [1]:

- *Genetic susceptibility*—Different ethnicities have great variation in the incidence of DM2. For example, in the United States, compared to Caucasians, African Americans have a twofold increase, Mexican Americans have a 2.5-fold increase,

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and Native Americans have a fivefold increase in the development of DM. This suggests there may be genetic differences that leave some more susceptible to DM2 than others.

- *Lifestyle*—There are a number of modifiable risk factors associated with the development of DM2. This includes obesity, sedentary lifestyle, and a Western diet (low fiber, high saturated fat).
- *Environmental factors*—Certain regions have been shown to have higher rates of DM than others. For example, the Pima Indians of Arizona have been shown to have a 50% rate of DM2, while the prevalence in China is only 1% [3]. These differences may suggest potential environmental factors contributing to the development of diabetes.

Obesity is one of the strongest risk factors for the development of DM2. Ninety percent of DM2 patients are overweight or obese [4]. Women with a body mass index of (BMI) >35 kg/m^2 have a 40-fold increase in the development of DM2 compared to women with a normal BMI [1]. Central obesity, in particular, has been linked to the development of DM2. Therefore, controlling obesity is essential to controlling obesity-associated diseases, such as DM2.

60.3 Bariatric Surgery and DM2

Bariatric surgery is one of the most effective treatments for obesity-associated diseases. The American Diabetic Association (ADA) recognized bariatric surgery as a possible treatment option for DM2 in 2009, and the International Diabetes Foundation (IDF) followed suit in 2011 [4]. It has been well demonstrated that bariatric surgery can improve DM2 or even lead to its remission. Compared to lifestyle and medical interventions, surgery is more likely to lead to remission of DM and is even associated with a decrease in DM2-related mortality.

There are a number of options for bariatric surgery, and each option has a different effect on DM2. Duodenal switch is one option for bariatric surgery and often the option with the most significant weight loss. It has also been shown to have excellent results with regard to DM2 control. Remission rates for DM following duodenal switch range between 50 and 95% (Table 60.1).

Table 60.1 Studies of remission rates for DM following duodenal switch

Author, year	Type of study	*N*	DM2 outcome	Follow-up
Cho et al. (2011) [5]	Retrospective	86	91% remission	1 year
Mingrone et al. (2012) [6]	RCT	56	95% remission	2 years
Mingrone et al. (2015) [7]	RCT	53	63% remission	5 years
Camerini et al. (2016) [8]	Retrospective	120	91% remission 85% remission	5–10 years 15 years
Fernandez-Soto et al. (2017) [9][a]	Prospective observational	49	78% remission	1 year
Mingrone et al. (2021) [10]	RCT	57	50% remission	10 years

[a]Includes RYGB and BPD

60.4 Mechanisms for DM2 Control

There are a number of mechanisms in which duodenal switch may contribute to improvement of DM2. Proposed mechanisms include decreased caloric intake, weight loss, malabsorption, and bypass of the proximal intestine. The exact mechanism is unknown and may be multifactorial.

60.4.1 Decreased Caloric Intake

Interestingly, a decrease in blood glucose levels can be seen following bariatric surgery even before weight loss [11]. One proposed mechanism for this is the severely decreased caloric intake, which is observed immediately postoperatively. In this theory, calorie restriction causes changes in the entero-insular axis, leading to improved glucose metabolism and insulin resistance [12]. The GI tract releases hormones called incretins as a response to glucose. These hormones are thought to play a major role in the control of insulin secretion. Altering caloric stimulation of incretins, like through a severely calorie restricted diet, can markedly affect glucose metabolism and insulin levels. There are a number of potential hormones involved in this. For example, glucagon-like peptide (GLP-1) and glucose-dependent insulinotropic polypeptide (GIP) are thought to control up to two thirds of insulin secretion. Another possibly involved hormone that has been well studied is ghrelin. Ghrelin is produced by the stomach and is linked to overeating and obesity. Some data suggests that ghrelin may also be involved in the regulation of insulin secretion and insulin resistance.

This theory is supported in both bariatric surgery and non-bariatric surgery patients. In non-bariatric surgery patients on a very low-calorie diet, reduction in fasting glucose is seen immediately, even before weight loss has been achieved. In addition, patients following intermittent very low-calorie diets have lower HbA1c levels compared to those with standard dieting. Following bariatric surgery, improvements in fasting blood glucose can be seen even before hospital discharge. It is postulated that the postsurgical diet leads to an interruption in the entero-insular axis, which allows for recovery of normal metabolism [12].

60.4.2 Weight Loss

Weight loss leads to decreases in fat mass and in changes in the release of adipocytokines such as leptin, adiponectin, and resistin. This is thought to improve glucose metabolism and insulin resistance [12]. Many studies have demonstrated a linear relationship between BMI and insulin resistance. This strong association between obesity and DM2 has led to the theory that adipose tissue may play a role in the regulation of glucose metabolism and beta-cell function. An abundance of evidence suggests that weight loss leads to improved DM2 parameters, including blood glucose and insulin levels. This has led to a recommendation from the National Institute of Health that "Weight loss is recommended to lower elevated blood glucose levels in overweight and obese persons with DM2." Duodenal switch is associated with a 75% reduction in excess body weight, making it a viable option for weight loss and DM2 control [13].

60.4.3 Malabsorption

Duodenal switch brings biliopancreatic secretion to the distal ileum, resulting in malabsorption. This is thought to play a key role in the weight loss seen with this operation and may have a role in DM2 control. The exact mechanism for this is unclear. Animal studies show that there is an overall decrease in digestible energy intake and increased fecal energy loss due to malabsorption following duodenal switch [14]. In addition, a study of postsurgical metabolite profiles compared postprandial glucose levels and insulin levels in duodenal switch patients to gastric bypass patients [2]. While both procedures bypass the proximal small intestine, duodenal switch has been shown to be more malabsorptive than gastric bypass. In this study, malabsorption was confirmed by testing postprandial total amino acid level, which was significantly lower for duodenal switch patients than in gastric bypass patients. Patients who had a duodenal switch were found to have lower postprandial serum glucose and lower insulin levels than those with gastric bypass [2]. Malabsorptive changes caused by the duodenal switch may lead to changes in hormonal signaling that plays a critical role in glycemic control.

60.4.4 Duodenal/Jejunal Bypass

Though all bariatric surgeries have been demonstrated to lead to some improvement and/or remission of DM2, duodenal switch and Roux-en-Y gastric bypass have the greatest improvement and highest rates of remission. This fact remains independent of the amount of weight lost, suggesting that bypassing the proximal portion of the small intestine may contribute to better DM2 control. Furthermore, while pure restrictive types of bariatric surgery, such as sleeve gastrectomy, lead to resolution of DM2, resolution is not as sustainable as for those who have undergone a bypass procedure [12].

In a study of patients who have undergone bypass surgery compared to nonsurgical patients who were matched in weight, age, and percent of body fat, the bypass patients had significantly lower serum fasting glucose levels [15]. This supports the theory that bypassing a proximal portion of the small intestine contributes to DM2 control, independent of weight. In animal studies, excluding the duodenum and part of the jejunum results in marked improvement in oral glucose tolerance despite no changes in food intake or weight [16].

The exact mechanism for this is unclear, but one possible explanation is that delivering nutrients to the distal portion of the intestine may enhance a physiologic signal that improves glucose metabolism. A candidate molecule for this signal is GLP-1 [16]. GLP-1 stimulates insulin secretion and enhances pancreatic beta-cell proliferation. However, other unknown distal intestine molecules may be involved. An alternative theory is that bypassing the proximal intestine prevents the secretion of a signal that could promote insulin resistance, though no exact molecule is known for this [16].

60.5 Conclusions

Duodenal switch is associated with substantial rates of complete DM2 remission, ranging between 50 and 95% at up to 15 years postoperative. While the exact mechanism for this is unknown, there are a number of theories. Possible contributing mechanisms include decreased caloric intake, weight loss, malabsorption, and bypass of the proximal small intestine. The true answer may be multifactorial and involve some component of all of these. While further studies are needed to uncover the true mechanism for DM2 control after duodenal switch, duodenal switch appears to be an excellent option for appropriately selected patients with obesity and DM2.

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Chapter 61
The Evolution of Single-Anastomosis Duodenal Switch

Daniel Cottam, Michelle Everly, and Amit Surve

61.1 Introduction

61.1.1 The Journey to the Duodenal Switch

The first attempt of surgically induced weight loss was made in the 1950s as the jejunoileal bypass. It worked well as a weight loss operation but had high rates of life-long complications such as renal failure, diarrhea, nephrolithiasis, liver disease, intestinal bacterial overgrowth, severe malnutrition, and immune complex-mediated arthritis-dermatitis [1]. In the 1960s, Drs. Mason and Ito developed the Roux-en-Y gastric bypass (RYGB). This eliminated many of the complications associated with the jejunoileal bypass and resulted in its worldwide adoption as the procedure of choice until very recently [2]. While the RYGB was performed often, it also had a unique set of complications such as marginal ulcers, perforations, strictures, internal hernias, dumping syndrome, and weight regain. Seeing the large numbers of RYGB patients with weight regain led Scopinaro in 1976 to develop the biliopancreatic diversion (BPD) [3]. The BPD required a hemi-gastrectomy and long Roux limb connection to the stomach with a 50-cm common channel. Dr. Nicola Scopinaro designed the BPD to have a strong malabsorptive component for long-term weight loss maintenance [4].

The first Roux-en-Y duodenal switch (DS) was a modified version of the BPD and was performed by Dr. Douglas Hess in 1986 [5]; it initially consisted of vertical sleeve gastrectomy (VSG) (instead of a hemi-gastrectomy) with a Roux limb brought up to the proximal duodenum (instead of the stomach). The total alimentary limb length was 40% of the small bowel length, with a common channel length of

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approximately 75–150 cm. The original DS was designed to preserve pyloric function to reduce the risk of dumping syndrome postoperatively.

The DS, as Hess performed it, had fewer marginal ulcers and dumping syndrome when compared to the RYGB, better long-term weight loss, and improved diabetes resolution [6]. Despite the many favorable peer-reviewed papers published, it was not widely accepted initially due to fears of long-term vitamin and protein deficiencies [7].

61.1.2 The Initiation of the Single-Anastomosis Duodenal Switch

In 2007, two surgeons from Spain altered the DS to eliminate the Roux limb [8]. Drs. Torres and Sanchez-Pernaute performed this proximal end (of the duodenum)-to-side (of distal ileum) bypass to preserve pyloric function while reducing the need for two anastomoses and to decrease operation times and operative complexity. The SG was performed with a 54-French gastric bougie, and the single anastomosis was hand-sewn, 4 cm distal of the pyloric sphincter to the ileum approximately 200 cm proximal to the ileocecal valve. This eliminated the existence of a Roux limb, and the patient was left with a 200-cm common channel alimentary limb and the afferent biliopancreatic limb. This procedure later changed to a common channel with a length of 250 cm reducing the rate of hypoproteinemia from 8 to 2% [9].

The procedure nomenclature has only recently been standardized as the single-anastomosis duodeno-ileostomy with sleeve gastrectomy (SADI-S). This name covers all single anastomotic procedures where the stomach has been "sleeved" (regardless of bougie size), the pylorus retains its functionality to manage enteric food flows (to reduce dumping syndrome), and there is a single anastomosis of the proximal duodenum to the distal small bowel regardless of the length of the bypassed bowel.

61.1.3 Ever-Evolving Variations

While most surgeons focus on Torres's pioneering work, Dr. Kazunori Kasama in Japan, also in 2007, introduced a novel procedure called "duodenojejunal bypass with sleeve gastrectomy" (DJB-SG), another derivative of the original DS procedure [10]. Unlike SADI-S by Drs. Torres and Sanchez-Pernaute, there were two anastomoses instead of one. Also, one of the two anastomoses was created using the duodenum and jejunum.

Dr. Wei-Jei Lee further modified the DJB-SG by Dr. Kasama in China. In July 2011, Dr. Lee used a loop limb instead of a Roux-en-Y configuration, eliminating one anastomosis (jejuno-jejunostomy) and named it "loop duodenojejunal bypass with sleeve gastrectomy (LDJB-SG)" [11]. The same concept of creating an anastomosis using a loop limb instead of a Roux-en-Y configuration was also used by Dr. Chih-Kun Huang for patients with type 2 diabetes (T2D) in October 2011 [12]. These derivatives of the original DS, the DJB-SG and loop DJB-SG, are mostly performed in the eastern part of the world like Japan, India, and China (Table 61.1) [8, 10–33].

Table 61.1 Articles on derivatives of DS

No	Surgery	First author (reference)	Country	First surgery (month, year)	First article (year)
1	DJB-SG	Kasama et al. [10]	Japan	2007	2009
2	DJB-SG	Raj et al. [13]	India	UA	2012
4	Loop DJB-SG	Huang et al. [12]	Taiwan	Oct., 2011	2013
3	Loop DJB-SG	Lee et al. [11]	China	2011	2014
5	DJB-SG	Ruan et al. [14]	China	Dec., 2011	2017
6	DJB-SG	Lin et al. [15]	China	Mar., 2012	2019
7	DJB-SG	Vennapusa et al. [16]	India	May, 2013	2020

No	Procedure	First author	Country	First surgery (month, year)	First article (year)
1	SADI-S	Sanchez-Pernaut et al. [8]	Spain	UA	2007
2	SADI-S	Mitzman et al. [17]	U.S.A.	June, 2013	2016
3	SADI-S	Gebelli et al. [18]	Spain	Nov., 2014	2016
4	SADI-S	Nelson et al. [19]	U.S.A.	Dec., 2013	2016
5	SADI-S	Neichoy et al. [20]	U.S.A.	Oct., 2013	2018
6	SADI-S	Surve et al. [21]	Australia	UA	2018
7	SADI-S	Dijkhorst et al. [22]	Netherlands	UA	2018
8	SADI-S	Heneghan et al. [23]	U.K.	UA	2018
9	SADI-S	Enochs et al. [24]	U.S.A.	Apr., 2014	2020
10	SADI-S	Yashkov et al. [25]	Russia	May, 2014	2020
11	SADI-S	Surve et al. [26]	Australia	Jan., 2017	2020
12	SADI-S	Robert et al. [27]	France	Oct., 2018	2020
13	SADI-S	Andalib et al. [28]	Canada	June, 2016	2021
14	SADI-S	Badshah et al. [29]	Qatar	Aug., 2017	2021
15	SADI-S	Admella et al. [30]	Spain	2014	2021
16	SADI-S	Wang et al. [31]	China	June, 2017	2021
17	SADI-S	Ruano-Campos et al. [32]	Spain	Mar., 2018	2021
18	SADI-S	Pereira et al. [33]	Portugal	Feb., 2015	2021

DS Roux-en-Y duodenal switch, *DJB-SG* duodenal-jejunal bypass with sleeve gastrectomy, *UA* unavailable, *SADI-S* single-anastomosis duodeno-ileal bypass with sleeve gastrectomy

In 2013, Drs. Cottam and Roslin in the USA altered the SADI-S further to enhance the restrictive component, utilizing a 40-French gastric bougie and increasing the common channel length to 300 cm [34, 35]. This variation was called the "stomach-intestinal pylorus-sparing surgery" (SIPS) [17]. The long-term outcomes show 78–95% excess weight loss occurring at 18 months postoperatively that are maintained out to 6 years [36]. The complication profile seems less than the RYGB and DS procedures [25, 37]. Compared to SADI-S, the weight loss between SG and RYGB is significantly different, with better weight loss with SADI-S [36, 37]. The SADI-S or DS has also been found to be safe and effective for failed weight loss following a failed AGB, RYGB, or SG [38–41].

In 2018, the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) accepted the SADI-S procedure as a standard of care, and in 2020, the American Society for Metabolic and Bariatric Surgery (ASMBS) has also accepted SADI-S as a standard of care as long as there is a program with proper nutritional supplementation and follow-up [42, 43].

With international recognition, it stands to reason those comparisons between the eastern hemisphere and the western hemisphere duodenal bypass procedures should occur. In 2021, Li et al. compared the outcomes of the SADI-S between the East and West [44]. According to Li et al. western hemisphere surgeons use larger bougies and have shorter common channels. This results in better weight loss and diabetes resolutions. However, this should lead to more nutritional complications, but there are currently not enough papers to support this conclusion. Surgical complications are the same between the two hemispheres.

The SADI-S approach to weight management is gaining popularity in many different parts of the world. There have been articles published from Spain, the USA, the Netherlands, China, Japan, Taiwan, Egypt, Brazil, Portugal, Italy, Russia, Canada, Australia, and Qatar (Table 61.1). The future of the SADI-S as a standalone procedure seems secured. Surgeons are increasingly being trained to do this laparoscopically and robotically. With any procedure that bypasses much of the small bowel, attention must be focused on vitamins B1 and B12; folate; iron; vitamins A, D, E, and K; and zinc [45]. Since this procedure is carbohydrate malabsorptive, patients need to be educated on eating a high fat and protein diet to avoid diarrhea and malodorous gas. There are still studies being conducted with respect to hormonal and physiological markers related to complications that will require further extensive follow-up [46].

61.2 Conclusions

The duodenal switch has undergone many significant changes simultaneously worldwide while keeping low complication rates when compared to Roux-based approaches. Now that all worldwide societies have approved the SADI-S, we expect many more rapid modifications around the work that will reduce both short- and long-term complications associated with this procedure while simultaneously improving weight loss outcomes.

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Chapter 62
Chapters on Metabolic Syndrome Control and the Influence of Hormonal Changes Post-duodenal Switch (DS)

David J. Tansey and Carel W. le Roux

62.1 The Hormonal Changes After a Duodenal Switch and Their Potential Mechanisms

The clinical improvements in obesity-associated complications seen after duodenal switch (DS) or biliopancreatic diversion (BPD) can be substantial. These include benefits to metabolic, cardiovascular, respiratory, reproductive and musculoskeletal health as well as improvements in renal disease and the reduction in overall and cardiovascular-associated mortality [1–3]. The mechanisms responsible that facilitates weight loss include:

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62.1.1 Reductions in Food Intake

When the first bariatric procedures were developed in the 1950s, the surgeons attempted to promote weight loss through the development of procedures that either restricted food intake or led to the malabsorption of calories. However, this hypothesis of inducing weight loss, through mechanical restriction, has been disputed in recent years, for several reasons. While on low-calorie diets, patients generally report an increase in hunger and a decrease in satiety [4, 5]. If DS/BPD's primary mechanism for weight loss was achieved through the restriction of food intake, one would expect similar symptoms in patients after surgery. However, these findings are very much in contrast with the eating behaviour seen in patients after DS. Patients report that they are generally less hungry and reach satiation faster during a meal [6, 7]. Caloric restriction through diet alone usually leads to a compensatory increase in the consumption of energy-dense food, but this occurrence is not observed in patients or animals after bariatric surgery [8, 9]. Indeed, one of the predominant reasons against the food restriction argument is seen in studies that demonstrate that patients who 'fail' bariatric surgery and have regained most of the initial weight loss can in fact consume the same amount of calories as pre-operatively, even though the size of their stomach has not increased substantially [10, 11]. Food intake can be higher after DS/BPD than after other procedures such as Roux-en-Y gastric bypass or sleeve gastrectomy alone, but it is important to note that the compensatory hyperphagia expected after DS/BPD, given the substantial weight loss, usually does not materialise even if calorie malabsorption is present [12].

62.1.2 Mechanical Factors

The research into the role of mechanical factors responsible for weight loss after DS/BPD has been conflicting, perhaps suggesting that its role is minimal or non-existent. The impact that different sizes of gastric pouches and stomas, in the case of RYGB and that of sleeve gastrectomy volumes, has on food intake and body weight is controversial. Some studies have shown that the smaller the gastric pouch and stoma diameter, the greater the weight lost [13–15], while other studies have disputed this [11, 13, 16]. Similarly, incongruent results have been found for the sleeve gastrectomy volumes [17–20]. Overall, the perceived influence of mechanical and restrictive factors on the effects seen after DS is widely accepted to have been previously overstated. It would appear that other mechanisms play a much greater role.

62.1.3 Malabsorption

According to Scopinaro, biliopancreatic diversion (BPD) is the classic malabsorptive bariatric procedure [2]. The degree of malabsorption for BPD/BPD-DS varies according to the length of the common channel (50–125 cm), in which the digestion and absorption occur [21]. The shorter the common channel, the more effective the weight loss [22–24], but equally the more common side effects such as diarrhoea and severe vitamin A and D deficiencies become [22].

In 2015, Li et al. quantified the calorie malabsorption after DS in rats [25] and showed that BPD and DS led to significant reductions in weight gain, percentage of fat, and adipose tissue weight when compared to SG. BPD and DS produced intestinal hypertrophy, as well as higher plasma GLP-1 and PYY in both fasted and refed states [25]. However, Li concluded that the metabolic benefits seen in BPD/DS appear to be largely caused by food malabsorption. The elevation of anorectic GLP-1 and PYY are additional consequences of BPD/DS, which, together with malabsorption, however may also promote the metabolic benefits of BPD/DS [25].

62.1.4 Hypothalamic Signalling

Obesity is now considered a disease of the subcortical areas of the brain [26]. Within the subcortical areas of the brain, the hypothalamus is the control centre of hunger and satiety. It is by way of gut signals acting upon stimulatory or inhibitory neurons in the hypothalamus that determines if we are hungry or satisfied. Alterations in patients' gut hormones post-DS changes the stimulation/inhibition of the hypothalamus, thereby affecting appetite and satiety. The arcuate nucleus of the hypothalamus contains two groups of neurons with opposite effects. The first group synthesises pro-opiomelanocortin-derived peptides, among which melanocyte-stimulating hormone acts via the melanocortin receptor 4 (MC4R) on the peri-ventricular nucleus, lateral hypothalamus and the ventromedial nucleus to reduce food intake and increase energy expenditure [27]. The second group of neurons synthesise neuropeptide Y, agouti-related protein (AgRP) and γ-aminobutyric acid, which increase food intake and reduce energy expenditure by inhibiting proopiomelanocortin, but also by projecting to the peri-ventricular nucleus, lateral hypothalamus, ventromedial nucleus and dorsomedial nucleus [27]. The arcuate nucleus is also in direct contact with blood, enabling it to be responsive to nutrients and circulating gut hormones [28]. From first principles, DS surgery influencing hunger, satiety and weight loss by way of its effect on these hypothalamic neurons postoperatively makes sense. However, in practice, little evidence exists that bariatric surgery or DS reduces the weight 'set point' by altering the expression of key signalling elements in the hypothalamic nuclei.

In humans, RYGB has been shown to be effective at inducing weight loss even in patients with heterozygous mutations for MC4R [29]. This suggests that if hypothalamic signalling plays a role in the weight loss seen post bariatric surgery, it is not the solitary mechanism involved. Future studies need to examine the expression of these peptides in animal models of subjects post-DS and other bariatric surgeries, as compared to pair-fed sham animals. However, it is unclear whether these studies will lead to any viable pharmacological targets for obesity. This is because of the failure of previously used centrally acting as weight loss drugs that were associated with substantial adverse effects (e.g. rimonabant, which has since been removed from the market) due to their action at multiple receptors and sites in the brain [30].

62.1.5 Gut Hormones and Leptin

In 1980, there was seminal work carried out that examined the hormonal changes after BPD surgery. Sarson et al. found reductions in the upper small intestinal hormones, motilin and gastric inhibitory polypeptide after both jejunoileal (JIB) and biliopancreatic (BPB) bypass surgery for morbid obesity, along with an increase in the ileal hormones, neurotensin and enteroglucagon [31]. Gianetta et al. studied insulin in these patients and found that postoperatively, there was a sharp reduction in basal and postprandial insulin values; however, this appeared to normalise after 15–20 months [32]. Finally, Civalleri et al. found that there were no significant differences in fasting and meal-stimulated peak plasma gastrin levels between patients with obesity and their control group and between any of the postoperative groups and the pre-operative group [33]. This work prompted decades of research into the hormonal changes seen after bariatric surgery and its relevance. The hormonal changes caused by these surgeries closely reflect the anatomical changes induced by each particular surgical technique. Today we know that DS changes the signalling from the gut to the hypothalamus and brainstem. The predominant hormones involved in this pathway are as follows:

62.1.5.1 Glucagon-Like Peptide-1 (GLP-1)

GLP-1 is secreted by the L-cells of the small bowel, with higher concentrations in the distal ileum and colon. The GLP-1 receptors are located in the hypothalamus, striatum, brainstem and substantia nigra, among other areas of the brain [34]. GLP-1 is produced in response to a meal and then increases satiety, reduces hunger and decreases food intake, through its effects on the hypothalamus and brainstem [35]. GLP-1 also increases insulin secretion, inhibits glucagon release and slows gastric emptying [36]. The postprandial GLP-1 levels are much higher after both RYGB and sleeve gastrectomy [37]. The altered anatomy and shorter gut seen in RYGB lead to the rapid delivery of nutrients to the distal ileum causing an increase of both GLP-1 (and PYY) levels [38]. Similar increases in gut hormones are seen after sleeve gastrectomy due to rapid gastric emptying [39]. In 2007, Borg et al. found that rats after BPD had higher levels of PYY, GLP-1 and GLP-2 when compared to the sham-operated group. They concluded that these higher levels were due to gut adaptation and hypertrophy that could be important in inducing and maintaining weight loss after bariatric surgery [40].

62.1.5.2 Oxyntomodulin (OXM)

OXM is an anorexigenic peptide co-secreted with PYY and GLP-1 in intestinal L-cells [41]. The administration of OXM reduces hunger, food intake and ghrelin levels as well as decreases gastric acid secretion, GE and duodenal motility [42]. Postprandial OXM is increased 1–2 months after RYGB [43] and may predict weight loss [40]. However, there have been very few studies looking at the change in OXM post BPD/DS.

62.1.5.3 Peptide YY (PYY)

PYY is also released from the L-cells of the distal small bowel after eating and acts at the arcuate nucleus of the hypothalamus, to decrease food intake but also via vagal afferents terminating at the nucleus of the solitary track, to signal satiety [44]. PYY also delays gastric emptying [45]. Patients with increased levels of PYY after RYGB had more weight loss [38, 46]. The postprandial release of the hormone peptide YY (PYY) is markedly higher after both RYGB and sleeve gastrectomy, but not after adjustable gastric banding or caloric restriction [4, 5, 47, 48]. The hypothesis is that PYY release is also higher in DS, although there is limited **data to support this**. Hedberg et al. found that although the pylorus is preserved in BPD/DS, stomach emptying is faster than in non-operated subjects. They observed how PYY levels are elevated in the fasting state after BPD/DS and a marked response to a test meal is seen, likely due to the rapid stimulation of intraluminal nutrients in the distal ileum [49].

62.1.5.4 Ghrelin

Ghrelin is a peptide produced by the X/A-like cells in the fundus of the stomach during fasting and acts on growth hormone secretagogue receptors [50]. Ghrelin levels are decreased after eating, with carbohydrates having more of a suppressive effect than protein and lipids [51]. Ghrelin stimulates neuropeptide Y-AgRP neurons within the arcuate nucleus [52] but also through the vagus and brainstem to increase food intake [53]. After sleeve gastrectomy, the levels of ghrelin are reduced [54]. Conversely, ghrelin levels are increased in the setting of calorie restriction and post-AGB [6]. A study on ghrelin concentration in patients with obesity prior to and 5 days and 2 months following BPD demonstrated that unlike after dieting or RYGB, only an initial reduction in ghrelin concentration was observed. However 2 months following BPD, when food intake had nearly completely resumed, ghrelin concentrations returned to the pre-operative levels [55]. This is consistent with the hypothesis that ghrelin production from the stomach is greatly influenced by the direct contact of ingested food with the gastric cells [56].

62.1.5.5 Leptin

Leptin is secreted by adipocytes and influences energy intake primarily by acting on the hypothalamus [57–59] to decrease food intake and increase energy expenditure [57]. Loss of fat mass and decreases in plasma leptin levels are seen in patients who restrict their calorie intake, either through dieting or post bariatric surgery [5, 60]. After dieting, hyperphagia is generally observed; however this is not seen in post bariatric surgery patients, suggesting that the additional physiological alterations after surgery are enough to counterbalance the reduced leptin levels [7]. de Marinis et al. studied BMI, insulin levels and leptin levels in patients post-DS. They found that leptin decreased rapidly, without correlation with BMI, indicating that body composition is not the only factor regulating leptin levels [61]. They also noted the consistent correlation between leptin levels with insulin levels suggesting an important interaction between these two hormones in post-BPD subjects [61].

62.1.6 Vagal Signalling

The contribution of the vagus nerve to weight loss after bariatric surgery and DS is an area that has not been adequately explored. However, its implication in the weight loss seen in patients post-DS is a source of great interest. The vagus nerve is a key signalling relay system between the gut and the brain and an important regulator of food intake and body weight. The presence of nutrients in the small intestine leads to the release of gut hormones, which exert part of their physiological effects through the vagus [62]. There is little data available that specifically examines the effect of DS on vagal signalling. Indeed, the limited data that does exist in the area looks at the effect of the other forms of bariatric surgery, e.g. RYGB or adjustable gastric banding and is inconclusive and often contradictory. In 2011, Seyfried et al. found that the preservation of vagal fibres during surgery was associated with greater and more sustained body weight loss in animal models of RYGB [63]. Bjorklund et al. human study supported this hypothesis by concluding that the rapid entry of food from the oesophagus, through the small gastric pouch, might trigger vagal signalling in the alimentary limb, which contributes to a reduction in food intake [64]. Conversely, Shin et al. suggested that the vagus did not play an important role after RYGB given that when they carried out a selective vagotomy to the hepatic branch of the vagus in rat models, it did not have an effect on food intake, weight loss and metabolic control [65]. Overall, the limited available data suggests that vagal signalling is the likely mechanism through which adjustable gastric banding reduces food intake and weight loss, rather than restrictive factors, and this is also likely to be the case in patients post-DS also.

62.1.7 Bile Acids

Bile acids can directly or indirectly affect food intake, energy expenditure and glycaemic control through their actions on membrane TGR5 receptors or nuclear FXR receptors and the release of fibroblast growth factors (e.g. fibroblast growth factors 19 and 21), which can exert their action on a wide range of tissues including the hypothalamus [66–68]. Bile acids also cross the blood–brain barrier, and their receptors have been identified in the brain [69, 70]. BPD/DS and other forms of bariatric surgery exert an effect on bile acid levels and type. These alterations in the levels or types of bile acids in the gut or the circulation have been implicated in the glycaemic improvements and even the reduction in food intake observed after bariatric surgery, particularly post-RYGB. Total plasma bile acids and their subfractions are higher after RYGB, but not adjustable gastric banding [71–74], and their levels negatively correlate with postprandial glucose levels [72]. Stefater et al. examined bile acids post sleeve gastrectomy and concluded that plasma bile acids are also elevated in animal models of sleeve gastrectomy [75]. This hypothesis is yet to be examined in BPD/DS. There is a need for further in-depth mechanistic analysis into the exact role that bile acids play as mediators of weight loss and glycaemic control after bariatric surgery, particularly after BPD/DS. However, by mediating the physiological effects of bile acids, fibroblast growth factors and their receptors, this represents exciting new therapeutic targets for obesity and type 2 diabetes.

62.1.8 Gut Microbiota

In recent years, there has been a focus on the potential role that alterations in gut microbiota have on obesity and weight loss. Some studies suggest that obesity is associated with unfavourable colonisation of the bowel with bacteria that are more efficient at extracting energy from nutrients and storing it as fat [76]. Indeed, part of the weight loss effect seen in patients after DS and other bariatric surgery may be achieved by a profound disturbance of this bacterial colonisation caused by the surgery. The data is limited, particularly when it comes to these bacterial changes post-DS but after RYGB that there is a reduction in the proportion of *Prevotellaceae*, *Archea*, *Firmicutes* and *Bacteroidetes* and an increase in the *Bacteroidetes*/*Prevotella* ratio and γ-proteobacteria postoperatively [77–79]. These alterations might be due to changes in dietary macronutrient composition, anatomical manipulations and pH and bile flow, among others [27]. Much like faecal transplant has proven to be very successful in the treatment of *Clostridium difficile* infections; a 2013 study by Liou et al. points towards the potential viability of a similar treatment modality for the treatment of obesity. Here, they observed how the transfer of the gut bacteria from mice post-RYGB to unoperated germ-free mice led to weight loss [80]. A rat study in 2019 found that BPD/DS caused marked alterations in faecal and small intestinal microbiota resulting in reduced bacterial diversity and richness. It suggested that the increased abundance of *Bifidobacterium* and reduced level of two *Clostridiales* species in the gut microbiota might contribute to the positive metabolic outcomes of BPD/DS [81]. Once again, more studies and data are needed to explore the exact mechanisms through which gut bacteria contribute to weight loss. Exploiting this concept could help us explain some of the effects we see post bariatric surgery and indeed lead to more potential therapeutic targets.

62.2 The Impact of DS on the Complications of Obesity

62.2.1 What are the Metabolic Issues Caused by Obesity and How Do They Change After DS?

Obesity is defined as abnormal or excessive fat accumulation that presents a risk to health [82]. It is associated with an increased risk of all-cause mortality, with CVD and malignancy being the most common causes of death [83–86]. Excess weight can cause both anatomical and metabolic complications. Anatomical complications such as obstructive sleep apnoea (OSA), obesity hypoventilation syndrome (OHS) and osteoarthritis (OA) can occur due to increased adipose tissue placing strain at various body sites [87–89]. Indeed, increased intra-abdominal pressure is also associated with oesophageal disorders such as gastro-oesophageal reflux disease (GORD) and Barrett's oesophagus [90]. Some of the major metabolic complications of obesity include type 2 diabetes mellitus (T2DM), hypertension, cardiovascular disease, coronary heart disease, stroke and fatty liver disease among many more.

Biliopancreatic diversion with duodenal switch (BPD-DS) surgery is the most effective treatment to produce sustained weight loss with a greater improvement or resolution in obesity-related comorbidities [91, 92]. Using the King's Obesity Staging Score [93], the impact of DS on complications of obesity can be summarised as follows:

62.2.1.1 Airway

The risk of developing OSA increases 1.14-fold for every unit increase in body mass index (BMI) [94, 95]. Resolution of OSA after bariatric surgery is caused by several factors including weight-dependent [96] and weight-independent mechanisms [97]. In 2009, Greenberg et al. compiled a meta-analysis of OSA resolution post bariatric surgery. The results corroborated the previously reported improvements in AHI after bariatric surgery. The overall effect size of the pooled, weighted data showed a reduction of 38.2 events per hour in the combined study results, a combined reduction in AHI of 71%. However, residual disease was seen in the majority of patients (62%) after bariatric surgery with a mean residual AHI of more than 15 events per hour [98]. It appears that while the more weight loss achieved post bariatric surgery, the more benefits that patients are going to see in terms of improvements in their OSA, the condition is unlikely to resolve altogether. This would favour BPD/DS, but more data are needed in relation to this.

62.2.1.2 BMI Reduction

Weight loss, the primary goal for most patients, is closely related to resolution rates of complications [99] and quality of life after bariatric surgery [100] although no exact cut-off point for these gains is established. In 2014, Hedberg et al. carried out a meta-analysis of 16 papers that compared the weight loss seen in patients post-DS vs. post-RYGB [101]. Significant weight loss was seen after both procedures, but DS led to an additional reduction of BMI. The weighted mean BMI loss after DS was 22.9 BMI units at 1 year, 25.0 BMI units at 2 years and 23.4 BMI units at more than 2 years. The corresponding results for RYGB was 17.1 BMI units at 1 year, 16.2–18.1 BMI units at 2 years and 15.8–18.3 BMI units at more than 2 years [101].

62.2.1.3 Cardiovascular Disease

Martin et al. found that weight loss after bariatric surgery can minimise and reverse obesity-associated left ventricular remodelling [102]. In a recent systematic review of studies evaluating cardiac structure and function before and after bariatric surgery using echocardiography or cardiac MRI, bariatric surgery was associated with improvements in cardiac structure (decreased left ventricular mass index, decreased left ventricular end-diastolic volume and left atrial diameter) as well as cardiac function (increased left ventricular ejection fraction and increased *E*/*A* ratio) [103].

Major adverse cardiovascular event rates in RCTs of bariatric surgery have been low, likely reflecting the relatively young age, short duration of diabetes and low prevalence of established microvascular disease among recruited individuals [102]. No significant differences in the occurrence of such events between surgically and medically treated patients have been demonstrated to date; however, cardiovascular risk factor reduction has been noted in bariatric studies:

Hypertension

Prevalence of HTN and OSA is higher in patients with severe forms of obesity in comparison to normal-weight patients [91, 104]. Prevalence of HTN can reach up to 70% in patients with obesity and OSA [105]. Hypertension is the complication for which bariatric procedures are least successful, with a resolution rate varying between 15 and 53% [92]. Factors believed to hinder the chance of resolution of hypertension include duration of hypertension and the number of anti-hypertensive agents being used pre-operatively [96]. Conversely, the resolution rate of OSA following bariatric surgery is higher than HTN, with 79–86% of patients experiencing remission [106]. Patients with greater weight loss postoperatively have a greater chance of achieving OSA remission [96]. In a systematic review by Vest et al. which included 73 studies and 19,543 individuals undergoing a range of bariatric procedures including sleeve gastrectomy, RYGB and adjustable gastric banding, postoperative resolution or improvement of hypertension occurred in 63% of patients, with follow-up ranging from 3 months to ~15 years [107]. Other studies such as the Swedish Obese Subjects (SOS) study showed that no significant difference in the incidence of hypertension was observed between the two groups at 2 years (34% surgery vs. 21% control) and 10 years (19% surgery vs. 10% control) [108]. However, the SOS study was non-randomised, and the HTN was not the primary outcome of the trail. In summary, interpretation of the limited data on the resolution of HTN is conflicting. More RCTs in the area are required, most particularly in relation to the effects of DS on HTN.

62.2.1.4 Diabetes Mellitus

'Diabesity' describes the concurrent obesity and T2DM epidemic over the past few decades because the risk of T2DM increases with BMI. A recent population study involving 2.8 million UK adults between 2000 and 2018 showed that a BMI of 30–35 kg/m^2 was associated with a five times increased risk of T2DM, which increased to a 12 times higher risk in those with a BMI of 40–45 km/m^2 [109]. Bariatric surgery is an extremely effective way of treating diabetes.

In the ROME RCT study, Mingrone and Rubino studied DM remission in patients post bariatric surgery over a 10-year follow-up period. Individuals were randomly assigned (1:1:1) to either medical therapy, RYGB or BPD [110]. Analysis of this study showed 10-year remission rates in the intention to treat (ITT) population were 5.5% for medical therapy; 50% for BPD; and 25% for RYGB. Twenty of the 34 participants (58.8%) who were observed to be in remission at 2 years had a relapse of hyperglycaemia during the follow-up period (BPD 52.6%; RYGB 66.7%) [110]. After 10 years, patients who underwent surgery exhibited significantly greater HbA1c percentage reduction from baseline than those in the medical arm, while target HbA1c of less than 7% was met in 87.5% of patients who underwent surgery and in none in the medical therapy group [110].

Hedberg's 2014 meta-analysis again looked at the remission of T2DM in patients post-DS vs. post-RYGB and found that after DS, 88% of patients were free from treatment of diabetes at follow-up compared with 76% of RYGB patients, $P = 0.18$ [101]. HbA1c was reported in two of the included studies, and both show significantly lower levels after DS compared with RYGB [111, 112].

These findings are supported by Buchwald et al. systematic review of 132,000 patients in 2009 which showed that diabetes was resolved in 95% of patients having had DS or BPD compared to 80% after RYGB [113]. The higher T2DM remission rates after DS could be an effect of greater weight loss, but the exact mechanisms remain to be elucidated [114].

A systematic review and meta-analysis of gastric bypass and duodenal switch reported remission of type 2 diabetes mellitus in 88% of patients after duodenal switch and 76% of patients after gastric bypass [101]. Risstad et al. observed significantly lower mean values for fasting plasma glucose and haemoglobin A1c levels after duodenal switch than RYGB [115]. This could be clinically relevant because fasting plasma glucose level is associated with future incidence of type 2 diabetes mellitus, even with glucose within the normal range [116–118].

62.2.1.5 Economic

People with obesity are more than twice as likely to take sick leave and almost three times as likely to avail of disability benefits [108]. Medication prescription is reduced by bariatric surgery with resultant reductions in healthcare costs that can persist for up to 20 years [119, 120]. However, studies are needed to look at the specific economic benefits seen after DS.

62.2.1.6 Functional

Basic activities of daily living such as walking and personal hygiene can be affected by severe obesity, and this loss of autonomy can be extremely distressing for the affected individuals [121]. Bariatric surgery results in improved function status, reduced levels of back pain and greater levels of independence [122]. However, the specific functional benefits of BPD/DS over other bariatric surgeries have not been studied.

62.2.1.7 Gonadal

Moxthe et al. carried out a systematic review in 2020 on the effects of bariatric surgery on male and female reproductive health. Overall, the evidence from this review indicated that fertility parameters including sex hormones in both men and women, seminal outcomes in men, menstrual cycle and PCOS outcomes in women and sexual function in both men and women improved due to significant weight loss after various bariatric surgeries [123]. A study from Spain in 2005 examined the effects of BPD and gastric bypass surgery on women suffering from PCOS. It found that all PCOS patients recovered regular and/or ovulatory menstrual cycles after weight loss [124]. Furthermore, it found that hirsutism improved, and serum androgen concentrations returned to the reference range in all but one patient [124], thereby curing the patients of PCOS after the bariatric surgery. Further research is also needed in assessing which type of bariatric surgery is most effective at weight loss and fertility improvements for obesity.

62.2.1.8 Health Status Perceived QoL

The fact of the negative effect of obesity and its related diseases on the quality of life is commonly known [125]. In 2020, Skogar et al. studied the differences in complications and QoL between RYGB and DS. They found that DS was associated with more early complications because of more open surgery, but long-term requirement of inpatient care was similar to RYGB [126]. They concluded that the increased risk of malnutrition/malabsorption and need for additional abdominal surgeries was contrasted with a greater improvement in QoL for DS [126]. More studies are needed to assess the effects of BPD/DS on QoL outcomes in patients.

62.2.1.9 Image

Body image dysphoria is often found in people with obesity, but this sometimes improves postoperatively [127]. A meta-analysis of both cross-sectional and longitudinal studies in 2018 suggest general improvements in body image occur following bariatric surgery [128]. However, there have been no studies specifically looking at these image changes following BPD/DS.

62.2.1.10 Junction of the Gastroesophagus

Gastroesophageal reflux disease is a common complication in bariatric patients [129]. Although weight loss and lifestyle modifications are important in reducing the symptoms of GERD, different bariatric surgeries have provided varying degrees of symptom alleviation [130]. Gastric banding has been shown to improve the symptoms of GERD in the short-term; however, a small subset of patients experience new reflux symptoms and oesophagitis in the long-term [131]. Laparoscopic sleeve gastrectomy has been associated with an increased incidence of GERD following the procedure [132]. The most effective bariatric procedure in the alleviation of GERD appears to be RYGB, which has been reported to have a similar efficiency as that of Nissen fundoplication [131, 133]. There has been a paucity of data looking at resolution of GERD following BPD/DS. Currently, significant GERD is a relative medical contraindication to BPD/DS that should prompt doctors to council the patient towards a RYGB rather than a DS, as gastric bypass achieves the greatest resolution of GERD-like symptoms. Furthermore, if a DS is performed on a patient with GERD and the symptoms persist despite maximal medical therapy, options for operative intervention are limited as the fundus of the stomach has been resected [131].

62.2.1.11 Kidney

In Mingrone et al. Rome study cohort, 16.%, 11% and 27% had albuminuria at baseline in the RYGB, BPD and IMT arms, respectively [112]. Albuminuria was present in 0% of the RYGB and BPD arms at 5-year follow-up compared with persistence of albuminuria in 27% of the IMT arm [134]. These results suggest that durable and sustained reductions in albuminuria are achieved in approximately 50% of patients at 5-year follow-up after bariatric surgery such as DS, compared with persistence or progression of albuminuria in those treated with best medical therapy alone [102]. Despite a potential beneficial impact on diabetic kidney disease, some concern exists that bariatric surgery, particularly RYGB and BPD, may be associated with adverse renal consequences such as hyperoxaluria and consequent nephrolithiasis [135, 136]. However, this has not played out in Mingrone et al. cohort where 'nephropathy' (defined as proteinuria >0.5 g/24 h) was also not significantly different between subgroups at 5-year follow-up (5%, 0% and 7% in the RYGB, BPD and IMT arms, respectively) [134]. Similar findings were seen in STAMPEDE and the Diabetes Surgery Study.

62.2.1.12 Liver: Nonalcoholic Fatty Liver Disease (NAFLD)

NAFLD is a spectrum of diseases that is associated with fatty infiltration of the liver that starts with simple fat accumulation (steatosis), which may progress into hepatic inflammation, termed as nonalcoholic steatohepatitis (NASH), with or without accompanying hepatic fibrosis/cirrhosis, with some patients eventually developing hepatocellular carcinoma [137–139]. There is a strong association of NAFLD with obesity, so weight loss has proved to have a beneficial effect on NAFLD [140]. Keshishian et al. reported the effect of DS on NAFLD. In this study, 697 patients were followed with a median of 6, 12 and 18 months and annually for 4 years. The histology results were only available in 78 out of 697 patients. These 78 patients had a second liver biopsy with a time interval ranging from 6 months to 3 years, depending on the need for a second operative procedure. Based on subjective assessment, the severity of steatosis had more than 50% reduction compared with baseline readings [141]. Similar results have been seen in studies looking at NAFLD following other bariatric procedures, e.g. Furuya et al. showed that (33%) of their patients displayed variable degrees of steatosis prior to surgery, which disappeared in 89% after 2 years ($P < 0.05$) [142]. However, once again more data from RCTs is needed to confirm this phenomenon and to better understand the underlying mechanism.

Patients with obesity and T2D have a quantity and distribution of adiposity causing pathologic levels of visceral and ectopic fat, insulin resistance, and impaired beta cell function [143]. While most bariatric surgeries are carried out electively, this variation in phenotype does present certain difficulties for the surgeon, theatre and hospital staff alike. The guidelines for pre-operative management of patients undergoing bariatric surgery are evolving, and any proposed standard of care is often based on opinion rather than level 1 evidence.

62.3 Glycaemic Control and Diet in Patients Undergoing Bariatric Surgery

Some authors suggest that patients pre-bariatric surgery should have an intensive 6-month programme of a supervised weight loss programme prior to any surgical intervention [144]. This process may aid the surgeon to be able to technically carry out the surgery, but it also provides the opportunity to intensify glycaemic management and to achieve glycaemic goals before surgery. If the patient has diabetes, then the adjustment of diabetes medications is usually required according to reductions in calorie and carbohydrate consumption and the level of glycaemic control of the patient [145]. Most bariatric centres also put patients on the 'liver shrinkage diet', i.e. a very low-calorie diet (VLCD) of <800 kcal/day for 2 weeks before surgery as a way of acutely reducing the size of the liver, making a laparoscopic technique easier and safer [145]. A VLCD can be achieved with meal replacements or a strict diet of portion-controlled lean proteins and non-starchy vegetables. Dose reduction or discontinuation of diabetes medications that can cause hypoglycaemia is required with initiation of these diets to prevent severe hypoglycaemia [146].

62.4 Pre-operative Glycaemic Management of the Patient with Diabetes Undergoing Bariatric Surgery

The AACE/TOS/ASMBS Bariatric Surgery Clinical Practice Guideline recommends that patients with T2D achieve a pre-operative HbA1c of ≤6.5–7.0%, a fasting blood glucose level of ≤110 mg/dL (6.1 mmol/L) and a 2-h postprandial blood glucose concentration of ≤140 mg/dL (7.8 mmol/L) [147], although these targets can be loosened in the cases of long-standing DM or if the clinician is happy to proceed. This guideline does not provide specific recommendations for diabetes medications to use pre-operatively but recommends discontinuation of insulin secretagogues and modification of insulin doses in the immediate postoperative period [147]. One large retrospective review of 468 patients with T2D who underwent RYGB procedures grouped them according to pre-operative A1C (<6.5, 6.5–7.9, and >8%) and found that those with the lower A1C levels experienced lower levels of postoperative hyperglycaemia, more weight loss and a greater likelihood of diabetes remission at 1 year. It remains difficult to conclude that these findings are due to patients with better glycaemic control having a less severe form of T2D. Postoperative hyperglycaemia was however independently associated with increased morbidity from wound infections and acute renal failure [148]. While there is limited similar data relating to DS, it is prudent to say that optimising the patient pre-op is most likely to lead to better postoperative outcomes. Therefore, patients should be encouraged to lose as much weight as possible, exercise regularly, eat and drink a healthy diet and keep their diabetes as well controlled as possible pre-operatively.

Patients taking oral and non-insulin injectable diabetes medications are advised to take their usual doses the day before surgery if their diet is not significantly changed [149]. Recommendations for adjustments to basal insulin are based on the patient's home regimen and generally can be in line with that for other major surgeries. All oral and non-insulin injectable diabetes medications should be discontinued on the day of admission for the bariatric surgical procedure. Patients with diabetes can have a capillary blood glucose (CBG) measured on arrival at the hospital and treated accordingly. Until more studies are performed and better data emerges, attention to glycaemic control minimises risk for adverse surgical outcomes similar to that which is observed with other surgical procedures. Poor glycaemic control as measured by HbA1c before surgery should however not be a contraindication to proceed with surgery [150–152]. This may be because the 2-week pre-operative diet is extremely effective at rapidly achieving near normoglycaemia before surgery [153], but also because the effect of surgery is so profound that even patients with poorly controlled diabetes often achieve normoglycaemia prior to discharge [154].

62.5 Psychologic Support Pre-operatively

The prevalence of psychosocial distress is high in patients seeking bariatric surgery [155, 156], and several studies have explored how psychosocial factors may predict weight loss, mental health and quality of life after surgery [157, 158]. Eating disorders are some of the most prevalent psychiatric disorders in the bariatric surgery patients [159]. Pre-operative binge-eating disorder (BED) is associated with more disturbed eating patterns after surgery and less favourable outcome, including greater weight regain [160]. There is some evidence that pre- and postoperative group counselling focusing on motivation for lifestyle changes and improving coping skills can be useful also for patients with psychiatric comorbidity and increase motivation and improve compliance with dietary and exercise guidelines [161]. Therefore, it is crucially important that psychological assessment and care is central to the pre-operative assessment and care of these patients. Not only has this been shown to improve postoperative success but also helps the medical team communicate realistic expectations for bariatric surgery for the patient. Often there is reduced capacity of psychological support pre-surgery and post-surgery. If faced with resource constraints, it may often be better to focus psychological support on the small number of patients who may benefit from it after surgery.

62.6 Dietician Support Pre-operatively

Nutritional deficiencies are commonly seen in patients presenting for bariatric surgery [162]. It is essential to screen and correct any abnormalities prior to surgery because pre-existing micronutrient deficiencies can involve poorer prognosis and postoperative complications [163].

The role of a bariatric dietician is central to the multi-disciplinary care of the bariatric patient pre-operatively for a number of reasons

1. Screen the patients: A thorough clinical nutrition evaluation that includes a micronutrient assessment should be carried out on all patients. This includes iron studies; B12; folic acid; vitamins A, C, D and E; zinc; copper; and selenium, among others [164].
2. Medical nutrition therapy (MNT): A second role of the dietitian is to prescribe to reduce weight pre-operatively, which can assist in minimising postoperative complications [165].
3. Pre-operative education: Recommended education strategies include nutritional consequences of the different bariatric surgery procedures, long-term follow-up requirements, compliance involved with adhering to a postoperative liquid diet and postoperative vitamin supplementation [147, 166].

A successful long-term outcome of bariatric surgery is dependent on the patient's commitment to a lifetime of dietary and lifestyle changes, so therefore it is essential to have a specialised dietician working with these patients throughout their journey through the bariatric service.

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Chapter 63
Staged Duodenal Switch for High-Risk Patients

Andrew Collins, Ibrahim M. Zeini, and Muhammad Ghanem

63.1 Introduction

In the USA, since the year 2000, the adult obesity rate has increased from 30.5 to 42.4% in 2018, with the subset of severely obese patients increasing rapidly. Hispanic and non-Hispanic Black adults had the highest age-adjusted prevalence of obesity [1]. This presents as a public health crisis, as the prevalence of obesity mirrors the prevalence and burden of many comorbid diseases, affecting several organ systems. Despite several pharmaceutical, lifestyle, and public health measures aimed to address the disease, the obesity epidemic in the USA continues to grow [2]. In patients suffering from morbid obesity refractory to lifestyle change, bariatric surgery has demonstrated effective long-term treatment. Given the procedural efficacy, safety, and utilization of laparoscopic methods, procedures such as the sleeve gastrectomy, Roux-en-Y gastric bypass (RYGB), and biliopancreatic diversion with duodenal switch (BPD/DS) have been increasingly utilized in the USA.

LAGB and RYGB are the most common bariatric procedures aimed for weight reduction; however, the BPD/DS is the most effective procedure, resulting in the greatest excess weight loss (EWL) among the various surgical options. Patients undergoing BPD/DS often experience decreased hunger due to the reduction in gastric volume and further EWL through diminished nutrient absorption within the

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alimentary limb. The procedure is technically intensive, requiring a skilled surgeon with clinical expertise for choosing appropriate patients. As a result, BPD/DS accounts for <1% of bariatric surgery, despite the powerful impact on weight and improved resolution of obesity-related comorbidities, such as type II diabetes. Increased perioperative morbidity and long-term nutritional adverse effects related to the nature of the technique add to the disinclination of its use. However, BPD/DS still maintains a critical role in the treatment of super obese patients (BMI >50 kg/m^2), due to the effective management of their disease. In high-risk or super-super obese patient groups (BMI >60 kg/m^2), a two-stage procedure may be utilized to limit procedure time, leading to a reduction in the perioperative morbidity and mortality. The first stage consists of a sleeve gastrectomy, followed by duodenoileostomy and ileoileostomy approximately 6–18 months after [3, 4]. The objectives of this chapter will be to (1) provide an overview of the procedure, (2) describe indications and contraindications, (3) briefly describe the surgical technique, and (4) outline surgical outcomes and complications related to staged BPD/DS.

63.2 Procedure

By staging the BPD/DS into two stages, (1) sleeve gastrectomy and (2) duodenoileostomy and ileoileostomy, operation duration is decreased, and complications related to increased time under anesthesia are reduced [4, 5]. Staging of procedures may be planned preoperatively, or the decision can be made during the sleeve gastrectomy portion. Indications for intraoperative decision for procedure staging include physiologic compromise of the patient or questionable technical feasibility of the remaining maneuvers. The SG and BPD portions of the procedure have also been reported using a robotic-assisted technique, with similar outcome to purely laparoscopic procedures [6]. In other bariatric procedures, such as the RYGB, a comparison of robotic-assisted surgery to laparoscopy demonstrated a potentially increased leak rate at the gastric pouch or remnant stomach level [7].

63.2.1 Stage 1: Sleeve Gastrectomy

Commonly a stand-alone procedure, the sleeve gastrectomy is conducted laparoscopically and is the first portion of the staged BPD/DS for high-risk or super-super obese patients. In this procedure, approximately 75–80% of the stomach is removed in a vertical fashion to limit food volume intake (Fig. 63.1). The stomach volume will be reduced from 2 L to 100–150 mL, and due to the removal of the fundus, the new stomach is largely resistant to stretch and accommodation of large ingested volumes. With the patient in supine position and surgeon standing on the patient's right and working ports in the right subcostal and mid-abdomen, the camera is in the

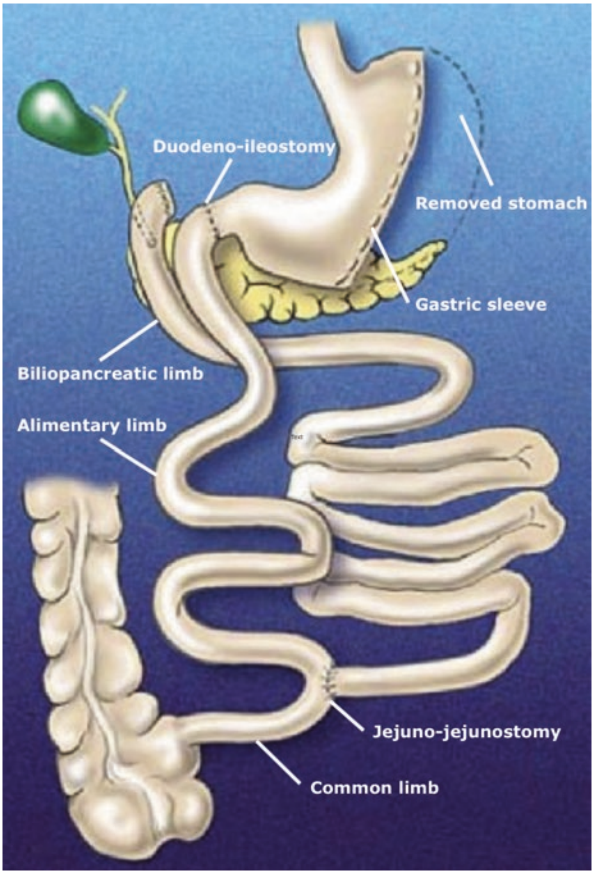

Fig. 63.1 Illustration of the BPD with DS procedure [5]

left mid-abdomen. A liver retractor is added to provide exposure. Using an ultrasonic or bipolar energy device, the greater curvature of the stomach is devascularized and mobilized approximately 4–6 cm from pylorus superiorly to the left crus of the diaphragm. After mobilization, a bougie typically 40–60 Fr in diameter is passed to guide the gastric division. If a hiatal hernia is noted during the procedure, repair is indicated to reduce postoperative gastroesophageal reflux and retained elements of the stomach leading to impaired weight loss. Creation of the gastric sleeve utilizes a thick tissue cartridge with a linear stapler. Stapling must be conducted in the same horizontal plane to avoid functional obstruction caused by a spiral-sleeve contour. Stapling along the bougie should not be overly tight, as improper staple firing may occur. The stapling will begin 4–6 cm above the pylorus to spare much of the antrum. In a two-staged procedure, the gastric specimen can now be removed, and the procedure is terminated. The weight loss goal for this first stage in high-risk patients is a 100–150 pound weight loss (or until weight plateau), often reached within 6–18 months after the sleeve gastrectomy.

63.2.2 Stage 2: Duodenoileostomy and Ileoileostomy

63.2.2.1 Duodenal Transection

Excessive visceral fat may complicate the dissection, and bleeding can blur the tissue planes. Due to this, the duodenal transection can be technically demanding; however it is critical to minimize excessive duodenal devascularization and injury to the duodenum and pancreas. With lateral retraction of the antrum to linearize the first portion of the duodenum, free the peritoneum on the inferior and superior portions of the duodenum, until the duodenum fuses posteriorly with the pancreas. Either a curved or right-angle dissector can be used to create this retroduodenal tunnel. A Penrose can be passed around the duodenum to help continue the dissection. Once 2 cm of duodenum are freely dissected, the duodenum can be transected with a stapler. Following transection, perfusion of the cuff can be assessed using indocyanine green (ICG) fluorescence to visualize limb microcirculation prior to anastomosis.

63.2.2.2 Alimentary Limb Creation

The greater omentum is opened toward the patient's right, allowing the ileum to be connected with the duodenum. Moving to the patient's left side, working through the LUQ subcostal and lateral mid-abdominal ports, identify the terminal ileum at the ileocecal junction. If the patient has a past abdominal surgery history, examine the region for intra-abdominal adhesions before duodenal transection. Measuring 125 cm from the cecum, mark the ileum at the site of later ileoileostomy. Another 125 cm past this point, transect the ileum using a stapler. Mark this distal end of the biliopancreatic limb to distinguish from the alimentary limb. The alimentary limb is carried through the omental window toward the duodenal cuff. If excessive tension is present, a second sagittal vascular stapling can be applied. If significant tension still remains on the alimentary limb, it can be brought through a mesocolic window opposed to the omental window.

63.2.2.3 Duodenoileostomy

The duodenoileostomy anastomosis may be implemented with many techniques. Understanding each technique allows for surgical flexibility depending on differing anatomy. The techniques include (1) hand-sewn technique, (2) circular stapler technique, and (3) linear stapler technique.

The hand-sewn technique avoids enlarging port sites for stapler accommodation and anvil manipulation. The method constructs more consistent sizing of anastomosis than either technique involving stapler use. The previously placed duodenal suture is tied to the previously placed ileal suture placed 125 cm from the cecum, to create the posterior outer row of the anastomosis. Enterotomies are made along the entire length of the ileum and duodenum, and the inner layer of the anastomosis is made with two sutures with anterior closure. A permanent running suture is placed as the outer layer conjoining the anastomosis.

The circular stapler technique creates the duodenoileostomy using an EEA stapler. The EEA anvil can be inserted directly to the duodenal cuff staple line or passed transgastrically, transabdominally, or transorally. Opening the proximal end of the alimentary limb and aligning it with the duodenal cuff bring the stapler through the antimesenteric border of the proximal alimentary limb and staple the join the segments at the anvil.

In the linear staple technique, the alimentary limb is brought to the duodenal cuff, and an enterotomy is made in the ileum and duodenum. A stapler is inserted, but due to difficult alignment of the stapler to form the anastomosis, two firings are often necessary. Due to these angulation challenges, there is inconsistency in the size and shape of anastomosis with this method. Lastly, the common enterotomy is hand-sewn closed.

63.2.2.4 Ileoileostomy

Following the alimentary limb distal from the duodenoileostomy to the marking 125 cm proximal to the ileocecal valve, identify the distal biliopancreatic limb. Approximate the alimentary limb and the distal biliopancreatic limb using a suture. With small enterotomies in either limb, create an anastomosis using a 2.5 mm stapler, then hand suture to join the remaining enterotomies using a single-layer stitch to avoid narrowing of the anastomosis.

63.2.2.5 Robotic-Assisted Laparoscopic BPD/DS

With the patient in Trendelenburg position, running the small intestine approximately 250 cm from the ileocecal valve, the surgeon will mark with a silk stich proximally and a Vicryl stitch distally. Prior to docking the robot, the patient is placed in reverse Trendelenburg position. Once docked, the duodenal switch is conducted by creating a window behind the duodenum, 2.5 cm distal to the pylorus (Fig. 63.2). The sleeve gastrectomy is begun by exposing the left crus by creating a window in the greater omentum from 6 cm proximal to the pylorus, up to the angle of His. A 34 French bougie is passed into the antrum. Using a linear stapler, the stomach is transected. Upon completing the gastric sleeve, the linear stapler is used to transect the duodenum through the same omental window. The duodenoileostomy is created by anastomosing the proximal portion of the duodenum to the ileal stitches 250 cm from the cecum, made earlier. Ileoileostomy is begun through a window around the ileum, proximal to the duodenoileostomy. Using a linear stapler, transect the biliary limb, and 125 cm distally on the small intestine from the cecum, anastomose the biliary limb and ileum. The duodenoileostomy and staple are both

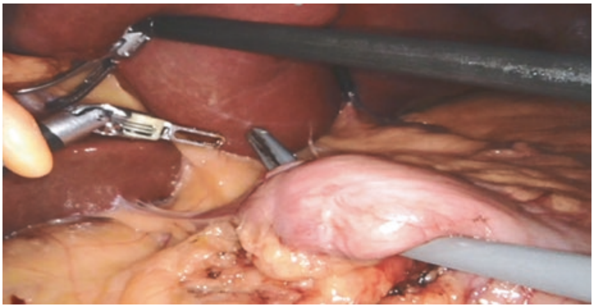

Fig. 63.2 Intraoperative image of robotic-assisted duodenal dissection

tested with saline and methylene blue submersion. The gastric remnant can be removed through the right lower quadrant port. Drains may be placed next to the sleeve gastrectomy staple line and anastomoses [8].

63.3 High-Risk Classification Leading to Staging

Preoperative

- Super-super obese patients (BMI >60 kg/m^2) [4]
- Patients unlikely to tolerate prolonged general anesthesia [9]
- High-risk classification according to the obesity surgery mortality risk score (OS-MRS)
  - Risk factors: BMI >50 kg/m^2, male gender, hypertension, pulmonary embolism risk, age >44 [10]

Intra-operative decision

- Physiological compromise in the patient
- Presence of adhesions
- Hepatomegaly
- Torque on instruments [9]

63.3.1 Postoperative Care

Telemetry and the use of continuous pulse oximetry can aid in the detection of early postoperative complications. Patients are NPO with IV fluid administration until the following morning. Variable methods for pain management may be utilized; common protocols include Dilaudid PCA with ketorolac [11]. Patients should be placed on chemoprophylaxis for venothromboembolism and should ambulate within 6 h of the surgery. Patients with obstructive sleep apnea should utilize their at-home airway device to maintain patency. Spirometry and other respiratory therapy may be utilized to decrease incidence of pneumonia and atelectasis following surgery [12]. To assess for early postoperative anastomotic leak, fistula, or stricture, an upper gastrointestinal endoscopy may be ordered [13]. Many patients may be discharged on the second postoperative day, while others, especially those classified as super-super obese, may require an extended stay and have less predictable comorbidities. For 2 weeks following the operation, patients will stay on a puree diet and transition to solid foods over the course of 1 month.

For 1 month after surgery, patients are instructed to take

- Proton pump inhibitor
- Multivitamin with iron
- Vitamin D
- Calcium citrate
- B complex vitamin
- 80–90 g of protein daily (as a liquid)
- Vitamin A (indefinitely)

63.3.2 Indications

- For BPD/DS, it is recommended that patient BMI exceeds 50 kg/m^2, while other weight loss surgeries may be indicated for less severe obesity [14]
- Staged BPD/DS is often indicated with super-super obesity (BMI >60 kg/m^2)
- Obesity with severe type II diabetes [5]
- Suboptimal outcomes of previous bariatric surgery (e.g., sleeve gastrectomy) [15]

63.3.3 Contraindications

- Non-correctable coagulopathy
- Large abdominal wall hernia
- Preexisting malabsorptive disorder (celiac disease, inflammatory bowel disease, malignancy)
- Severe gastroesophageal reflux disease (sleeve gastrectomy may worsen reflux)
- Other: inability to maintain follow-up, inadequate support, active substance or alcohol abuse, smoking, patient financial standing to afford postoperative supplements and medications [16]

63.3.4 Complications

63.3.4.1 Surgical

The laparoscopic BPD/DS is the most technically demanding bariatric surgery and, not surprisingly, has high surgical complication rates up to 15–38% in the proceeding weeks to months. However, it is important to note that this procedure is conducted in the most severely obese patients with comorbid diseases, increasing morbidity and mortality. More recently, the use of a staged BPD/DS has led to a reduction of related morbidity and mortality [17, 18].

Major surgical complications of BPD/DS
- Anastomosis leaks (at any staple or suture line, commonly duodenal or gastric leaks)
- Features: tachycardia, elevated white blood cell count, fever
- Intra-abdominal abscess
- Pulmonary embolism (manage with aggressive perioperative prophylaxis)
- Congestive heart failure or pulmonary hypertension exacerbation (use perioperative fluids conservatively)
- Myocardial infarction
- Obstruction and stricturing
- Digestive bleeding
- Intraperitoneal hemorrhage
- Internal hernia

Minor surgical complications of BPD/DS
- Pneumonia and atelectasis
- Stenosis
- Food intolerance
- *C. difficile* colitis
- Pancreatitis
- Wound infection

63.3.4.2 Nutritional

There is a reasonable likelihood for nutritional deficiencies to develop from vitamin and mineral and protein malabsorption. The long-term nutritional risks can be minimized with careful patient selection, nutritional supplementation, education, and follow-up [19, 20]. Protein deficiencies can result from reduced intake (due to decreased gastric volume), obligate loss, and malabsorption. However, the amount of protein loss to malabsorption is uncertain, as studies have demonstrated that 50 cm duodenal segments are sufficient in absorbing protein loads [21]. This study highlights the importance of the surgeon's choice of limb-length measurements during the DS as it impacts both protein and fat absorption. Mild-moderate protein deficiencies can be managed with dietary supplementation and patient education. In the instance of severe protein deficiencies, treatment with hyperalimentation and diuresis is indicated, and refractory surgery to lengthen the common channel may be required. Despite prophylactic vitamin and mineral supplementation, there is a high prevalence of micronutrient deficiencies or insufficiencies in DS patients [22]. The subsequent malabsorption of micronutrients in these patients may cause their deficiency status to be refractory to supplementation.

Compared to RYGB, DS switch patients categorized as super-obese were more likely to experience lower levels of vitamins A and D and had a larger decrease in thiamine levels after surgery. These super-obese patients may require more intense supplementation or frequent alimentation and regular nutritional status monitoring [23].

Long-term (15–20 years) metabolic outcomes result from nutritional deficiencies [20]

- Albumin and hemoglobin deficiency
- Vitamin A, B9, B12, and D deficiency
- Iron deficiency
- Calcium deficiency
- Hyperparathyroidism

63.3.5 Outcomes

BPD/DS has demonstrated superior weight loss to all other bariatric procedures, resulting in over 70% EWL, compared to 61.2% for gastric bypass and 68.2% for gastroplasty [24]. The efficacy of the procedure is highest among super obese patients, resulting in the highest percent EWL and percent BMI reduction compared to other bariatric surgeries [25]. As a secondary or staged procedure, BPD/DS is gaining popularity. From 2015 to 2017, the total bariatric case load increased 19.2%, BPD/DS increased 63.7%, and revision procedures increased 114.1% [26]. Expert consensus points to the use of BPD/DS in the case of revisional bariatric surgery or for planned staged surgery in super obese and high-risk patients [19]. BPD/DS has also shown a more powerful effect in treating obesity-related diseases, such as type II diabetes, hypertension, and hyperlipidemia, when compared to RYGB [27].

63.4 Conclusions

While bariatric surgery is the only proven lasting method for weight loss in morbidly obese patients, BPD/DS is the most effective method to maximize EWL. However, this procedure comes with potential surgical risks and long-term metabolic deficits due to nutrient malabsorption. In super-obese or other high-risk patients, the procedure can be implemented in a staged fashion, with the duodenoileostomy and ileoileostomy following 6–18 months after gastric sleeve placement. Revision duodenal switch surgery may also be indicated in the setting of revisional bariatric surgery and is gaining popularity for this use.

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Chapter 64
Duodenal Switch in Patients with Metabolic Syndrome

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64.1 Introduction

Obesity is related to the development of cardiovascular disease, type 2 diabetes, hypertension, and obstructive sleep apnea. These diseases are believed to be mediated by the metabolic syndrome produced by obesity. Metabolic syndrome formally is defined as three or more of the following:

1. Abdominal obesity (>102 cm in men; >88 cm in women)
2. Triglycerides >150 mg/dL
3. Low HDL (<40 mg/dL in men, <50 mg/dL in women)
4. Hypertension with systolic blood pressure (SBP) >130 or diastolic blood pressure (DBP) >85 mmHg
5. Raised fasting glucose >110 mg/dL [1]

Metabolic syndrome can give rise to type 2 diabetes which is the world's leading cause of blindness and renal failure and represents a significant cause of morbidity, mortality, and expenditure of healthcare dollars in the United States [2, 3]. Attempts have been made to mediate metabolic syndrome with lifestyle modification and medication, but this has resulted in non-sustained resolution of the syndrome. Instead, bariatric surgery has proven to alter the course of the disease with sustained effect over time. While many forms of bariatric surgery have been proven to mediate this disease, malabsorptive procedures and especially the duodenal switch (DS) have proven to provide the best remission from this disease process [4]. Many

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theories have attempted to hypothesize the reason for the improvement in weight loss and obesity-related comorbidities related to bariatric surgery, and this chapter will seek to elucidate the hormonal changes and anatomic alterations.

64.2 Hormones Impacted by Bariatric Surgery

Many gastrointestinal hormones have been implicated as causes of resolution of obesity-related comorbidities. First, we will introduce the hormones and discuss their physiologic role in patients who have not undergone bariatric surgery.

64.2.1 Leptin

Leptin is a hormone created by adipocytes and enterocytes. It is believed to regulate energy balance within the body by controlling hunger and mediating fat storage. Leptin levels are elevated in obesity, which makes sense since adipocytes create this chemical. Obese patients have a decreased sensitivity to leptin which causes an inability to achieve satiety. Bariatric surgery has been known to decrease leptin resistance.

64.2.2 Ghrelin

Ghrelin is a neuropeptide made by cells within the gastric fundus. Ghrelin communicates with the central nervous system to regulate satiety. It stimulates neuropeptide Y to be produced within the hypothalamus; this is a potent mediator of appetite and especially promotes carbohydrate intake [5]. With prolonged fasting, ghrelin levels are increased, and the inverse is true in post-prandial states.

64.2.3 Incretins

Incretins include glucose-like peptide 1 (GLP-1) and gastric inhibitory polypeptide (GIP). These hormones are produced by L cells within the ileum when the enterocytes are stimulated by a glucose load. Incretins are responsible for improving insulin sensitivity. They also delay gastric emptying, decrease appetite, and promote weight loss. They are believed to enhance glucose-dependent insulin production in the beta-islet cells of the pancreas, and incretins inhibit glucagon production [6].

64.2.4 Polypeptide YY

Polypeptide YY is secreted along with GLP-1 and functions to increase insulin sensitivity and inhibit neuropeptide Y produced by the hypothalamus, thereby decreasing its orexigenic effects [1].

64.3 Metabolic Syndrome and the Duodenal Switch

64.3.1 Weight Loss

The goal of all bariatric surgeries is to promote weight loss, improve associated comorbidities, and improve quality of life. Several historical bariatric procedures have sought to address these goals; however, many have fallen out of favor. Perhaps the most well-known bariatric surgery is the Roux-en-Y gastric bypass (RYGB), whereby a gastric pouch is created and the duodenum is "bypassed" by nutritional content. The RYGB is considered safe in short- and long-term studies and has been shown to reduce the risk factors that contribute to metabolic syndrome. In 1979 Scopinaro developed the biliopancreatic diversion (BPD) which was later modified by Hess and Marceau to create the BPD with duodenal switch (DS) that we now know today. This is a sleeve gastrectomy with a preserved pylorus and 2 cm of duodenum that is then anastomosed to a segment of small bowel about 250 cm proximal to the ileocecal valve. The biliopancreatic limb is anastomosed about 100 cm proximal to the ileocecal valve. In this procedure, food bypasses the duodenojejunal segment [7]. The DS has been slow to gain favor owing to its perceived operative complexities and long-term complications of fat malabsorption, vitamin deficiencies, and protein-calorie malnutrition [8]. However, when results of weight loss are compared, DS provides more weight loss than that of the RYGB.

In a study by Skogar in 2017, patients who had undergone RYGB versus DS were followed for 4 years, and their weight loss was documented. Patients who underwent DS were found to have significantly lower BMI compared to the RYGB group at the end of 4 years (BMI 31 in DS v. 36 in RYGB). Moreover, in the United States about 25% of all patients seeking bariatric surgery qualify as "super obese," meaning their BMI is greater than 50. Of all super obese patients undergoing a RYGB, about half are considered severely obese (BMI >35) after surgery [9]. The DS procedure produces more weight loss even in patients with large preoperative BMIs. Not only does the DS provide more substantial weight loss, but it also provides greater resolution of diabetes mellitus, hypertension, and dyslipidemia [10].

64.3.2 Diabetes and Pre-diabetes

Type 2 diabetes (T2DM) and pre-diabetes involve alterations in glucose resistance within peripheral tissues. Often high circulating levels of insulin are not recognized by the body's cells, which in turn continues to stimulate the beta-islet cells of the pancreas to produce more insulin as the blood glucose level remains high. In patients with T2DM, the secretion of the incretins GLP-1 and GIP are blunted. The beta-islet cells of the pancreas responsible for glucose production are believed to become dysregulated over time. Reasons as to the cause of insulin resistance were blamed on obesity itself, but later scientists found that lean patients also developed T2DM despite a normal BMI. In fact, early within the postoperative course of RYGB or DS, patients are noted to have significant increases in insulin sensitivity. If insulin sensitivity and circulating insulin levels are measured within 10 days of surgery, one would find marked increases in the amount of insulin sensitivity and a decrease in the amount of circulating insulin levels. Within 10 days of surgery, patients have very minimal weight loss, so weight loss alone must be only weakly related to insulin sensitivity [11].

Insulin sensitivity continues to increase as time passes after a DS. There is a 95–100% resolution or improvement of T2DM in patients undergoing DS [2], while T2DM fully resolves in only 74–89% of patients who undergo RYGB [12] over 5–10 years. While the exact mechanism of how this occurs is under investigation, several theories have been created in an attempt to explain these observed findings.

64.3.2.1 "Gastric Hypothesis"

The first part of a DS procedure involves creation of a gastric sleeve. The fundus of the stomach is removed in this portion of the surgery, and hydrochloric acid production is decreased in this process. With decreasing levels of hydrochloric acid, the vagally innervated antral mucosa secretes gastrin-releasing peptide (GRP) which stimulates GLP-1 release [1]. GLP-1 in turn increases insulin sensitivity and signals a downregulation of glucagon which theoretically decreases hepatic-produced glucose.

64.3.2.2 "Foregut Hypothesis"

The foregut hypothesis is based on the observed findings of increased insulin sensitivity as seen in patients who undergo RYGB and DS. This theory surmises that food bypassing the duodenum and proximal jejunum must prevent the secretion of a signal that promotes insulin resistance [4, 13]. Unfortunately, the responsible signal has not yet been determined. The foregut is considered an extremely active organ, overstimulation of which may lead to hyperinsulinemia and insulin resistance [3].

64.3.2.3 "Hindgut Hypothesis"

The hindgut hypothesis surmises that food and nutrients that bypass the duodenojejunal bowel segment enter the ileum faster than they would physiologically. This in turn causes the L cells to release GLP-1 [1, 14]. Again, GLP-1 increases insulin sensitivity to help relieve hyperinsulinemia and elevated serum glucose.

64.3.2.4 Fat Malabsorption Theory

DS causes fat malabsorption which, over time, denies muscle cells fat for energy. The muscle cell will become reliant on glucose for energy and will upregulate glucose receptors, and insulin sensitivity will improve [12]. Free fatty acid oxidation is also believed to contribute to insulin resistance by inhibiting glucose oxidation and dysregulating beta-islet cells of the pancreas. Free fatty acid absorption is decreased in DS patients which may contribute to decreased insulin resistance and decreased dysregulated pancreatic cells. Mice models have further supported this theory; mice fed with a chronic high-fat diet will decrease the expression of Glut2 in beta-islet cells of the pancreas. Glut2 is required for glucose-stimulated insulin secretion. High-fat diets may cause lipotoxicity that contributes to a dysregulation of the beta-islet cells. However, mice who undergo BPD in experimental studies (and whom have an impaired fat absorption) continue to produce Glut2 receptors and do not experience dysregulation of the pancreatic islet cells [15, 16].

64.3.2.5 Effect on Ghrelin

Since ghrelin is produced by the fundus of the stomach and the fundus is removed during DS, ghrelin levels are seen to decrease after surgery. Ghrelin has been shown to inhibit glucose-induced insulin release from the beta-islet cells, so its decrease in the body is theorized to increase pancreatic cell production of insulin. Ghrelin is further inhibited by insulin [4].

While the majority of patients with pre-diabetes or T2DM who undergo DS have resolution of their disease, not all patients have this outcome. Factors to predict which patients will have non-remission of their T2DM include patients with a high preoperative BMI, those requiring insulin prior to surgery, and those with low levels of fasting insulin [12]. This suggests beta-islet cell dysregulation may not be reversible with bariatric surgery.

64.3.3 Hypertension

Hypertension is another contributor to metabolic syndrome that is improved with DS. Obesity increases the risk of hypertension by 300%. Hypertension is noted to be more predominant among those with diabetes than in those in the non-diabetic obese population. Based on this observation, it is theorized that hypertension may be related to hyperinsulinemia and improvement in this, as described in the last section, will resolve hypertension [17].

Elevated blood pressure in obese patients may also be due to increased sympathetic tone and overstimulation of the renin–angiotensin–aldosterone system. To test this, an experiment in 1996 by Ikeda et al. sought to provide a normocaloric diet low in salt to obese subjects for 4 weeks. In this time, the subjects had a decrease of their blood pressure by 13% along with a decrease in their total cholesterol and triglycerides and an increase in their HDL. Those who adhered to a low sodium diet were noted to have more weight loss and more improvement in their blood pressure. However, subjects who had baseline insulin resistance were found to have increased circulating levels of norepinephrine in their bodies which suggests stimulation of the sympathetic nervous system. This, again, supports the idea that hyperinsulinemia contributes to hypertension. In patients who underwent semistarvation, their serum norepinephrine and plasma renin axis were all decreased which suggests the lack of nutrients and the decrease of circulating insulin contributed to a lower blood pressure [18].

64.3.4 Dyslipidemia

Another phenomenon appreciated by DS is the resolution of hyperlipidemia and hypertriglyceridemia. Rubino and colleagues in 2004 attempted to compare BPD in murine models. Their study demonstrated that in Goto-Kakizaki mice who were not obese but who underwent BPD, all had lower levels of serum free fatty acids and decreased cholesterol [19]. This was further supported in a randomized control trial (RCT) in Norway and Sweden completed in 2015 that followed patients who underwent DS for 5 years postoperatively. Five years after DS, all patients had a significant decrease in their serum triglycerides and a significant increase in their HDL levels [20].

The theory behind a reduction in triglycerides is attributed to the malabsorption of fat as seen in DS. There is believed to be an increased loss of bile salts after DS which causes an increase in hepatic bile salt production. This synthesis depletes the pool of stored cholesterol. As the body has a decreased capacity to obtain bioavailable free cholesterol from food sources, the body stimulates production of LDL receptors. Increased LDL receptors promote removal of LDL cholesterol from the bloodstream, thereby decreasing circulating LDL and improving patients' lipid profiles [16].

64.4 Conclusion

As obesity becomes more prevalent along with obesity-related comorbidities, the search for a cure of this disease will become more important. It is estimated that for every 5 kg/m^2 increase in BMI over 25, there is a nearly 30% increase in all-cause mortality from metabolic and vascular disease [10]. Medication and lifestyle modification have not provided long-term relief of this disease especially in those who are super obese. This has promoted interest in the field of bariatric surgery in an attempt to determine the safest and most effective surgical option for these patients. While RYGB has shown that it is safe long-term, newer data favor DS for selected patients as it is more effective in weight loss and resolution of metabolic syndrome sequelae. To re-emphasize the RCT of Norway and Sweden of 2015, of the patients who underwent a DS, 79.3% had metabolic syndrome preoperatively, and only 3.6% continued to have metabolic syndrome 5 years postoperatively. This is in comparison to RYGB which demonstrated 64.5% preoperatively and 11.1% postoperatively [20]. This study further demonstrates the positive metabolic benefits of DS versus RYGB.

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Chapter 65
Duodenal Switch (DS) for the Surgical Treatment of Diabetes and Metabolic Disease

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65.1 Introduction

It seems incongruent that there is clear evidence that duodenal switch procedures [biliopancreatic diversion-duodenal switch (BPD-DS) and single anastomosis duodenal ileostomy-switch (SADI-S)] offer the greatest chance of resolution of diabetes and long-term glucose control, yet represent a substantial minority of total cases performed. Roux-en-Y gastric bypass (RYGB) remains the procedure of choice by many bariatric surgeons. This discrepancy is based on many factors. It includes traditional bias, the viewpoint that RYGB offers the proper balance between reasonable efficacy while minimizing long-term detrimental consequences, along with familiarity with the procedure. Often not accounted for is the increased glucose variability following RYGB and its propensity for recurrence. Additionally, it is our

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belief that since DS versions offer the best results for those with advanced and recurrent disease, the path to this construction should be preserved.

The purpose of this chapter is to review the evidence supporting DS for diabetes and suggest an alternative decision-making process for providers. That is to say, DS is underutilized, and the data demonstrating its strong effectiveness should not be ignored.

The message for surgeons: forget labels and preconceived notions and ask the right questions. Outside of weight loss, reduction in percent body fat, and reduced caloric intake, are there separate aspects of our procedures that improve glucose tolerance and treat diabetes? If so, how do different procedures vary? Additionally, what physiological factors in our operations promote and provide for lasting weight loss? It is apparent that while there may be hosts of physiologic changes that contribute to improved glucose control, their efficacy for weight loss and metabolic improvement directly correlates. Thus, DS procedures are generally more effective than either RYGB or laparoscopic sleeve gastrectomy (LSG). Many argue that the long-term risk of micronutrient deficiency exceeds the benefits of increased efficacy.

The best way to answer these questions would be randomized controlled trials using matched appropriate patients. Unfortunately, these trials take years to perform, and getting long-term data on an adequate number of patients is unlikely.

Therefore, we turn to other sources to gain insight. We need to examine comparative trials and meta-analyses that compile data from published studies. Focus should be placed on subjects with profound insulin resistance that require large doses of insulin. Since this is the most difficult sub-group to manage, positive results should be more meaningful. Under-appreciated is the degree of relapse or recidivism following certain surgical procedures. It is clear that even following surgery, weight is like a rubber band and gravitates toward its initial shape. As a result, RYGB cannot be considered a solitary cure, and the path for BPD-DS and SADI-S should be preserved.

65.2 Comparative Literature

Buchwald et al. [1–3] have performed several detailed meta-analyses comparing bariatric surgical procedures and their probability of diabetes resolution. Duodenal switch (DS) and biliopancreatic diversion (BPD) are reported to have resolution rates that exceed 90%. In comparison, rate of remission with RYGB is approximately 70%. Laparoscopic adjustable gastric banding (LAGB), a procedure that few believe has an independent metabolic effect, has a resolution rate of 50%.

Unfortunately, these studies caused the proliferation of LSG, establishing it as the most common bariatric procedure. With increased data, the impact of LSG on diabetes is becoming clearer. Schauer et al. [4] published the 1-, 3-, and 5-year results of the Stampede trial that compared RYGB and LSG, to medical therapy. At 5 years, RYGB was associated with greater weight loss than LSG, with fewer diabetes medications. However, the trial was not powered sufficiently to detect small but clinically significant differences between the two procedures. Further clarification of the advantage of RYGB over LSG was seen in the 5-year SLEEVEPASS trial from Finland [5], specifically concerning T2DM. In this trial, complete or partial remission was seen in 37% of LSG patients and 45% RYGB recipients. An opt conclusion is that the impact of the intestine and its role in maintaining the resiliency for weight loss become more apparent with time. The longer length of the biliopancreatic limb and the portion of the intestine not exposed to food are of key importance for preventing weight regain and preventing diabetes recurrence.

Increasingly, surgeons have moved away from offering bands to diabetic patients, as the results with RYBG are superior. However, a reasonable question is why is the difference between 70% for RYGB and 50% for LAGB so pivotal? Should not the opposite be true?

If bands do not have independent metabolic factors, it would mean that the maximal effect, independent of weight loss, would be the 20% difference. In comparison, for DS the difference is a minimum of 40%. Thus, if looking for independent variables not associated with weight loss, DS is far more likely to incorporate them.

In a non-randomized study, Prachand et al. [6] have compared the resolution of comorbid conditions in patients undergoing DS or RYGB. They concluded that DS is substantially more effective in improving all metabolic variables, including diabetes. In fact, the only comorbid condition associated with better results following RYGB was GERD.

Dorman et al. [7, 8] at the University of Minnesota have done several comparative studies comparing DS and RYGB. Although popular opinion highlights an increased complication rate and creation of long-term morbid conditions, they found that when cases were matched, there was no increase in complicated outcomes. DS has frequently been offered to patients with higher BMI and those with severe comorbid conditions. This bias certainly has impacted outcome data.

Sovik et al. [9] also compared DS to RYGB. They demonstrated that DS was associated with superior weight loss. However, they reported a tendency for an increased probability of poor nutritional outcomes. Despite the differences not being statistically significant, Dr. Edward Livingston published an editorial [10] that suggested this tendency did not justify the performance of DS as a bariatric procedure. Unfortunately, the DS performed was outside accepted principles. In this study, the sleeve aspect of the procedure was done over a 32-French bougie, and total bowel length was 2.5 m. A 32-French bougie is the smallest accepted size for an independent VSG. Certainty, it is not surprising to find deficiencies when tight restriction is combined with an aggressive bypass. In a detailed review of the BOLD database, Nelson et al. [11] reported an impressive difference in lasting weight loss between DS and RYGB. Additionally, as the time from surgery increased, this difference becomes more pronounced.

Guerron et al. [12] investigated diabetes remission prediction with diverse procedures (LAGB, LSG, RYGB, and BPD/DS) over a 16-year period using the DiaRem score. This multivariate analysis showed that BPD-DS resulted in higher odds of diabetes remission at 1 year postoperatively, with LAGB and LSG being lower than RYGB.

65.3 Randomized Controlled Trials for Diabetes

In the last several years, multiple randomized controlled trials have been published that have compared surgical to medical therapy. The field of metabolic surgery became popular following the publication of two landmark articles in the *New England Journal of Medicine* (NEJM) in 2012 that received international recognition in the mainstream media. Schauer et al. [13] published the 1-year results of the Stampede trial that compared RYGB and VSG to medical therapy. Both surgical arms were vastly superior to medical therapy, with no significant difference in diabetes outcomes between RYGB and VSG. A follow-up of this paper was recently published in the NEJM [14]. It demonstrated a lasting advantage for surgical treatment. Again, there was still no statistical difference between VSG and RYGB, but the authors suggested the data supports an advantage to RYGB. Importantly, the article reports on the characteristics of patients least likely to achieve remission. Patients requiring insulin for a lengthy period are the ones least likely to improve. Thus, potentially, those with the greatest problem may not be ideal candidates for RYGB, and these results may provide insight into the dominant changes in glucose regulation caused by RYGB.

In comparison, in the same 2012 edition of the *New England Journal*, Mingrone et al. [15] presented a 2-year trial that compared RYGB and BPD to medical therapy. Both arms were superior to medical therapy. But BPD was greatly superior to RYGB with a resolution rate of 95% for BPD and 75% for RYGB. Therefore, similar to the Guerron study [12] above, advanced cases that have required high-dose insulin can frequently achieve remission following DS procedures.

Prior to these publications, Dixon et al. [16] compared LAGB to optimal medical therapy for patients with very early diabetes. They demonstrated near-complete resolution with LAGB in this group with new onset diabetes. Combining these studies leads to these thoughts. Very early diabetes or insulin resistance can be treated with any effective weight loss intervention, but for patients with lengthy disease, procedures with a strong intestinal component are far more likely to be effective.

This point is clearly demonstrated by the work of Kapeluto et al. [17]. They studied the 10-year results in type 2 diabetes undergoing BPD-DS who required insulin therapy prior to surgery. In this group, deemed by most to be the least likely to achieve complete remission, 90 of 121 patients were complete responders at 10 years. Only 11 of the 121 patients had recurrence. Comparatively, recurrence following RYGB is much higher, even in subjects that do not require insulin preoperatively.

65.4 Recidivism of Diabetes Following RYGB

Of increasing concern are the increasing reports of the recurrence of diabetes several years following RYGB. Interestingly, in a substantial number of cases, the recurrence precedes weight regain. DiGiorgio et al. [18], Chikunguwo et al. [19], and Arterburn et al. [20] have all reported rates that approach 30–40%. If you add the 25% that do not reach remission, then the true rate of persistent T2DM with RYGB is far higher than suggested by the literature.

Furthermore, as Campos et al. [21] have suggested, many of these recurrences are not associated with weight regain or inadequate weight loss. This becomes more disturbing as we are beginning to witness an increased number of patients with late weight regain. The combination of early recurrence rates from progressive metabolic factors combined with a potential rise in insulin resistance if weight regain occurs will potentially result in long-term resolution that are lower than expected by most surgeons.

Although the results of the Stampede trial [22] and the study from Salt Lake City by Adams et al. [23] certainly document the long-term viability of RYGB for T2DM, there are few effective metabolic surgical options for those that fail gastric bypass. Endoscopic rescue therapy is unlikely to be effective. LAGB is decreasing in popularity secondary to long-term complications [24–26]; thus, banding the bypass does not appear to be a realistic long-alterative. Conversion to a distal bypass without preservation of the pyloric valve or fundus can lead to diarrhea that is difficult to control and severe protein malnutrition. Conversion to DS has the potential to be effective, but is an extremely complex procedure.

Perhaps the most convincing evidence comes from results from continuous glucose monitoring (CGM). Ramos-Levi et al. [27] utilized this in patients 2 years post SADI-S and RYGB. As compared to SADI-S, RYGB had far more glucose variability. Of great interest, the degree of glucose variability and maximum glucose excursions was predictive of diabetes recurrence.

65.5 Comparative Physiology

An anatomic comparison between RYGB and DS shows that there are many attractive aspects to DS. It combines a long narrow pouch that preserves the pyloric valve with an intestinal bypass. The pylorus can alter transport from the stomach. Preservation allows for a more aggressive intestinal bypass that minimizes the likelihood of diarrhea. Resection of the fundus causes lasting changes in enteral hormones involved in hunger and satiety.

Alternatively, the anatomy of RYGB results in changes in glucose metabolism which may not be ideal for a bariatric procedure. A short small pouch based on the lesser curvature of the stomach allows for rapid emptying into the jejunum. In fact, it is possible that distension of the jejunum mediated by vagal fibers provides a substantial reason for early satiety following RYGB. With time, this effect seems to dissipate. Many widespread theories that have contributed to the acceptance of RYGB are questionable and not validated by experimental data.

If it is a restrictive procedure, then why does it work so well for reflux where a low pressure would be desired? Why do some long-time surgeons who have had years of experience, like Fobi et al. [28], believe a silicone band is required for long-term efficacy? Where are the data that dumping actually deters sweet consumption? Alternatively, the high glucose level reached soon after eating should make sugar more addictive, similar to other drugs where rapid elevation of blood levels drives pleasure sensors in the brain. How much malabsorption occurs when complaints of constipation are more frequent than soft stools and the vast majority of intestine remains in contact with food? If the two most important variables regarding the intestinal aspect of RYGB are the total length of the portion of the intestine in contact with food and common channel, why do these values seem different for every procedure an individual surgeon performs?

An increasing number of reports have shown that RYGB results in hyperinsulinemic hypoglycemia [29, 30]. In fact, entities that were rarely described, such as non-insulinoma pancreatogenous syndrome and nesidioblastosis after RYGB, have been the subject of an increasing number of publications [31, 32]. Furthermore, CGM has shown that post-RYGB, the majority of time is spent hyperglycemic, followed by hypoglycemia, resulting in a normal average. Very little time is spent euglycemic. In comparison, the majority of time spent following VSG is spent in a normal range [33].

There are many possible explanations for rising obesity, but a significant cause is an increase in simple carbohydrate consumption. The domestic consumption of simple carbohydrate has increased, which can cause a rapid rise in blood glucose. This results in an insulin surge. Insulin is anabolic hormone and drives nutrients into cells. Preventing this response has become the cornerstone of medical weight loss and nutritional guidance. To offset hunger, nutritionists produce a small rise in insulin production. This is the bases of Mediterranean-type diets and other low-carbohydrate plans.

This discrepancy appears to be counterintuitive. Medical weight loss emphases reduced insulin fluctuations, but the most common surgical procedure promotes fluctuation. The impact of oral glucose tolerance testing on RYGB has been previously tested by our group [29]. We demonstrated that abnormal glucose tolerance was extremely common and that more than 80% of patients tested had reactive hypoglycemia. Many patients had both hyperglycemia and hypoglycemia. These findings have been confirmed by other investigators [30, 34], and it has been clearly shown that even asymptomatic patients can have abnormal oral glucose challenge test (OGCT) results after RYGB [33].

But what happens when VSG and DS are subjected to glucose challenge? We recently studied the effect of glucose tolerating testing with both oral and liquid glucose challenge on patients undergoing RYGB, VSG, and DS, which resulted in a consistent pattern for all three procedures [21]. RYGB produced a rapid rise in glucose, and the 1-h insulin level was high than at baseline at both 6 months and 1 year. With a solid muffin, the rise was lower but still more pronounced than VSG and DS. In comparison, DS had a much lower rise in glucose and 1-h insulin. The difference was statistically significant for 1-h insulin compared to RYGB at 6 months and the aggregate for all data points.

The response for VSG was intermediary to the response seen with DS and RYGB. The rise in insulin was less dramatic than RYGB but greater than DS. This study indicates that DS produces euglycemia without causing hyperinsulinemia.

Exactly what mechanisms account for this change remains a subject of investigation. Mingrone et al. [35] have shown a sharp reduction in insulin resistance at the muscle level. Strain et al. [36] have shown that DS causes a far greater reduction in fat mass than other bariatric procedures leading to a marked reduction in insulin resistance. To summarize, the effect of DS on glycemic control appears to be peripheral and not reliant on increased insulin production.

Along with this work has come a better understanding of insulin resistance. Insulin resistance begins in the muscle cell. Fat saturates cell membranes and directly reduces the binding of insulin to its cell membrane receptors. The primary impact is that rather than glucose being converted to glycogen, glucose is converted to fat. The insulin resistance ultimately inhibits the proper oxidation of fat and carbohydrate within the mitochondria. How surgical procedures impact these pathways is an active area of investigation. Preliminary evidence suggests that obesity causes metabolic inflexibility. This means that the muscle cell has difficulty oxidizing fat when at rest or nominal activity, to carbohydrate when more efficiency is required for more robust activity. The key point is that the increased insulin secreted that is necessary to overcome the blockage then impacts the liver. It seems that the sharp reduction of fat available is decreased far more substantially in operations that bypass the proximal intestine. This results in greater changes in the muscle cell which then impact liver function.

65.6 Effect of Physiology on Metabolic Syndrome

The above data seems to provide a link to what is occurring clinically. RYGB allows patients to make more insulin when challenged with a small amount of food. Weight loss and other aspects make them less insulin resistant. This combination results in resolution for the majority of patients. However, in patients with poor beta cell function who cannot mount the increased insulin needed, improvement is less likely.

So how can we explain the 95% resolution rate seen by Buchwald et al. [1] in their meta-analysis and Mingrone et al. [37] in the paper comparing BPD to RYGB? In comparison to RYGB, DS and BPD patients require less insulin to maintain euglycemia. The effect of DS seems to be away from the pancreas. During comparative study [33], when challenged with glucose, DS patients did not produce or require a hyperinsulinemic response.

The clinical importance of these facts is highlighted by Frenken et al. [38] who studied diabetic patients that required insulin therapy for more than 5 years with DS surgery. This is the exact group least likely to improve following RYGB according to the Stampede trial [22]. For patients on insulin for more than 5 years and less than 10 years, the lasting remission rate was 88%. For those on more than 10 years of insulin therapy, the resolution rate still was 66% or close to what is seen in all comers following RYGB.

When you combine the results of our study of glucose regulation and these publications, several factors become clear. All procedures result in weight loss, improved insulin resistance, and better glucose control. RYGB involves creating a small pouch based on the lesser curvature of the stomach. The intestine is attached directly to the small pouch and then a distal attachment created to restore bowel continuity. When glucose is given, it travels from the small pouch directly to the small bowel, bypassing the pyloric valve, duodenum, and proximal jejunum. It is believed that the increased insulin production is primarily caused by increased incretins [glucagon-like peptide-1 (GLP-1)], which are stimulated by food entering the small bowel directly (McLaughlin et al. [39]), showing that when a gastrostomy tube is placed into the remnant of a post-RYGB patient with abnormal glucose tolerance, glucose is normalized with liquid mixed meal into the remnant. Thus, the cause of the abnormal glucose challenge test is the result of nutrient delivery directly into the small bowel. Improved or enhanced insulin production is considered to be an important factor for improvement of glucose tolerance after RYGB. As a result, it is not surprising that those with long-standing disease are less likely to have remission. They have reduced beta cell function and despite increased incretins cannot produce more insulin.

In contrast, the DS results in euglycemia without hyperinsulinemia. For this to occur, the impact has to be peripheral and involve reduced insulin resistance at the cellular level, especially in muscle or the liver. Clinically, we have observed patients with very low c peptide levels who do not require insulin therapy following DS. However, if stressed by infection, we have seen glucose levels rise to pathologic levels and short-term insulin required. This means that the improvement in resistance is adequate for most situations, but when stressed cannot produce the required increased supply.

65.7 What Are the Potential Pathways to Explain?

A large focus of conjecture for the role of bariatric surgery and the resolution of diabetes has been bypassing the duodenum (foregut theory) or stimulation of the distal intestine (hind gut theory). Since both RYGB and DS bypass the duodenum and reduce transit time to the distal intestine, similar responses could be expected. Yet results of many studies show significant differences. As a result, other factors are responsible for these findings. Of interest is the similar results obtained with both BPD and BPD-DS. How can this be explained? Possibilities include the rate of nutrient entry, a change in the microbiology of the gut, the impact of altered fat absorption, and a reduction of inflammatory factors that promote insulin resistance. Interestingly, before there were reports that highlighted diabetes resolution following gastrectomy or RYGB, it was known that jejunoileal bypass could result in remission [40].

Both obesity and diabetes are increasingly being recognized as inflammatory diseases. Thus, rather than increased insulin production secondary to incretins, does separating bile from food result in reduced inflammation, and is this an important component of the equation? Support for this hypothesis is a series of recent publications [41, 42] showing the impact of drugs like ursodeoxycholic acid for metabolic syndrome. Therefore, are bile salts and the diversion of biliary flow important aspects of the equation? Clinically, those with the greatest level of insulin resistance have hepatic steatosis. It appears that increasing lipid excretion has a substantial impact on hepatic insulin resistance.

65.8 SADI-S and Its Impact on DM

Another pivotal point to address is whether BPD-DS and SADI-S are similar. In the US clinical trial for the SIPS version of SADI, Cottam et al. [43] reported diabetes resolution of greater than 90% of recipients that required insulin. Sanchez-Pernaute et al. [44] reported 5-year results of diabetics undergoing SADI; 84% had HgbA1c less than 6%. A recent meta-analysis of the procedure demonstrated over 90% efficacy for resolution. A randomized trial from Spain has recently compared the weight loss of the classic BPD-DS to SADI-S. Weight loss appears similar at 3 years as does resolution of comorbid conditions. There is a perhaps a marginal advantage for diabetes in BPD-DS after 3 years. It is clear that SADI-S is certainly a robust alternative that offers results beyond LSG and RYGB with glucose curves similar to BPD-DS. Finally, although there are many reasons to avoid, conversion of SADI-S to BPD-DS is certainly feasible.

65.9 Clinical Application to the Practicing Surgeon

What does this mean to the practicing bariatric surgeon? Do all with type 2 DM require a DS? The answer is no. The majority of individuals on oral agents with controlled parameters will improve with any weight loss procedure. For those with high insulin requirements, the DS operations offer the best chance for resolution. By leaving an adequate common channel, and have total bowel length of 3 m, the risk of short bowel syndrome can be mitigated. Dorman et al. [7] have shown in a 5-year matched case-control trial that, although resolution of comorbidities is greater with DS, long-term complications are not increased.

Bariatric surgeons need to learn how to stratify their patients to get optimal results. They need to analyze the patient and what the principal objectives of the procedure are. For those with profound insulin resistance and hyperlipidemia, the DS is a superior procedure. For those with super morbid obesity, the majority will still be morbidly obese 5 years after RYGB. Conventional wisdom is that the RYGB has adequate efficacy and mitigates against long-term difficulties. However, are you letting your metabolic surgery patients know that the failure rate is five times higher [43] and weight regain far more likely? Additionally, patients seeking surgical therapy are seeking definitive options; do they realize that should RYGB not be effective, that there are alternatives?

In comparison, the DS is the sum of a LSG and intestinal bypass. Despite conjecture, current clinical evidence suggests very few patients will have remission with RYGB that would not have remission with LSG. Yet, conversion of LSG to DS can be thought of as a secondary primary procedure, rather than complex revision. As a result, the most complex decision is whether a VSG should be first-line therapy or offering one-stage DS when it safely can be performed by those likely to require it. Additionally, are there any technical modifications of the DS that can be studied that preserve efficacy and reduce the trepidation of many practicing surgeons?

In conclusion, examination of meta-analyses, comparative trials, results from the most advanced patients, and examination of the comparative physiology of current procedures demonstrate that DS-type procedures offer the best chance for long-term remission of metabolic syndrome. RYGB promotes glucose variability, and there are few options for patients with recurrence. It is our advice that the path to BPD-DS and SADI-S be preserved. In our practice, RYGB is only utilized when there is a relative contraindication for the creation of the sleeve gastrectomy component such as Barrett's esophagus. If performed, the biliopancreatic limb is at least 150 cm to offer a true intestinal component. For the majority of our patients, our preference is to realize that both obesity and diabetes are chronic diseases characterized by exacerbations. As a result, we want to be able to offer the most effective surgical procedure if required, which is currently BPD-DS or SADI. Thus, we limit creation of a gastric bypass pouch to only those who are not candidates for longitudinal gastrectomy.

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Chapter 66
Postoperative Care

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66.1 General Considerations

Although the duodenal switch is one of the most complex laparoscopic bariatric procedures, it also benefits from the enhanced recovery protocols [1, 2]. These protocols involve different practices aimed to maintain physiological function, enhance mobilization, reduce pain, and facilitate early oral nutrition postoperatively by reducing perioperative surgical stress. These protocols have shown to reduce morbidity and hospital stay, enhancing early recovery and return to normal activity.

The main aspects of the enhanced recovery protocols after duodenal switch can be summarized in the following points

- Analgesia—Implementation of multimodal analgesia avoiding usage of opioids. Acetaminophen and short-term NSAIDs are recommended
- Nausea and vomiting prophylaxis—Liberal use of antiemetics from two different classes is recommended, typically dexamethasone and ondansetron
- Prevention of postoperative ileus—Restricted use of fluids is highly recommended, as well as early ambulation. Early discontinuation of intravenous fluid therapy is strongly recommended

The typical pathway goes as follows. Patients are encouraged to wake up 4 h after surgery, meaning that pain should be controlled early on, but without drugs that may limit patient's awareness. Early ambulation will favor bowel mobilization and better fluid tolerance and should be encouraged and instructed before surgery.

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As a continuation of early ambulation, patients are given clear fluids 6–8 h after surgery. This measure will allow the discontinuance of intravenous fluids and facilitate better food tolerance. Patients should be instructed to drink slowly and in small volumes. The sleeve gastrectomy component may induce some nausea and oral tolerance difficulties in the early hours after surgery, so antiemetics should be used routinely.

Moreover, respiratory physiotherapy is crucial in bariatric surgery patients. Patients should have been instructed prior to surgery in breathing exercises to learn how to expand the thoracic cavity and the lungs. Breathing incentives can be given to the patients to complete this task.

Finally, thromboembolic events should be addressed, as they are potentially deathly complications after bariatric surgery. Thromboprophylaxis in duodenal switch patients should be multimodal. Patients will need lower limb stockings, and the use of intermittent compression pumps is highly recommended. Pharmacological prophylaxis will include low molecular weight heparins or unfractionated heparins. The first dose should be as early as 8 h after surgery, with half the daily treatment dose, and continued for at least 7–10 days. High-risk patients will need to continue prophylaxis for up to 4 weeks. Special attention may be taken in patients with previous anticoagulation of pro-thrombotic conditions, and consultation to hematology is advised to obtain tailored prophylaxis. All these measures have to be completed by early ambulation and instruction to avoid sedentarism after surgery.

66.2 Postoperative Admission to ICU

Bariatric surgery patients usually do not need admission to an intensive care unit (ICU). General recommendation is to perform strict surveillance and monitorization for the first 6–24 h. This monitorization will include pulse, blood pressure, oxygen saturation, and pain control.

All patients should be prophylactically supplemented with oxygen in a head-elevated or semi-sitting position. A low threshold for initiation of positive pressure support must be maintained in the presence of signs of respiratory distress. Patients with obstructive sleep apnea (OSA) that were previously treated with CPAP or BiPAP therapies must continue this treatment in the early postoperative weeks.

Some centers reserve ICU for patients with high-risk respiratory comorbidities such as hypoventilation, high-risk obstructive sleep apnea, or other uncontrolled or poorly controlled diseases. Patients with cardiac comorbidities as low left ventricle output, dilated myocardiopathy, or severe ischemic damage could be also candidates of ICU. In these cases, cardiac monitoring and some prophylactic therapies may be needed. Finally, in patients with unexpected surgical or anesthetic intraoperative complications, it could be also recommended to keep the patient under intensive care at least some hours after surgery.

66.3 Routine Examinations After Surgery

Routine complementary examinations are not usually mandatory after bariatric procedures. However, some protocols recommend a blood test 24 h after surgery, to check hemoglobin and C-reactive protein levels. Elevated C-reactive protein levels have been correlated with surgical complications, but evidence is still low, and cut-off levels have not been clearly defined.

Moreover, it is not recommended to systematically perform any image test to check for leaks or other complications. Nevertheless, in case of intraoperative complications or the slightest clinical suspicion, a CT-scan should be considered.

66.4 Patients' Comorbidities Management After Surgery

66.4.1 Type 2 Diabetes

Glitazones, glinides, and dipeptidyl-dipeptidase 4 inhibitors (DDP4i) should be discontinued 24 h before surgery, with a reduction of basal insulin dosage to 0.3 U/kg of body weight [3]. Metformin should be discontinued on the day of surgery. As in any hospitalized patient, from the day following the operation until discharge, target glucose values should be 140–180 mg/dL. Basal insulin at a dose of 0.1 U/kg may be prescribed if values are above 180 mg/dL in two consecutive determinations.

Early after surgery patients are instructed to drink fluids, but caloric intake would be minimal anyway. Thus, glycemic control is usually significatively improved. Treatment is directed predominantly toward fasting glucose values. Patients should be instructed to test blood glucose at least twice a day, during morning fast and through the day, with target values of 100–120 mg/dL in fast and less than 180 mg/dL 2 h after a meal.

If glycemic control after surgery is adequate, patients with oral hypoglycemic drugs may discontinue these treatments after discharge. If glucose levels are constantly high after surgery, low-dose metformin once or twice a day is recommended. Patients under poor glycemic control, or high doses of insulin prior to surgery, should be monitored postoperatively and may need metformin or lower doses of insulin depending on glycemic controls. In these cases, endocrinology consultation prior to discharge is advised.

66.4.2 Hypertension

Patients are recommended to reduce their usual dosing of medications, especially those with better control before surgery [3]. In the short term, weight loss improves blood pressure, and usually treatments can be discontinued early on. Daily monitoring and early check-up with a cardiologist is highly recommended after surgery.

66.4.3 Dyslipidemia

Hypertriglyceridemia and hypercholesterolemia improve after bariatric and metabolic surgery due to weight loss [4]. There is no consensus about resuming or not preoperative medications after surgery. One strategy could be not to rule them out initially, but reconsider this premise later on and depending on weight loss outcomes and the evolution of blood test. Patients using atorvastatin or drugs with similar pharmacokinetic properties should be closely monitored for both therapeutic effects and adverse events during the first years after gastric bypass and duodenal switch.

66.4.4 Obstructive Sleep Apnea

OSA is a quite common condition in morbidly obese patients. CPAP and BiPAP treatments should be continued just after surgery, following the same patterns that were in use prior to surgery. There is no contraindication for these treatments after duodenal switch.

Once the weight loss begins to be significant, patients may feel improvement of OSA and usually complain of worse tolerance to CPAP or BiPAP. Patients should be reviewed by their pneumologist in order to determine whether the BiPAP/CPAP pressures need adjustment and if a new sleep respiratory assessment should be undertaken.

66.4.5 Other Pharmacological Treatments

Duodenal switch will modify drugs' pharmacokinetics in different directions. While the absorption of drugs is predominantly reduced, tissue distribution, drug metabolism, and elimination also change their bioavailability, usually with unknown net balances. Immunosuppressants and other sensitive drugs, if possible, should be closely monitored, while weight is still changing in order to progressively adapt the dosage. Moreover, women with oral contraceptives are encouraged to use other non-oral contraceptive treatments due to reduced efficacy of oral contraceptives after duodenal switch.

On the other hand, it should be taken into consideration that during the first postoperative weeks, the patient may be incapable of taking solid drugs, so a change to a liquid presentation, when possible, may be recommended. Finally, NSAIDs and steroids should be avoided to prevent gastritis and anastomotic ulcers. In fact, patients are encouraged to keep on proton pump inhibitors for 3–6 months even when asymptomatic.

66.4.6 Other Considerations

After bariatric and metabolic surgery, patients are encouraged to have an active way of life, to go walking, to do some exercise, and to improve their physical condition. These activities should be initiated as soon as they feel able to. After discharge, patients are recommended to walk daily for at least 20–30 min.

Prophylaxis of metabolic deficiencies should be initiated as soon as possible. After duodenal switch, the most common deficiencies are iron, calcium, and vitamins A and D [5]. B family vitamins are also important, especially in patients with increased nausea and vomiting. Some patients will need parenteral B12 supplementation, but usually not in the early postoperative stage but months later. Multivitamin supplementation with calcium and vitamin D is the most common recommendation. Other common deficiencies should be checked during the follow-up routinary blood tests, every 3 months for the first year and every 6 months later.

Patients should go home with complete information about the procedure that has been performed, the recommended diet, and the possible complications. Health and sanitary education from the surgeon and the allied health professionals will improve the results and will avoid unnecessary consultations.

66.4.7 Patient Discharge

The discharge of the patient can be prepared for the second to the fourth postoperative day, depending on the postoperative evolution. Specific criteria for discharge vary between different hospitals, but they generally adhere to the main principles of meeting normal hemodynamics, not having pain or fever, having good oral tolerance, moving without difficulties, accepting to leave, and understanding the alarm criteria.

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Chapter 67
Metabolic Syndrome and the Influence of Bile Acids

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67.1 Bile Acids

Bile acids (BAs) are synthesized from cholesterol in the liver and are components of bile. Traditionally, BAs have the function of emulsifying lipids and assisting in the absorption and digestion of dietary fats. They play a key role in the absorption of fat-soluble vitamins such as vitamins A, D, E, and K. After taking part in small intestine digestion processes, bile acids are almost completely (95%) resorbed in the distal ileum and then are taken up from portal blood through the liver (enterohepatic circulation). Excess cholesterol in the body is also converted into bile acids and eliminated by bile, thus maintaining cholesterol hemostasis [1]. Bile acids not only play a role in the absorption of lipids in the intestine but also seem to be part of a larger physiological system in response to ingested nutrients which involves glucose metabolism [1, 2]. Bile salts induce hepatic glycogen synthesis, inhibit gluconeogenesis, improve insulin sensitivity, and control glucose metabolism [2].

It has been suggested that BAs are important mediators of weight loss and metabolic changes after bariatric surgery and different BA fractions have been associated with different characteristics of glucose metabolism [3–5]. They perform as signaling hormones, activating nuclear and membrane-coupled receptors in the intestine, liver,

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muscle, and adipose tissue. Furthermore, they regulate the balance of bacterial flora, while the latter reciprocally regulate the metabolism and composition of Bas [4].

Thus, understanding the physiology of BA regulation after bariatric surgery is an important therapeutic target in treating severe obesity and its metabolic sequelae.

67.2 Bile Salt Physiology

Bile is predominantly composed of water and several dissolved substances, including cholesterol, amino acids, enzymes, vitamins, heavy metals, bile salts, bilirubin, phospholipids, and other constituents such as drugs and toxins. The cells that line the intrahepatic and extrahepatic bile ducts have the function of altering and refining the content of hepatically synthesized bile through a complex mechanism, controlled by a multitude of molecules, hormones, and neurotransmitters [1, 2]. Bile acids undergo chemical modification through conjugation in the liver and dehydroxylation by intestinal bacteria [6]. It is important to stress the fact that bariatric surgery also results in significant changes in intestinal microbiome and the dynamic interactions between bile acids and intestinal microbiota after bariatric surgery may contribute to metabolic improvements, although the detailed mechanisms leading to these effects require further investigation [6].

Bile salts participate in enterohepatic circulation in two types of chemical structure—primary, cholic acid and chenodeoxycholic acid, and secondary, deoxycholic acid and lithocholic acid—which are formed in the terminal ileum from the primary bile salts as a result of a structural change called 7-alpha dihydroxylation, by the action of microflora bacteria, especially the anaerobic ones. In humans, the reuptake of conjugated Bas is performed by transport protein Na^+ taurocholate cotransporting polypeptide (NTCP), while the non-conjugated bile acids are absorbed by organic anion transporters which also absorb bilirubin and other anions. The total pool of bile acids in humans is tightly controlled by coordinated regulation of the expression of genes involved in the synthesis, secretion, reabsorption, and reuptake of bile acids by the liver [7, 8].

67.3 Increased Bile Acid Levels and the Improvement of Metabolic Syndrome After Bariatric Surgery

For over four decades, it has been known that deficiencies in insulin signaling and glycemic control can precipitate multiple disruptions in BA physiology. Several studies have shown that bile acid levels and composition are altered after bariatric surgery [2, 5, 9].

Creating a long biliopranceatic limb that is then not exposed to other nutrients other than lipids from bile and also allowing bile to reach the distal without mixing with other nutrients, which takes place, for example, in DS and RYGB surgeries, is associated with weight loss, increased serum bile acid levels, improved glucose tolerance, and increased postprandial GLP-1 secretion. The altered anatomy leading to changes in bile acids contact and interaction with the small intestines and other nutrients have been implicated as one of the main mediators for the effect on GLP-1 levels after surgery. GLP-1 is a incretin hormone secreted by the L cells of the distal intestine usually in response to intestinal nutrients and stimulates insulin secretion [10].

67.4 FXR and TGR5 Bile Acid Nuclear Receptors as Molecular Targets of Surgery Bariatric

In the twenty-first century, there was the identification of BA receptors: the farnesoid receiver X receptor (FXR) and the G protein-coupled bile acid receptor 5 (TGR5). They perform as signaling molecules to regulate the lipid and glucose homeostasis [2, 9].

Animal model studies have shown that the effects of bile acids on glucose metabolism can be mediated by the activation of L cells via the TGR5 receptor and the FXR signaling [5, 9, 11]. FXR and TGR5, along with BAs, participate in the insulin release signaling mechanism. It is important to consider that BAs and their targets are present and involved in cellular bioenergetic control within the same organs and tissues impaired by insulin resistance in severe obesity. Strong evidence links markedly anomalous BA metabolism to the pathophysiology of severe obesity, insulin resistance, NAFLD (nonalcoholic fatty liver disease), and T2D (type 2 diabetes) [9].

FXR is expressed at high levels in the liver and intestine. Similar to other nuclear receptors, once activated, FXR is translocated to the cell nucleus, where it forms a dimer (in this case a heterodimer, with) and binds to hormone response elements on the DNA, which regulates the expression of certain. BAs function as endogenous ligands for FXR, so that enteric and systemic release of BAs induces FXR-driven changes in gene expression networks. The complex role of FXR in metabolic homeostasis is evident in studies in mice [11, 12]. In the liver, FXR activation suppresses hepatic BA synthesis, changes BA composition, and contributes to liver regeneration, as well as to glucose, lipid, and cholesterol homeostasis.

In addition to expression in the liver, FXR is also expressed in the intestine, where it regulates the production of the endocrine hormone FGF19 which, along with the hepatic FXR, seems to be involved in the control of the synthesis, transport, and metabolism of BA [11–13]. FXR plays a central role in mediating the negative feedback regulation of BA synthesis. Bile acid biosynthesis is tightly controlled by intrahepatic negative feedback signaling elicited by bile acid binding to FXR, as well as by enterohepatic communication involving ileal bile acid reabsorption [3, 8]. In severely obese non-diabetic adults, the body mass index can be positively correlated with FXR mRNA expression in the liver and ileum, and inversely related to hepatic NTCP expression [9, 14]. That reduces fasting or postprandial BA reuptake in the liver [14]. In fact, the expected inhibitory effects of FXR positively regulate BA synthesis [9, 14, 15].

BAs in the small and large intestine partly regulate the intestinal microbiota, incretin secretion, and FGF15/19 production, which then assists modulating whole-body lipid, glucose, and energy homeostasis. As a primary bile acid receptor, FXR has been investigated for its role in bariatric surgery [11]. Absence of FXR in animals results in those being unable to maintain lower body weights after vertical gastroplasty; rather, they increase energy intake to compensate for early postsurgical weight loss [2, 16].

Conversely, TGR5 functions as a cell surface receptor for bile acids. The receptor is implicated in the suppression of macrophage function and in the regulation of energy homeostasis by bile acids [5]. Bile acids, through the activation of TGR5 in muscle and brown adipose tissue, are capable of increasing energy expenditure and preventing—or even reversing—induced obesity in mice [5, 9, 17]. These changes resulted in increased TGR5 signaling in the ileum and brown adipose tissues, concomitant with improved glucose control and increased energy expenditure. It is accepted that bariatric surgery achieves its postoperative therapeutic effects through improving TGR5 signaling.

67.5 Bile Acid and Duodenal Switch and Its Derivatives

T2D resolution occurs most commonly and rapidly after Roux-en-Y gastric bypass (RYGB) and biliopancreatic bypass (BPD), which share the common feature of a proximal small intestine bypass. Surgically induced decrease in caloric intake, weight and fat mass loss, changes in carbohydrate, fat and protein absorption, or changes in intestinal hormone release all combined promote the dramatic effect of bariatric surgery on T2D [9, 10, 18].

Research in humans indicate that gene expression of the farnesoid X receptor (FXR), which is a target of the BAs, is increased in the liver but decreased in the small intestine after RYGB. In contrast, intestinal expression of the transmembrane G protein-coupled BA receptor (TGR5) is upregulated after surgery. These changes were followed by NAFLD and/or T2D regression after 1 year [9]. Animal models suggest that the control of T2D after gastrointestinal bypass surgery may result directly from the redirection of nutrients in the intestine [4, 15].

Systemic BA concentrations can begin to increase as early as 1 week after RYGB and VSG (vertical gastrectomy), which contrasts directly with the reduced BAs after non-surgical diet [2, 6, 15]. Interestingly, higher systemic concentrations may help explain why intestinal FXR and TGR5 are differentially impacted by RYGB. Whereas FXR is a nuclear receptor and requires intracellular BA transport for ligand-dependent activation, TGR5 is a basolateral receptor that, unlike FXR, shows an increased signaling potential in response to increased systemic BAs. Growing evidence indicate that altered BA physiology and signaling through FXR and TGR5 may support or enhance metabolic improvements related to weight loss [15].

Since FXR inhibits glycolysis, downregulation of FXR after DS and other derivations may support the improvement in glucose uptake and use in the small intestine, observed after bariatric surgery [11, 14, 15]. In addition to the direct effects of FXR signaling in hepatic BA, glucose, and lipid metabolism, the inhibition of intestinal FXR after RYGB is also associated with upregulation of TGR5 [5, 9], which probably contributes to increased postprandial levels of hormones such as GLP1 and YY peptide (PYY) by means of enteroendocrine L cells after bariatric surgery [9, 15].

BAs stimulate the secretion of gastrointestinal hormones (such as GLP-1, PYY, and GIP) through the activation of TGR5 receptors located on the basolateral membrane of enterocytes. Therefore, the higher GLP-1 postprandial levels observed in individuals who underwent BPD/DS (biliopancreatic diversion with duodenal switch) can be attributed to bile acid interactions across a longer intestinal length, leading to greater stimulation of GLP-1-producing cells [19].

Importantly, DS, VSG, and RYGB result in greater weight loss and changes in BA concentrations, as well as greater changes in FXR and TGR5 signaling and higher cardiometabolic improvements as compared to the restrictive-only adjustable gastric band procedure [2, 4, 9].

Total bile acid concentrations increased substantially at 5 years after RYGB and DS with greater increases in total and primary bile acids after DS; however this effect was greater in patients with prior cholecystectomy. Higher levels of total bile acid in 5 years have been associated with decreased body mass index (BMI), greater weight loss, and lower total serum cholesterol [4]. A long biliopancreatic loop may be important for metabolic improvement after bariatric surgery and suggests that BAs are involved in this process [4, 12].

The mechanisms explaining the higher BA concentrations after BPD/DS (biliopancreatic diversion with duodenal switch), when compared to RYGB, are unknown and may have several different origins. Differences in intestinal absorption may contribute to it. The longer biliopancreatic loop in BPD/DS leads to the transport of high concentrations of primary BAs through a longer segment of small intestine that sees no other form of luminal nutrients than lipids of bile and only mixing with food and promoting digestion and absorption of fat in the common loop. The higher primary BA concentrations after BPD/DS were predominantly due to an increase in unconjugated and glycine-conjugated primary Bas, but the site of greater absorption (BP or common channel) and whether differences in liver BA reuptake from portal circulation occurs are still under investigation [4, 9, 15].

In normal anatomy, BAs in the proximal intestine are mostly conjugated primary BAs. A possible explanation for the increase in unconjugated BAs could be the microbial contamination in the small intestine due to changes in intestinal anatomy, resulting in higher unconjugated BA production by the intestinal microflora bacteria and the subsequent absorption at the biliopancreatic loop [4, 14, 15]. This may mean that the higher BA levels we observed after BPD/DS (and also RYGB) does not necessarily reflect an actual increase in the size of the bile salt reservoir, but may be a result of shorter enterohepatic cycles [4, 15, 20]. Altered microbial metabolism may be involved, since it may modulate the BA pool. Changes in the BA synthesis or excretion may also be involved [14, 15].

67.6 Conclusions

Several studies have shown that fasting and postprandial bile acid levels and composition are altered after bariatric surgery. The hormonal roles of bile acids in metabolic regulation make them prime candidates for mediators of the beneficial effects of bariatric surgery. Growing evidence indicates that altered BA physiology and signaling through FXR and TGR5 may support or enhance metabolic improvements related to weight loss. BAs stimulate the secretion of gastrointestinal hormones (such as GLP-1, PYY, and GIP) through activation of TGR5 receptors located in the basolateral membranes of enterocytes.

A long biliopancreatic loop seems to be related to an increase in unconjugated BA through a higher concentration of primary BAs, and this mechanism may be one of the driving forces of metabolic improvement after bariatric surgery.

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Index

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